Prebiotics: A Review of Therapeutic Potential
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Abstract
Prebiotics are 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. Prebiotics are reported for various activities, particularly for protective role in colon cancer and inflammatory intestinal conditions, immune modulation, curbing obesity, metal sequestering, glucose intolerance, hypolipidemic activity, antimicrobial activity and anticarcinogenic activity. Fructooligosaccharides (FOS) are reported to have a prominent role in the alteration of cecal microbiota, cecal pH, cecal weight, and serum lipid levels, and also an inhibitory effect on precancerous colon lesions. Lactulose and its metabolites draw water into the bowel, causing a cathartic effect through osmotic action. Mannanoligosaccharides influenced the solubility of nutrients by their higher water binding capacity and also increase calcium absorption and possibly magnesium absorption, while promoting intestinal bacteria. Inulin has a minimal impact on blood sugar and in sharp contrast to fructose it is not insulemic and does not raise triglycerides, making it generally considered suitable for diabetics. Isomalt-oligosaccharides favorably modulate serum cholesterol in normal cholesteremics as compared to FOS and inulins which are more active only in hypercholesteremics. Prebiotics are mostly combined with foods and beverages and incorporated into biscuits, confectionery, cereals, dairy products, drinks, infant formula feeds and weaning foods. With increasing significance of gastrointestinal health and its positive effect on prevention of various other diseases, role of Prebiotics alone or in synergistic combination with probiotics is now well recognized and studies are ongoing regarding development of synergistic formulations utilizing various polymers.

Keywords: Bifidobacteria, Dietary fibre, Fructo-oligosaccharides, Prebiotics.

INTRODUCTION
The term prebiotic was introduced by Gibson and Roberfroid ¹ as "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." This definition more or less overlaps with the

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definition of dietary fiber, with the exception of its selectivity for certain species. This selectivity was shown for bifidobacteria, which may be promoted by the ingestion of substances such as fructooligosaccharides and inulin\textsuperscript{2-3}, transgalactosylated oligosaccharides \textsuperscript{4-6}, and soybean oligosaccharides\textsuperscript{7-8}. Unlike probiotic bacteria, prebiotic carbohydrates are not destroyed when cooked\textsuperscript{9-10}. Prebiotics consist mainly of oligosaccharides, sugar molecules of three to six chains and soluble fiber. Oligosaccharides coat mucus membranes and are found in plants, saliva, and breast milk, which were more than 130 different combinations of oligosaccharides in human breast milk alone necessary to fight off harmful organisms and support beneficial ones thus making babies healthier\textsuperscript{11}.

**PREBIOTICS ACTION**

Probiotic bacteria are not normally found in the human intestine. They also do not colonize well when introduced and are eliminated quickly. Therefore, prebiotic foods are vital to encourage probiotic organisms to survive and thrive in the human gut. Beneficial bacteria must constantly be introduced in the diet and fed proper fibrous diet to encourage them to adhere to the intestinal wall rather than passing through the digestive, which explains the difference in GIT flora of vegetarians and non-vegetarians\textsuperscript{9}.

Also, it is an established fact that vegetarians are ill less often than non-vegetarians reason for this is that probiotic bacteria, and the short-chain fatty acids (SCFAs) that are produced by them, restrict the growth and activity of less beneficial species. In addition, the vegetarian intestinal tract discourages putrefactive and disease-causing bacteria and yeast because plant-based foods move out of the intestine more quickly than do animal products. This “crowding out” of undesirable organisms is known as competitive exclusion, an action which promotes better gut integrity and function, increases immune system function, and improves calcium absorption and cholesterol maintenance.

In fact, most of the energy required by the colon is provided directly by SCFAs, the decreased quantity of which decreases integrity and function, resulting in various “starved bowel” disorders known collectively as IBS (irritable bowel syndrome) or IBD (irritable bowel disease). For those sufferers, the prebiotics most recommended are lacto sucrose, oligofructose, inulin, bran, psyllium, and germinated barley foodstuff (GBF).

The bacterial flora of the intestine is strictly connected with the process of digestion and its composition has a direct influence on state of health. A healthy intestinal flora helps safeguard the efficiency of our guts immune system, helps keep bad bacteria in check by the help of SCFAs from prebiotics which decreases luminal pH and thus suppresses growth of bad organism and transforms certain human waste products into substances that are
useful to the organism. This flora balance can be upset by everyday factors like stress, antibiotic treatments and poor diet, so safeguarding this precious equilibrium is therefore vital. A good probiotic-prebiotic composition uses US-GRAS (GENERALLY RECOGNIZED AS SAFE) accredited strains safe for human consumption, can survive the gastric juices on the way to the gut, be self stable and ideally contain inulin prebiotic that acts as a food for beneficial bacteria which although present in some food is not generally available in most diets.

Several important factors influence the total oligosaccharide effects in the bowel, particularly the nature of the oligosaccharides, the dose, and the duration of the treatment, the place where their fermentation mainly occurs (proximal or distal colon) and the initial composition of intestinal flora. Although there is no recommended daily dose of prebiotics, doses of 4-20 g/day have shown efficacy in adults.12-15

THERAPEUTIC POTENTIAL OF PREBIOTICS

There is mounting scientific evidence that the symbiotic relationship between prebiotics and probiotics significantly contribute to health. Together, they have been reported with,9

- Anticarcinogenic activity,
- Antimicrobial activity,
- Hypotriglyceridic activity,
- Antihyperglycemic activity,
- Immunostimulant activity,
- Improving mineral absorption and balance,
- Ridding the gut of harmful microorganisms,
- Help prevent constipation and diarrhea,
- Antiosteoporotic activity.

COMMERCIAL PREBIOTIC FOODS

Prebiotic carbohydrates are found naturally in some fruit and vegetables as bananas, berries, asparagus, garlic, wheat, oatmeal, barley (and other whole grains), flaxseed, tomatoes, Jerusalem artichoke, onions and chicory, greens (especially dandelion greens but also spinach, collard greens, chard, kale, mustard greens, and others), and legumes (lentils, kidney beans, chickpeas, navy beans, white beans, black beans, )10.

The various oligosaccharides classified as prebiotics and added to processed foods and supplements include Fiber gums, Fructo-oligosaccharides (FOS), Inulins, Isomalto-oligosaccharides, Lactitol, Lactosucrose, Lactulose, Oligofructose, Pyrodextrins, Soy oligosaccharides, Transgalacto-oligosaccharides (TOS), and Xylo-oligosaccharides. Each is dealt with separately under prebiotic substances12-13.

USES14

The international consumer is well aware of the health benefits of prebiotics, gut integrity, probiotic microflora, and their respective roles in health maintenance. Prebiotics are being made available in
almost every product imaginable; and, as they become increasingly popular, more and more uses of them are going to be adopted by the commercial industry. So far, such uses include kefir, yogurt and other dairy drinks, sports products, functional waters, nutrition bars, weight loss products, soymilk, infant foods and formulas, green foods, probiotic supplements, mineral supplements, medical foods, as well as pet foods and animal feeds.

PREBIOTICS SUBSTANCES
Fructo-oligosaccharides

Fructo-oligosaccharides or FOS typically refer to short-chain oligosaccharides comprised of D-fructose and D-glucose, containing from three to five monosaccharide units. FOS, also called neosugar and short-chain FOS (sc FOS), are produced on a commercial scale from sucrose using a fungal fructosyltransferase enzyme and stimulate the growth of Bifidobacterium species in the large intestine. FOS are marketed in the United States in combination with probiotic bacteria and in some functional food products. Two different classes of fructooligosaccharide (FOS) mixtures are produced commercially, based on inulin or polyfructose (a polymer of D-fructose residues linked by β (2-1) bonds with a terminal α (1-2) linked D-glucose) degradation or transfructosylation processes. FOS produced by degradation is mainly marketed commercially by Orafti Ltd., Tienen Belgium, which markets the product as Oligofructose (or Raftilose). FOS is extracted from fruits and vegetables like bananas, onions, chicory root, garlic, asparagus, barley, wheat, jicama, and tomatoes and being more soluble than inulin are need as yogurt and dairy product additives. The Jerusalem artichoke and its relative, yacon have been found to have the highest concentrations of FOS of cultured plants. FOS serve as a substrate for microflora, particularly bifidobacteria, in the large intestine result in reduced pH after fermentation and increase calcium absorption (as Calcium is more soluble in acid medium). It has also been touted as a supplement for preventing yeast infections. Since fructooligosaccharides are non-digestible, they provide almost no calories and are thus used as substitute sweeteners. Fructooligosaccharides have approximately one-half the sweetness of sugar. They are also being added to a variety of food products because they provide a combination of sweetness and low calories plus the additional health benefits that have been mentioned. Although fructooligosaccharides occur naturally in many foods, a large proportion of these products are now synthesized commercially.

Inulins

Inulins refer to a group of naturally-occurring fructose-containing oligosaccharides. Inulins belong to a class of carbohydrates known as fructans derived from the roots of Chicory (Cichorium intybus) and Jerusalem artichokes mainly
comprised of fructose units and typically have a terminal glucose with β-(2-1) glycosidic linkage. The average degree of polymerization of inulins marketed as nutritional supplements is 10 to 12. Inulins stimulate the growth of *Bifidobacterium* species in the large intestine, \(^{19}\) has unusual nutritional characteristics ranges from completely bland to subtly sweet and can be used to replace sugar, fat, and flour\(^{20}\). This is particularly advantageous because inulin contains a third to a quarter of the food energy of sugar or other carbohydrates and a sixth to a ninth of the food energy of fat. It also increases calcium absorption\(^{21}\) and possibly magnesium absorption, \(^{22}\) while promoting intestinal bacteria. Inulin has a minimal impact on blood sugar\(^{23}\).

There are two types of dietary fiber i.e. soluble and insoluble. Insoluble fiber increases the movement of materials through the digestive system and increases stool bulk; it is especially helpful for those suffering from constipation or stool irregularity. Soluble fiber dissolves in water to form a gelatinous material. Some soluble fibres may help in lowering blood cholesterol and glucose levels. Inulin is considered a soluble fiber\(^{22}\). Plants that contain high concentrations of inulin include\(^{23}\)

- Elecampane (*Inula helenium*)
- Dandelion (*Taraxacum officinale*)
- Wild Yam (*Dioscorea spp.*)
- Jerusalem artichokes (*Helianthus tuberosus*)
- Chicory (*Cichorium intybus*)
- Jicama (*Pachyrhizus erosus*)
- Burdock (*Arctium lappa*)
- Onion (*Allium cepa*)
- Garlic (*Allium sativum*)
- Agave (*Agave spp.*)
- Yacon (*Smallanthus sonchifolius spp.*)

**Isomalto-oligosaccharides**

Isomalto-oligosaccharides (IO) comprise a mixture of α-D-linked glucose oligomers, including isomaltose, panose, isomaltotetraose, isomaltohexaose, nigerose, kojibiose, isopanose and higher branched oligo-saccharides. Isomalto-oligosaccharides are produced by various enzymatic processes\(^{24}\). They act to stimulate the growth of *Bifidobacterium* species and *Lactobacillus* species in the large intestine. Isomalto-oligosaccharides are marketed in Japan and United States as dietary supplements and in functional foods\(^{25}\).

Abnormal bowel function, particularly constipation, is a common complaint of the ill or inactive elderly population\(^{26}\). Purified dietary fibers such as guar gum, oat fiber and soy fiber have been incorporated into commercial liquid formulas. However, the constipated elderly population still requires suitable dietary fiber supplements that could easily be incorporated into their ordinary diet for maintaining regular bowel movement\(^{29-31}\).

Isomalto-oligosaccharides may also modulate serum cholesterol in normal cholesterolics as compared to FOS and inulins which are more active only in hypercholesteremics. It also modulates
serum electrolyte concentrations since calcium and magnesium absorption from the colon and rectum increased in rats fed FOS\textsuperscript{27, 28, 32, 33}.

**Lactitol**

Lactitol is a disaccharide analogue of lactulose. Its pharmaceutical use is in the treatment of constipation and hepatic encephalopathy. It is resistant to digestion in the upper gastrointestinal tract and it is fermented by a limited number of colonic bacteria, resulting in an increase in the biomass of bifidobacteria and lactobacilli in the colon. Lactitol is known chemically as 4-0-(β-D-galactopyranosyl)-D-glucitol. Lactitol is not approved for the treatment of hepatic encephalopathy or constipation in the U.S., and its use as a prebiotic is considered experimental. Lactitol is used in Europe as a food sweetener\textsuperscript{34-36}.

**Lactosucrose**

Lactosucrose is a trisaccharide comprised of D-galactose, D-glucose and D-fructose. Lactosucrose is produced by the enzymatic transfer of the galactosyl residue in lactose to sucrose. Lactosucrose is resistant to digestion in the stomach and small intestine. It is selectively utilized by intestinal *Bifidobacterium* species resulting in significant induction of growth of these bacteria in the colon. Lactosucrose is also known as 4G-β-D-galactosylsucrose. It is widely used in Japan and in the United States as a dietary supplement and in functional foods, including yogurt\textsuperscript{35, 36}. Oral supplementation of 10g lactosucrose daily for 2 weeks was effective in multiplying oxalate-degrading bacteria including various bifidobacterium species, but not in reducing urinary oxalate excretion under free non-restricted dietary intake.\textsuperscript{37}

**Lactulose**

Lactulose is a semisynthetic disaccharide comprised of the sugars D-lactose and D-fructose. The sugars are joined by a β-glycosidic linkage, making it resistant to hydrolysis by human digestive enzymes. Lactulose is, however, fermented by a limited number of colonic bacteria. This can lead to changes in the colonic ecosystem in favor of bacteria, such as lactobacilli and bifidobacteria, which may confer some health benefits.\textsuperscript{35, 36, 38} Lactulose is a prescription drug in the United States for the treatment of constipation and hepatic encephalopathy. Its use in the United States as a prebiotic substance is still experimental. In the treatment of chronic constipation, its metabolites draw water into the bowel, causing a cathartic effect through osmotic action. Lactulose is metabolized in the colon by bacterial flora to short chain fatty acids, acidifying the colonic contents. This favors the formation of the nonabsorbable NH\textsubscript{4}\textsuperscript{+} from NH\textsubscript{3}, trapping NH\textsubscript{3} in the colon and effectively reducing plasma NH\textsubscript{3} concentrations. Some common brands of lactulose are;\textsuperscript{39} • Generlac® • Cephulac® • Cholac®
• Constilac®
• Enulose®
• Acilac®
• Heptalac®
• Actilax®
• Duphalac®
• Kristalose®
• Apo-Lactulose

Pyrodextrins
Pyrodextrins comprise a mixture of glucose-containing oligosaccharides that is derived from the hydrolysis of starch. Pyrodextrins have been found to promote the proliferation of *Bifidobacterium* species in the large intestine. They are resistant to digestion in the upper gastrointestinal tract. Pyrodextrins are being developed for the nutritional supplement market place \(^40\).

Soy oligosaccharides
Soy oligosaccharides refer to oligosaccharides found in soybeans and also in other beans and peas. The two principal soy oligosaccharides are the trisaccharide raffinose and the tetrasaccharide stachyose. Raffinose is comprised of one molecule each of D-galactose, D-glucose and D-fructose. Stachyose is comprised of two molecules of D-galactose, one molecule of D-glucose and one molecule of D-fructose. Soy oligosaccharides act to stimulate the growth of *Bifidobacterium* species in the large intestine \(^41\).

Transgalacto-oligosaccharides
Transgalacto-oligosaccharides (TOS) are a mixture of oligosaccharides consisting of D-glucose and D-galactose. TOS are produced from D-lactose via the action of the enzyme β-galactosidase obtained from *Aspergillus oryzae*. TOS are resistant to digestion in the upper gastrointestinal tract and stimulate the growth of bifidobacteria in the large intestine \(^42\).

Xylo-oligosaccharides
Xylo-oligosaccharides are comprised of oligosaccharides containing β (1→4) linked xylose residues. The degree of polymerization of xylo-oligosaccharides is from two to four. Xylo-oligosaccharides are obtained by enzymatic hydrolysis of the polysaccharide xylan. A study evaluated the effects of xylooligosaccharides (XOS) and fructooligosaccharides (FOS) on the alteration of cecal microbiota, cecal pH, cecal weight, and serum lipid levels, and also their inhibitory effect on precancerous colon lesions in male Sprague-Dawley rats. The results suggest that XOS and FOS dietary supplementation may be beneficial to gastrointestinal health \(^43\)-\(^44\).

Human milk oligosaccharides
Oligosaccharides are one of the main components of human milk, which contains, on average, 10 g/L of neutral oligosaccharides and 1 g/L of acidic oligosaccharides. They express an essentially bifidogenic effect and confer anti-infective properties to human milk. Breast-fed infants show a predominance of bifidobacteria and/or lactobacilli in comparison to formula-fed infants, who develop an intestinal microflora richer in...
Enterobacteria and gram-negative organisms.

Oligosaccharides might contribute to the natural defence against infections in two ways that is, either directly, acting as receptor analogues to prevent attachment of enteropathogens on the epithelial surface and interacting with immune cells, or indirectly, altering the commensal gut microflora toward a healthier composition.

CLINICAL TRIALS OF COMBINATION PREBIOTICS IN INFANTS

A synergistic mixture of neutral galacto-oligosaccharides (GOS, derived from lactose) and long-chain fructo-oligosaccharides (FOS, derived from chicory) was administered for 28 days, at concentration of 0.4 g/100 mL or 0.8 g/100 mL, respectively, when it exhibited a dose-dependent stimulating effect on the growth of bifidobacteria and lactobacilli in the intestine. This combination resulted also in an increase of stool frequency and a reduction of stool consistency, closer to reference breast-fed infants.

A study with term infants has evaluated the nutritional efficacy and bifidogenic characteristics of a new infant formula containing partially hydrolyzed whey proteins, modified fats with high β-palmitate contents and prebiotics with starch. According to the results, the new formula supported satisfactory growth, led to higher counts of bifidobacteria in the feces, and was well tolerated.

POSSIBLE MECHANISM OF ACTION OF VARIOUS PREBIOTICS

Anticarcinogenic activity

The possible anticarcinogenic activity of prebiotics is not well understood. It may be accounted for, in part, by the possible anticarcinogenic activity of butyrate. Butyrate, along with other short-chain fatty acids, is produced by bacterial fermentation of the various prebiotic oligosaccharides in the colon. Some studies suggest that butyrate may induce growth arrest, cell differentiation and may also upregulate apoptosis, three activities which could be significant for its possible anticarcinogenic activity. The prebiotic oligosaccharides may also aid in increasing the concentrations of calcium and magnesium in the colon. Elevated concentrations of these cations in the colon may help to control the rate of cell turnover. Elevated concentrations of calcium in the colon may help to control the formation of insoluble bile or salts of fatty acids. This might reduce the potential damaging effects of bile or fatty acids on colonocytes. The prebiotics may stimulate the growth of bifidobacteria and lactobacilli in the large intestine. There are in vitro and animal data suggesting that these bacteria can bind and inactivate some carcinogens, can directly inhibit the growth of some tumors and can inhibit bacteria that may convert precarcinogens into carcinogens.

Antimicrobial activity

The possible antimicrobial activity of the prebiotics may be accounted by their...
growth-promoting effects on bifidobacteria and lactobacilli. These bacteria can reinforce the barrier function of the intestinal mucosa, helping in the prevention of the attachment of pathogenic bacteria, essentially by crowding them out. These bacteria may also produce antimicrobial substances and stimulate antigen specific and nonspecific immune responses

**Hypolipidemic activity**

The prebiotics may lower triglyceride levels in some individuals. Decreased hepatocyte de novo synthesis of triglycerides is one hypothetical possibility. The prebiotics may also lower total cholesterol and LDL-cholesterol levels in some individuals. The mechanism of this possible effect is unclear. Propionate, a product of oligosaccharide fermentation in the colon, may inhibit HMG-CoA reductase, the rate limiting step in cholesterol synthesis.

**Glucose tolerance**

The oligosaccharides may delay gastric emptying and/or shorten small intestinal tract transit time. This may be via the short-chain fatty acids produced from the oligosaccharides in the colon. Short-chain fatty acids may be involved in the so-called "ileocolonic brake," which refers to the inhibition of gastric emptying by nutrients reaching the ileo-colonic junction. Short-chain fatty acids may also stimulate contractions of the ileum and shorten ileal emptying. In addition, propionate may inhibit gluconeogenesis by its metabolic conversion to methylmalonyl-CoA and succinyl-CoA. These metabolites could inhibit pyruvate carboxylase. Propionate may also reduce plasma levels of free fatty acids. In short, the mechanisms of the possible effects of prebiotics on glucose tolerance are not well understood.

**Metal Sequestering**

The oligosaccharides may bind/sequester such minerals as calcium and magnesium in the small intestine. The short-chain fatty acids formed from the bacterial fermentation of the oligosaccharides may facilitate the colonic absorption of calcium and, possibly, also magnesium ions. This could be beneficial in the prevention of osteoporosis and osteopenia.

**Prebiotics could curb obesity**

Initial results from animal studies have shown that inulin and oligofructose-fed animals have lower fat mass. This is linked to the increased levels of a gut-brain hormone called glucagon-like peptide one (GLP-1), which boosts glucose-stimulated insulin secretion.

**Immune modulation by prebiotics**

A study with pigs (an animal with an intestinal tract similar to humans) was carried out. The pigs were supplemented short-term (three weeks) and long-term (three months) with inulin and oligofructose and markers of immune function were measured in a variety of gut immune tissues. Short-term supplementation resulted in increased phagocytic activity of white blood cells and increased numbers of so-called natural killer T-cells (NKT-cells) in the spleen. In the long-term experiment, the
prebiotic enhanced NK cell activity in Peyer’s patches [part of the lymphatic system] and splenocytes [a white blood cell found in the spleen], overall suggesting a boost of innate immunity not only systematically but also locally in the gut\textsuperscript{48}.

**Role of prebiotics in inflammatory intestinal conditions**

Studies have shown that a combination of inulin and oligofructose (Synergy1) was effective in preventing the development of colitis in animals and, when given in combination with probiotics, reduced the level of inflammation in a small human trial because of decreased levels of pro-inflammatory cytokines and increased levels of anti-inflammatory cytokines\textsuperscript{36}. A small human study in people with Crohn’s disease reported that people receiving a daily supplement of 15g of inulin-type fructans (Prebio1) had reduced disease activity\textsuperscript{49}.

**Protective role of prebiotics in colon cancer**

Harmful and beneficial bacteria commonly found in the intestine generally differ in their enzymatic activities. Bifidobacteria and lactobacilli have lower activities of these xenobiotic-metabolizing enzymes, e.g., β-glucuronidase than do bacteroides, clostridia, and enterobacteriaceae. Because of these enzymes, toxic compounds that are already detoxified in the liver by conjugation are regenerated by the release of toxic aglycones. Furthermore, products of hydrolysis of glucuronides can reenter enterohepatic circulation and thus delay the excretion of compounds\textsuperscript{51, 52}. In several human intervention studies, LAB strains were shown to influence the activity of nitroreductase and β-glucuronidase\textsuperscript{53}.

A common characteristic of the microflora is fermentation of undigested polysaccharides, resistant starch, and fiber, enhancing the formation of LAB and short-chain fatty acids as fermentation products leading to a decrease in the pH of colon content and consequently, reduced incidence of colon cancer in various populations.\textsuperscript{54} Resistant starch and wheat bran favor the production of butyrate, whereas pectin leads to a higher formation of acetate\textsuperscript{55}. Butyrate is associated with many biological properties in the colon, e.g. affecting degree of DNA methylation, which may affect colon cancer, and enhancing cell proliferation, and inhibiting apoptosis in normal cells and suppressing proliferation and increasing apoptosis in transformed cells\textsuperscript{56–57}. Butyrate has also been shown to increase glutathione transferase in colon cells\textsuperscript{58} which is an important enzyme involved in the detoxification of both electrophilic products and compounds associated with oxidative stress. Thus, enzyme induction by butyrate, or by the microflora and increased activity by prebiotics may be an important mechanism of protection against carcinogen-enhanced colon cancer\textsuperscript{50, 59}.

**RECENT ADVANCEMENTS IN PREBIOTICS FORMULATIONS**
Prebiotics (specifically FOS) in yogurt applications

The addition of prebiotics (specifically FOS) in yogurt applications served as the topic for a pair of research projects and sensory analysis revealed that the yogurts with FOS and inulin were regarded as smoother and thicker; in fact, yogurt with 4% FOS (on a weight/weight basis) had the highest overall acceptability. From a formulator's standpoint, inulin offers several interesting characteristics. It has a low cariogenicity, glycemic index, sweetness and calorie value, and is soluble in hot water, but it is only slightly soluble in cold water or alcohol. Inulin can improve body and mouthfeel, and has a high moisture-retaining capacity, acid and heat stability, the ability to help mask the aftertaste of intense sweeteners, and the ability to alter a food's freezing point, to some extent, and prolong shelflife.

In low-fat products

Inulin can be used to improve the body and mouthfeel of low-fat products, delivering roundness and creaminess as well as a better balanced flavour. It also stabilizes emulsions and dispersions and improves the stability of mousse and foams.

Synergy/combination products (Beneo™ Synergy1):

Beneo™ Synergy1 is a unique composition of oligofructose and inulin that has been specifically formulated to improve digestive health in general and bone health in particular. Prebiotics are often deliberately incorporated into biscuits, confectionery, cereals, dairy products, drinks, infant formula feeds and weaning foods.

CONCLUSION

Various research studies on prebiotics either alone or in combination with probiotics shows many significant therapeutic effects. Many natural resources are being tapped upon and investigated for nondigestible prebiotic oligosaccharide content with growth promoting effect on gastrointestinal flora, mainly Bifidobacteria and Lactobacilli. Thus prebiotics are becoming necessary component of various prescriptions either alone or in combination with probiotics and appropriate formulation development should ensure that they are available in suitable dosage forms to provide maximum therapeutic activity. Further more research work should be carried out for investigation of effects of various prebiotics on treatment of various diseases. Mechanism of action of all the available prebiotics should be clearly investigated.

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