Significance of Probiotics and Prebiotics in Health and Nutrition

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ABSTRACT

The positive effects of probiotics and prebiotics on human health are being widely promoted by health and nutrition professionals in today's scenario. Probiotic and prebiotic treatment has been shown to be a promising therapy to maintain and repair the intestinal environment. Consumption of healthy live microorganisms (lactic acid bacteria) with prebiotics (inulin, galactooligosaccharide and oligofructose, etc.) may enhance healthy colonic microbiota composition. This combination might improve the survival of the bacteria crossing the upper part of the gastrointestinal tract, thereby boosting their effects in the large bowel. In addition, their effects might be additive or even synergistic. The objective of this paper is to review existing literature concerning the effects of probiotic and prebiotic food in promoting health and treating diseases.

Keywords: Functional food, Microbiota, Prebiotics, Probiotics

1. INTRODUCTION

Functional foods or functional food ingredients exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond their nutritive value [1,2]. Probiotics (i.e., living microbial food supplements) and prebiotics (i.e., non-digestible carbohydrates which stimulate the growth of intestinal probiotic bacteria) considered as functional food, have received much attention and they target the gastrointestinal microbiota. It is well documented that the large intestine is one of the most densely populated ecosystem in nature consisting of over 500-1,000 different species of bacteria [3,4] of which Bifidobacteria are generally considered to be health promoting and beneficial [5]. The equilibrium of the ecosystem is dynamic and may be negatively affected by ageing, daily diet and other environmental factors [6]. It is believed that the maintenance of the gastrointestinal bacterial population, which mainly contains beneficial species, is important for overall gastrointestinal health and wellbeing. Research has focused on the ability of probiotic bacteria to ferment prebiotics and produce short-chain fatty acids (SCFA) which is thought to be beneficial to gut health [6,7].

Probiotics are living microbial food components that beneficially affect the host by improving its intestinal microbial balance [8]. The most common probiotics currently used, belong to the genera Bifidobacterium and Lactobacillus [9,10]. Intake of probiotic foods has been associated with a number of health benefits [11], because probiotics do not permanently colonize in the intestine. Hence, sufficient quantities (>1 X 10¹⁰/day) of probiotics must be taken, to maintain adequate amounts in the colon [9]. It is important that the ingested bacteria reach the large intestine in an intact and viable form.
Fermented foods and foods that contain live bacteria are known throughout the world. The most commonly consumed probiotics are fermented dairy products such as yoghurt and butter milk [12].

Prebiotics are more recent concept. Here, the selective growth of indigenous gut bacteria is required. Prebiotics are indigestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a number of health-promoting colon/ probiotic bacteria and thus improve host health [1,8,13]. This definition was updated in 2004 and prebiotics are now defined as “selectively fermented ingredients that allow specific changes in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well-being and health” [14]. Prebiotics should escape digestion in the upper gut by pancreatic and brush-border enzymes, reach the large bowel (especially, the cecum), and be utilized selectively by a restricted group of micro-organisms that have clearly identified, health-promoting properties, i.e., the probiotic bacteria, usually Bifidobacteria and Lactobacilli [15].

In practice, combined mixtures of probiotics and prebiotics are often used because their synergistic effects are conferred onto food products, such mixtures are known as synbiotics. Symbiotic food is defined as “a mixture of probiotics and prebiotics [16,17] that beneficially affects the host by, i) improving the survival and implantation of live microbial dietary supplements in the gastro-intestinal tract, and ii) selectively stimulating the growth and activity of one or a limited number of health-promoting bacteria, and thus improving host health and welfare” [8]. It is expected that adding prebiotic would benefit the survival of Bifidobacteria during the shelf life of the dairy products. Symbiotic products often are composed of a combination of inulin-type fructans, Bifidobacteria, and lactulose in conjunction with Lactobacilli [18]. Currently, only limited variety of symbiotic products such as probiotic yoghurt and dairy drinks are available in the market.

2. PROBIOTICS

The word ‘probiotic’ means ‘for life’ and is derived from the Latin ‘pro’, which means ‘for’, and the Greek ‘biotikos’, which means ‘living’. According to Preidis and Versalovic [19] probiotics are “live microorganisms, which, when consumed in requisite amounts, confer a health benefit on the host”.

Probiotics are nonpathogenic organisms (lactic acid bacteria) in foods that can exert a positive influence on the host’s health and modulate the GI tract [20]. The theory is that live microorganisms with in foods or in the form of a supplement improve the microbial balance of the intestinal tract. These are all gram positive, facultative bacteria that are normal inhabitants of the human colon and constitute a predominant part of the anaerobic flora. Fermented milk products such as yoghurt are the most familiar probiotic products [21]. For use in foods, probiotic micro-organisms should not only be capable of surviving passage through the digestive tract but also have the capability to proliferate in the gut [22].

Lactic acid bacteria (LAB) is the most important group of microorganisms commercially used as starter cultures for the manufacture of dairy based probiotic foods [23] and have been established as a natural consumer. Strains of the genera Lactobacillus, Bifidobacterium, and Propionibacterium are the most widely used and commonly studied probiotic bacteria. LAB satisfy the criteria that have to be met by the organisms to be selected as probiotics like resistance to the enzymes in the oral cavity, survival through the GI tract, arrival at the site of action in a viable physiological state and adherence to the host cell surface [24].

2.1 Mechanism of action of probiotics

Experimental models have suggested that probiotics greatly differ in their mechanism of action. However the molecular details of probiotic mechanism remain unresolved. Sartor [25] illustrated in his research study that beneficial effects of probiotics may be direct or indirect through (A) adherence and colonization of the gut:- the competition for space to adhere between indigenous and exogenous bacteria result in competitive exclusion of exogenous pathogens [26]. Microbes, i.e., Bifidobacteria and Lactobacilli adhere to the mucosal tissues in a strain explicit manner [27,28,29,30]. It enhances intestinal endurance of probiotics and limits pathogen access to the epithelium. (B) Modification of local gut micro-environment:- probiotics are receptive to intestinal conditions and metabolically active in vivo [31,32]. Probiotics mediate antimicrobial compounds by reducing the lumen acidity [33] that can directly inhibit pathogens and enhance the richness and heterogeneity of beneficial components of intestinal microflora [34]. (C) Improvement of intestinal barrier function:- a variety of intestinal disorders cause alterations in epithelial transport and barrier functions [35]. Some probiotics have been indicated in preservation of epithelial barrier function, prevention and reconstruction of mucosal damage triggered by food antigens, drugs, enteric pathogens and pro-inflammatory cytokines [29,36,37,38]. These protective effects are intervened by following mechanisms (i) induction of mucus secretion by
goblet cells [39], (ii) maintenance or enhancement of cytoskeletal and tight junction protein phosphorylation [40], (iii) restoration of chloride secretion, (iv) augmentation of trans-epithelial resistance [34]. (D) Suppression of intestinal inflammation: pathogenic micro-organisms cause proinflammatory response in gut cells by activating the transcription factor NF-KB. In contradiction, nonpathogenic micro-organism can weaken this response by secreting the counter regulatory factors IKB [41]. This phenomenon was seen in nonpathogenic bacteria that attenuated Interleukin-8 secretion elicited by pathogenic S. typhimurium [42]. (E) Stimulation of mucosal and systemic host immunity: signals induced by commensal bacteria are essential for optimal mucosal and immune development and to maintain and repair gut [43,44]. In the alimentary canal immunosensory cells (i.e., enterocytes, M cells and dendritic cells) are constantly sampling and responding to intestinal bacteria [45]. Oral administration of probiotics is related to immune engagement and demonstrable systemic immunologic changes [46]. Complex carbohydrates rich in prebiotics pass through the small intestine to the lower gut where they become available for some colonic bacteria but are not utilized by the majority of the bacteria present in the colon [47].

2.2 Impact of probiotics on health

The microbiota within the human distal gastrointestinal tract (GIT) are the largest body community and it provides an excellent milieu to investigate inflammatory processes. Evidence suggests that the bacterial load and the products of the intestinal microbiota might positively influence inflammatory disease pathogenesis [48,49].

2.2.1 Diarrhoea

Diarrhoea is a major world health problem which has its impact on several million deaths each year. Rotavirus is main cause of diarrhoea in young children [50]. Probiotics can potentially provide an important means to reduce the occurrence of diarrhoea. Some probiotics are useful in prevention and treatment of acute diarrhoeal conditions. The ability of probiotics to decrease the incidence or duration of certain diarrhoeal illnesses is perhaps the most substantiated health effect of probiotics. Co-administration of probiotics to patients on antibiotics significantly reduced antibiotic-associated diarrhoea in children [51,52,53,54]. Children with acute gastroenteritis who received a probiotic supplement (Lactobacillus rhamnosus, Lactobacillus reuteri, Lactobacillus casei) also had significantly decreased duration of diarrhoea [55].

2.2.2 Inflammatory bowel disease (IBD)

Inflammatory bowel disease (IBD) is clinically characterized by two overlapping phenotypes, Crohn’s disease (CD) and ulcerative colitis (UC), which predominantly affect the colon (UC and CD) and/or the distal small intestine (CD). The intestinal bacteria are now believed to be involved in the initiation and perpetuation of IBD. Resident bacterial flora has been suggested to be an essential factor in driving the inflammatory process in human inflammatory bowel diseases [56]. Environmental factors such as the composition and metabolic activity of the gut flora, immune system reactivity and genetic factors are all believed to play a role in the progression of IBD states [57]. Strain of Lactobacillus casei is able to reduce the number of activated T-lymphocytes in the lamina propria of Crohn’s disease, which may restore the immune homeostasis [58].

2.2.3 Irritable bowel syndrome (IBS)

The pathophysiology of irritable bowel syndrome (IBS) is not well known; however, alteration in the intestinal flora has been postulated as one of the etiologies. There is also no cure, so the treatment is mainly focused on symptom relief, and probiotics have been tried as a therapeutic modality. Probiotics may have a significant benefit in preventing and treating IBS. Several controlled trials of probiotics in IBS have been published [59,60,61,62,63]. IBS symptoms, such as flatulence, bloating and constipation have been alleviated by organisms, such as Lactobacillus GG, Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, the probiotic ‘cocktail’ VSL#3 and Bifidobacterium animalis. However, only a few products have been shown to affect pain and global symptoms in IBS [64,65,66,67,68]. Numerous factors, including a reduction in gas production [60,69], changes in bile salt conjugation, an antibacterial or antiviral effect (in the case of post-infectious IBS), the promotion of motility [70], effects on mucus secretion or, even an anti-inflammatory effect, could be relevant to the benefits of specific probiotic strains in IBS.

2.2.4 Lactose intolerance

Worldwide many millions of people experience lactose malabsorption. The frequency of the disorder increases with age. Lactose intolerance is a physiological state in human beings where they lack the ability to produce an enzyme named lactase or β-galactosidase. This lactase is essential to assimilate the disaccharide in milk and needs to be split into glucose and galactose. Individuals lacking lactase will not be able to digest milk and it often poses a
problem in newborn infants [71]. This decline in activity results in lactose malabsorption. This incomplete absorption causes flatus, bloating, abdominal cramps, and moderate to severe diarrhoea. A major consequence of this sequence of events is a severe limitation in consumption of dairy products, which is particularly pronounced in the elderly [72]. Fermented milk products have been observed to be tolerated well by lactose maldigesters as compared to milk. This can be explained by the presence of β-galactosidase in the bacteria fermenting the milk. Upon ingestion, the bacteria are lysed by bile in the small intestine, the enzyme is released and degrades lactose. In addition to this, the more viscous properties of fermented milks, compared to plain milk, gives them a longer gastro-caecal transit time, thus further aiding digestion of lactose [73]. This beneficial effect is usually more associated with products fermented with \textit{Lactobacillus delbrueckii} subsp. \textit{bulgaricus} and \textit{Streptococcus thermophilus}. Martini et al [74] conducted a research to evaluate the ability of different species of lactic acid bacteria to digest lactose in vivo, yoghurt (containing mixtures of strain of \textit{Streptococcus salivarius} subsp. \textit{thermophilus} and \textit{Lactobacillus delbrueckii} subsp. \textit{bulgaricus}) and fermented milks (containing individual species of \textit{S. thermophilus}, \textit{L. bulgaricus}, \textit{L. acidophilus} or \textit{Bifidobacterium bifidus}) that varied in microbial β-gal activity were produced and were fed to healthy people who cannot digest lactose and breath hydrogen production was monitored. All yoghurts dramatically and similarly improved lactose digestion regardless of their total or specific β-gal activity.

### 2.2.5 Other potential health benefits

Probiotics may exert a beneficial effect on allergic reaction by improving mucosal barrier function. In addition, probiotic consumption by young children may beneficially affect immune system development. Probiotics such as \textit{Lactobacillus GG} may be helpful in alleviating some of the symptoms of food allergies such as those associated with milk protein [71]. Probiotic consumption may thus be a means for primary prevention of allergy in susceptible individuals. They may help to prevent or treat infections such as postoperative infections, respiratory infections and the growth of \textit{Helicobacter pylori}, a bacterial pathogen responsible for type B gastritis, peptic ulcers and perhaps stomach cancer [75,76]. Regular intake of probiotics (i.e., a fermented milk drink containing a mixture of \textit{L. rhamnosus GG}, \textit{Bifidobacterium}, \textit{L. acidophilus}, and \textit{S. thermophilus}) has been demonstrated to reduce potentially pathogenic bacteria in the upper respiratory tract of humans [77]. They could have a potential effect on bone accretion independent of prebiotics. This could occur via microbial production of metabolites or enzymes or synthesis of vitamins [78,79] because several vitamins are also involved in calcium metabolism and are required for bone matrix formation and bone accretion as are vitamin D, C, or K [80] or folate.

Hepatic encephalopathy (HE) is a life threatening liver disease. Various probiotics, i.e., \textit{Streptococcus thermophilus}, \textit{Bifidobacteria}, \textit{Lactobacillus acidophilus}, \textit{Lactobacillus plantarum}, \textit{Lactobacillus casei} and \textit{Lactobacillus delbrueckii bulgaricus} contain therapeutic effects that could disrupt the pathogenesis of HE and may make them superior to conventional treatment and lower portal pressure with a reduction in the risk of bleeding [55,56,81,82,83]. Acute pancreatitis is a serious condition with an incidence that continues to increase worldwide [84]. It ranges from a mild, self-limiting illness to pancreatic necrosis and infected pancreatic necrosis with a mortality rate of up to 30%. Colonization of the lower gastrointestinal tract and oropharynx with gram-negative organisms often precedes contamination of the inflamed pancreas. Systemic antibiotic prophylaxis is used to prevent secondary infection in acute pancreatitis [85]. Human studies in which patients with acute pancreatitis received \textit{L. plantarum} 299v showed a decrease in occurrence of pancreatic infection/abscess and a shorter hospital stay [86,87]. Probiotics have also been tried with some success in the prevention of uncomplicated diverticular disease [88] and diverticulitis [89], reduction of symptoms from collagenous colitis [90], treatment of functional constipation [91], prevention of necrotizing enterocolitis in preterm infants [92] and treatment of functional abdominal pain disorders in children [93].

Probiotics are used to control \textit{Candida} infection and risk of hypo-salivation and feeling of dry mouth in elderly patient. Elderly are more prone to \textit{Candida} infection provoked by chronic diseases, medications, poor oral hygiene, reduced salivary flow and impaired immune response. Bacteria like \textit{Lactococcus lactis}, \textit{Lactobacillus helveticus}, \textit{Lactobacillus rhamnosus} \textit{GG} (ATCC53103), \textit{Lactobacillus rhamnosus} \textit{LC705} when used in one of the study, showed significant reduction of \textit{Candida} infection [94]. It should also be noted that as most probiotics are in dairy forms containing high calcium, they possibly reduce demineralization of teeth. Regular use of probiotics can help to control halitosis [95]. After taking \textit{Weissella cibaria}, reduced levels of volatile sulfide components produced by \textit{Fusobacterium nucleatum} were observed by Kang et al [96]. The effect could be due to hydrogen peroxide.
production by Weissella cibaria, causing Fusobacterium nucleatum inhibition.

Some preliminary evidence suggests that food products derived from probiotics bacteria could possibly contribute to blood pressure control [97,98]. This antihypertensive effect has been documented with studies in spontaneous hypertensive rats. Two tripeptides, valine-proline-proline and isoleucine-proline-proline, isolated from fermentation of a milk-based medium by Saccharomyces cerevisiae and Lactobacillus helveticus have been identified as the active components. These tripeptides function as angiotensin-1-converting enzyme inhibitors and reduce blood pressure [99]. Some experimental animal and human investigations suggest that probiotics may reduce the risk of heart disease by their beneficial effects on blood lipid levels [100] and alleviate kidney stones [101] and decrease inflammation associated with arthritis [102].

3. PREBIOТИCS

In 2010, the International Scientific Association for Probiotics and Prebiotics Working Group defined dietary prebiotics as “selectively fermented ingredients that result in specific changes, in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health” [103]. Typically, prebiotics are low molecular weight carbohydrates with 2-10 degrees of polymerization [104]. The main characteristics of a prebiotic are resistance to digestive enzymes in the human gut but fermentability by the colonic microflora, and bifidogenic and pH-lowering effects [105,106]. By this last effect, prebiotics inhibit certain strains of potentially pathogenic bacteria, especially Clostridium, and prevent diarrhoea [107]. The most prevalent forms of prebiotics are nutritionally classed as soluble fiber. Traditional dietary sources of prebiotics include soybeans, inulin sources (such as banana, Jerusalem artichoke, jicama, and chicory root), raw oats, unrefined wheat, unrefined barley, garlic, onion, raw wheat bran and cooked whole wheat flour [108].

3.1 Types of prebiotics

The most widely described prebiotics are non-digestible oligosaccharides like fructo-oligosaccharides (FOS) [109]. The others include polyols (xylitol, sorbitol, mannitol), disaccharides (lactulose, lactitol), oligosaccharides (raffinose, soybean), oligofructose, other non-digestible oligosaccharides (palatinose, isomaltose, lactosucrose) and polysaccharides (inulin, resistant starch) [103].

Fructo-oligosaccharides (FOS) are a naturally occurring oligosaccharide that is not digested in the upper gastrointestinal tract but is degraded in the colon by indigenous bacteria. It is a sweet product derived from native inulin and is approximately 30-60% as sweet as sugar [110]. Prebiotic (FOS) is gaining increasing recognition as agents to modulate the colonic microbiota in humans. It is mainly known for its ability to stimulate the growth of beneficial bacteria, especially Bifidobacteria, and thus improves host health. Inulin, a polyfructan, occurs as a reserve carbohydrate in many plant families, representing more than 30,000 species. Inulin has excellent nutritional and functional characteristics and can be used to replace fat, flour and sugar. Inulin may offer more health benefits than other fibers. Galactooligosaccharides are digestion-resistant oligosaccharides naturally found in both human and cow’s milk [111]. Lactulose is a synthetic disaccharide used as a drug for the treatment of constipation and hepatic encephalopathy. Breast milk oligosaccharides are present in breast milk. An exclusively breastfed baby has flora dominated by Lactobacilli and Bifidobacteria, which are part of the baby’s defence against pathogens and which is an important primer for the immune system [112,113]. These floras are nurtured by the oligosaccharides of breast milk, which is considered to be the original prebiotics.

3.2 Production of short chain fatty acids

It has been observed that anaerobic breakdown of prebiotics and their subsequent fermentation by probiotics not only enhances the growth of probiotics (LAB) further but also leads to production of SCFA like butyrate, acetate and propionate of varying quantity as byproducts of fermentation. These SCFA acidify the colon environment, which may contribute to their anticancer action [114] and it is beneficial for the development of bacteria such as Bifidobacteria and Lactobacilli, and detrimental to the growth of potential pathogenic species [115,116]. All the SCFA are rapidly absorbed from the colon and then metabolized by various tissues: butyrate by the colonic epithelium, propionate and acetate (partly) by the liver and acetate (partly) by muscle and other peripheral tissues [8,116]. Out of the 3 SCFAs, butyrate has been most extensively studied. Butyrate-treated colon cells have been found to be more protected against hydrogen peroxide-induced oxidative damage than those of untreated ones because this SCFA is an important protective fuel for colon cells. In colon cells, butyrate has been found to increase the formation of glutathione S-transferase pi, which is an important enzyme involved in the detoxification of both electrophilic products and

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3.3 Health benefits of prebiotics

The nutritional properties of prebiotics are related directly to the physiological changes they induce in the host. Bacterial metabolites are probably the main effectors of most observed effects. The most important metabolites are the short-chain fatty acids (SCFA) acetate, propionate and butyrate [15]. Prebiotic consumption can double the pool of SCFA in the gastrointestinal tract. The postulated beneficial effects of prebiotics are summarized below.

3.3.1 Anticarcinogenic effect

It has been suggested that prebiotics can be protective against the development of cancer. Secretion of carcinogens and tumor promoters by some species of bacteria of the colon can occur through the metabolism of certain types of food; proteolysis in the colon is recognized as a mechanism for production of potentially malignant end products [103]. Modification of the gut microflora may interfere with the process of carcinogenesis and this opens up the possibility for dietary modification of colon cancer risk. Prebiotics modify the microflora by increasing numbers of Lactobacilli and/or Bifidobacteria in the colon [104]. The development of aggressive tumor cells in muscle tissue was showed down and an increase in life span was induced in the case of ascitic tumors [119]. More pronounced effects were achieved by symbiotics and long-chain inulin-type fructans compared to short-chain derivates (sustained activity of the saccharolytic fraction of the intestinal microbiota), especially in the more distal parts of the colon [120,121]. Colorectal cancer is the third most common cancer, accounting for around 12% of cancer deaths worldwide. It is estimated that altering the gut microflora through diet towards predominance of beneficial species could help in the prevention of the disease. The roles of short chain fatty acids, for example, acetate, propionate and butyric acid are being extensively studied because they have shown to inhibit the growth of colon tumor cells, encourage cell turnover and support normal gene expression [121,122].

3.3.2 Antiallergic effect

It is recognized that specific bacteria in the gut can potentially promote anti-allergenic processes. Different allergies affect different tissues and may have local or general effects. Some beneficial effects have been attributed to the consumption of these prebiotics. It is believed that their beneficial effects result from the metabolism of these compounds. Fermentation of these oligosaccharides results in the production of various organic acid and CO₂ [123]. Delsenne and Roberfroid [124] have stated that the balance of such a complex process is likely to produce 40% SCFA, 15% lactic acid and 5% CO₂.

3.3.3 Increased mineral absorption

Prebiotics have putative beneficial effects on calcium bioavailability. Calcium is mainly absorbed in the small intestine; however, some is also absorbed in the colon [125]. Numerous animal studies have indicated that prebiotics increase calcium, iron, zinc, copper and magnesium absorption from the colon and stimulated the bacterial hydrolysis of phytic acid [126,127,128], resulting in an improvement of absorption, in increased bone density and bone trabecular structure [129,130,131]. Intake of prebiotics acidifies the intestinal contents, which aids the solubilisation of minerals [127]. Bacterial fermentation products, predominantly lactate and butyrate, enlarge the absorption surface by promoting proliferation of enterocytes [132]. Other mechanisms that have been proposed include suppression of bone resorption rate relative to bone formation rate [133], release of bone-modulating factors such as phytoestrogens [129] and improvement in gut health and gut-associated immune defense [17].

3.3.4 Other potential health benefits

Prebiotics are helpful in modulating immune system. It has been observed that consumption of inulin-type fructans increases the phagocytic capacity of macrophages [134]. There is increasing evidence from animal studies that the addition of fermentable fiber to the diet can modulate the type and function of cells from different regions of the gut-associated lymphoid tissue (GALT) [135]. Furthermore, prebiotics improved the manifestations of atopic dermatitis in children above two years [136] and reduced the incidence of atopic dermatitis during the first six months of life in high-risk infants [137].

Fructo-polysaccharides such as inulin are non-digestible carbohydrate substrates in the diet that target certain components of the gut microbiota in the human large intestine such as Bifidobacteria and Lactobacilli [7]. Inulin can stimulate the growth...
and/or activity of these types of bacteria in the colon and this stimulation can improve the intestinal flora composition, enhance the immune system and thereby contribute to the health of the host [138,139]. Prebiotics increase fecal bulk and optimize stool consistency primarily by increasing fecal microbial mass. All carbohydrates that reach the large intestine have a laxative effect on bowel habit. It can be predicted, therefore, that prebiotics will be laxative. In carefully controlled studies it has indeed been shown that prebiotics that are fermented completely increase bowel frequency [140], bringing relief from constipation in chronically constipated subjects. Evidence suggests prebiotics can favorably influence serum glucose and insulin levels in a variety of ways. Digestion resistant oligosaccharides, i.e., inulin-type fructans, galactooligosaccharides, lactulose, isomaltooligosaccharides, xylooligosaccharides, soyoiligosaccharides, gentooligosaccharides and nigeroligosaccharides [141] and other prebiotics can reduce the amount of glucose available for absorption into the bloodstream. Prebiotics also prevent excessive blood glucose elevations after a meal by delaying gastric emptying and/or shortening small intestine transit time. Bacterial fermentation yielding short-chain fatty acids is another mechanism whereby prebiotics can modulate glycemia and insulinemia [142]. The gut acts like an endocrine organ, producing a range of hormones that are devoted to the regulation of behavioral and metabolic function, by sending signals to the brain or other key target organs (e.g. liver and pancreas). This can affect appetite, energy and nutrient metabolism. The addition of inulin-type fructans [143] and oligofructose [144] in animal diet showed beneficial effect in experimental animals. In human studies, inulin and oligofructose have had a favorable impact on lipid and glucose metabolism [145].

4. CONCLUSION

The intestinal microbiota forms a diverse and complex ecosystem. However, there is much variability in bacterial numbers and populations between the stomach, small intestine and colon. In comparison with other regions of the GI tract, the human colon is an extremely densely-populated microbial ecosystem. These gastrointestinal microflora are important elements in the health of the host animal. Environmental factors, diet, medication and stress can all adversely affect the composition and/or activity of the gut flora. The deficiencies created can be repaired either by added viable organisms (probiotics) or by stimulating specific components (e.g. *Bifidobacteria*) of the flora with chemical supplements (prebiotics). Probiotics and prebiotics are gaining popularity because of the innumerable benefits, e.g. treating lactose intolerance, hyper cholesterol problems, cardiac diseases and managing cardiac problems like atherosclerosis and arteriosclerosis. Probiotic microbiota can have a significant influence on the treatment and prevention of various diseases. Prebiotics have similarities with dietary fiber functionality in that microbial fermentation of carbohydrate occurs. In addition to their physiological functions and health benefits, non digestible oligosaccharides (NDOs) also provide useful modifications to the physicochemical properties of foods. At present, a number of oligosaccharides have been used in foods and beverages such as candies, confectioneries, bakery products, fermented products, fruit juices, desserts, and spreads as taste improver, sweetener, fat replacer, emulsifier, viscosity increasing agent and stabilizer of proteins, flavors and colors. Foods supplemented with NDOs can have a potential to improve well-being and/or reduce the disease risk. While the mechanisms of their effects on gut bacteria are slowly being unraveled, their effects on health are much more difficult to demonstrate.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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