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Review

Effect of prebiotics on the health of the elderly

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ABSTRACT

The longevity of the human population has increased in many countries, due to better quality of life generated by improved diet and medical advances. Ageing is related to diseases and alteration in the intestinal microbiota that predispose to changes in the immune system and the metabolism of glucose, lipids, and minerals. The use of prebiotics has shown a positive effect on the production of short-chain fatty acids (SCFAs) by the intestinal microbiota and has demonstrated efficacy against pathological conditions that are more frequently found, including irritable bowel syndrome, ulcerative colitis, intestinal cancer and heart disease. However, additional intervention studies should be conducted amongst the elderly to prove the efficacy of prebiotics in this population. Moreover, studies that analyse the mechanisms of action of these compounds during the senescence are particularly important. The aim of this review is to discuss the effect of prebiotics on the health of the elderly people.

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1. Introduction

The ageing of the population is a subject of great concern for health agencies. In developed countries, this phenomenon has occurred slowly, whereas ageing has quickly gained significance in developing countries with a sharp increase in the elderly population relative to the general population (Giatti & Barreto, 2003). The growth rate of the elderly population in Brazil has been systematic and steady. The relative number of elderly in the total population of Brazil rose from 9.15% to 11.3% in the period from 1999 to 2009. According to the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística — IBGE), this growth will increase the life expectancy at birth to 81.29 years in 2050 (IBGE, 2010).

The prevalence of chronic degenerative diseases increases with the life expectancy at birth, which predominantly affects the elderly population; thus, longevity is not necessarily related to healthy ageing (Chaimowicz, 1997). Chronic non-communicable diseases and illnesses can trigger impairments that impact daily activities, which compromise the quality of life of the elderly. Ageing is associated with histological and physiological changes in the gastrointestinal tract that have implications in the digestion and absorption of nutrients and mucosal damage. There is a correlation amongst ageing, chronic diseases, and changes in the composition of the intestinal microbiota and the host immune system (Rowland & Gill, 2008). In combination with chronic diseases and cachexia, the changes of intestinal microbiota and damage of gut epithelium may contribute to inflammatory processes in the elderly (Murphy, Murphy, & O'Mahony, 2009; Schiffrin et al., 2007).

Following birth, the human gastrointestinal tract (GIT) is colonised by microbiota, which constitute a population of beneficial and pathogenic microorganisms that include approximately 10 million bacteria from

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1000 different species (Wallace et al., 2011). These bacteria develop close interactions with the host, thereby promoting the health and wellbeing (Bäckhed et al., 2005). Through fermentation of undigested dietary residues, the intestinal microbiota produce a variety of compounds that may have positive and/or negative effects on the intestinal physiology and systemic influences (Gibson & Roberfroid, 1995). The genus Bacteroides and saccharolytic species are able to use carbohydrates in the colon. The saccharolytic species belonging to the genera, *Bifidobacterium*, *Ruminococcus*, *Eubacterium*, *Lactobacillus* and *Clostridium*, which do not contain known pathogens, produces a range of antimicrobial agents and SCFA as end products of the fermentation (Roberfroid, 2000) and the pathogenic species, such as *Clostridium perfringens* and *Escherichia coli*, ferment protein and amino acids (Macfarlane & Cummings, 2006).

It is possible that the health-promoting effects attributed to the intestinal microbiota could be related to their metabolism capacity for producing vitamins, antioxidants, defensins against pathogenic microorganisms and include the growth inhibition of pathogenic microorganisms through competition for ecological niches and metabolic substrates, improved digestion of lactose in lactose-intolerant individuals, improved absorption of ions, such as calcium, magnesium, and iron, stimulated synthesis of vitamins, particularly B vitamins groups, and proteolytic enzymes, better intestinal function, modulation of the immune system, gene expression, and intestinal cell differentiation as reviewed by Roberfroid (2008), cholesterol reduction, and regulation of inflammatory bowel diseases (Wallace et al., 2011).

There is an interaction of host–microbe (Wells, Saulnier, & Gibson, 2008), including bacteria–gut epithelium interaction, bacteria–immune system interaction and bacteria–bacteria interaction. When a change in the intestinal permeability occurs, the balance of the intestinal bacteria can be disrupted, which results in a predominance of harmful bacteria. The organism subsequently becomes more susceptible to infections and immunological changes. The increase in pathogenic bacteria enables their fixation on the surface of the intestinal epithelium, which allows the colonisation and invasion of the intestinal wall and triggers a decline in biliary function, hypochlorhydria, an inflammatory response (Dubert-Ferrandon, Newburg, & Walker, 2008), and increased susceptibility to infectious and non-infectious diseases (Vulevic, Drakoularakou, Yaqoob, Tzortzis, & Gibson, 2008). Non-sporulating anaerobic bacteria, including *Bacteroides spp.*, *Bifidobacterium spp.*, *Eubacterium spp.*, *Clostridium spp.*, *Lactobacillus spp.*, *Fusobacterium spp.*, and several gram-positive cocci, predominate in the adult intestine. *Enterococcus spp.*, *Enterobacteriaceae*, *methanogens*, and sulphate-reducing bacteria are found in lower numbers (Wallace et al., 2011).

Under normal conditions, the total number of anaerobic bacteria seems to remain relatively constant in older people, but the composition of the microbiota does change with age. However, it may change in response to various factors, including medication, gastrointestinal infections, and diet (Tiihonen, Ouwehand, & Rautonen, 2010; Tuohy, 2007). Several human studies have examined the composition and changes in the intestinal microbiota during ageing and have shown a decrease in the number of *bifidobacteria* and an increase in the levels of *enterobacteria*, *lactobacilli*, and some species of *Clostridium* (Gavini et al., 2001; Hopkins, Sharp, & Macfarlane, 2001). Ageing decreases the number of *Bifidobacteria* and the viable counts of Bacteroides, as well as the species diversity within the genus Bacteroides (Bartosch, Fite, Macfarlane, & McMurdo, 2004; Hopkins & Macfarlane, 2002). These changes may have metabolic and health consequences for the host, because of the consequent responsiveness of the intestinal immune system and for other bacteria in the ecosystem that rely on a complex network within the gut (Woodmansey, 2007). Besides, the decrease in the productions of SCFA by lactobacilli, bifidobacteria and other fermentative bacteria, changes luminal pH with consequences for the host, including malnutrition and intestinal dysmotility (Murphy et al., 2009).

The human immune system undergoes morphological and functional changes that peak during puberty and gradually decline with ageing (Ewers, Rizzo, & Kalil Filho, 2008); these changes predispose the elderly to infectious and non-infectious diseases (Aspinal & Andrew, 2000). The immune function can be affected by nutrition. Probiotics, prebiotics, and symbiotics are amongst the ingredients responsible for the improvement of the immune response. Studies using prebiotics, inulin, oligofructose, and galacto-oligosaccharides in animal models and human trials have shown positive effects for the reduction of colon cancer and inflammatory bowel disease and protection against metabolic disease (Langlands, Hopkins, Coleman, et al., 2004; Pool-Zobel, 2005; Tuohy, 2009).

Probiotics and prebiotics stand out amongst the bioactive components that are found in functional foods. The prebiotic concept has been known for over 100 years, but recent studies have shown its scientific and beneficial effects on health and the prevention and treatment of diseases. This review aims to discuss the effect of prebiotics on the health of the elderly by addressing the main studies done on this area. The main results of several human studies of the effects of prebiotics on elderly are reported.

2. Prebiotics

Prebiotics are defined as ingredients that selectively stimulate the growth and/or activity of one or a limited number of species/genera of bacteria in the microbiota, thereby conferring benefits to the health and wellbeing of the host (Roberfroid et al., 2010). Prebiotics have attracted the interest of researchers and the food industry due to their nutritional and economic benefits, and they are used in food, particularly in the production of functional foods (Bosscher, 2009; Macfarlane & Cummings, 2006). A food component must meet the following requirements to be considered prebiotic: be resistant to salivary, pancreatic, and intestinal enzymes; be fermentable by the intestinal microbiota; and selectively stimulates the growth and/or activity of intestinal bacteria to contribute to health and wellbeing (Gibson, Probert, Van Loo, & Roberfroid, 2004). A recent study showed that inulin-type fructans (ITF), such as inulin and fructooligosaccharides (FOS), and galactooligosaccharides (GOS) exhibit prebiotic effects (Roberfroid et al., 2010).

Many plant species, such as chicory, onion, Jerusalem artichoke, and yacon, contain ITF as reserve carbohydrates (Bhatia & Rani, 2007; Carabin & Flamm, 1999). Fructans are carbohydrates that consist of one or more fructose units linked or not linked to a terminal sucrose molecule, which may have a linear or ramified structure, with molecules united by β(2-6) or β(2-1)-type fructosyl–fructose bonds. According to their degree of polymerisation (DP), ITF are divided into inulin, with a DP from 10 to 60 units of monosaccharides and related compounds, and FOS, with a DP lower than 10 (Roberfroid & Slavin, 2001).

3. Functional effects of prebiotics on the health of the elderly

The health-promoting effects of prebiotics include benefits to host nutrition, the growth inhibition of pathogens, and the promotion of beneficial microbiota (Choque-Delgado, Tamashiro, Maróstica-Júnior, Moreno, & Pastore, 2011). Ageing is characterised by physiological changes in the gastrointestinal tract with a consequent imbalance of the intestinal microbiota. The changes in the structure and composition of the intestinal microbiota may be related to conditions that are common in the elderly, such as immunosenescence, metabolic syndrome, diabetes, and sarcopenia (Biagi, Candela, Fairweather-Tait, Franceschi, & Brigidi, 2012). During ageing, intestinal changes may compromise the health of the elderly. Hypochlorhydria resulting from gastric atrophy is common in the elderly and is responsible for the decreased absorption of calcium, iron, and vitamin B12 (Russel, 1992). The decrease in food intake (Murphy et al., 2009) in combination with the slowing of the intestinal motility results in reduced faecal weight (Woodmansey, 2007) and constipation, which lead to reduced excretion