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Review Article

The Role of Prebiotics and Probiotics in Prevention and Treatment of Diseases

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Abstract

The human body cells are around 90% microbial, in this sense correlations between changes in composition and activity of the gut microbiota and common disorders such as cancer, hypertension, hypercholesterolemia, inflammatory bowel diseases, obesity, oral health, etc., have been proposed. And, it is known that diet has a key role in the management of the gut microbiota. Clinical data have supported positive results among the consume of probiotics and prebiotics and intestinal health. However, probiotics validity and health claims have continuously been rejected on the basis of "biomarker deficiency". But, due to increase in health spending, a preventive approach to medicine with the development of probiotics and prebiotics or symbiotic products is being advanced. This review discusses the relationship among prebiotics and probiotics consume in preventing and treating certain diseases.

Keywords

Functional Food; Gut Microbiota; Intestinal Health; Prophylaxis

Introduction

In the last years an increase in the prevalence of no infectious chronic diseases such as obesity, cancer, hypertension, diabetes, hypercholesterolemia, autoimmune diseases, inflammatory bowel diseases, obesity, oral health and others was found. And, according to Sousa et al., this has been related with food consumption patterns which is influenced by social development, culture, religion, beliefs, media, and even social networks [1].

Modern society is pursuing healthier lifestyles and has given preference to foods containing substances that have the properties of strengthening the body and at the same time preventing and fighting diseases - the so-called functional foods. In this context, the relationship between health and food has taken a prominent place in the eating habits of the world population [2]. Nowadays, is known that intestinal health is strongly related with a balanced diet and consume of prebiotics and probiotics. Besides, attention has been paid to the prevention of chronic diseases and hence, probiotic and prebiotics containing foods are abundant on the market [3].

A recent study demonstrated that bacterial community composition is considerably altered in diseases such as obesity and periodontal disease, with healthy subjects usually exhibiting distinct, diverse and temporally stable bacterial populations at these sites when compared with patients displaying disease symptoms [4].

The intestinal microbial termination is related to a species of living microorganisms (greater than anaerobic), which colonize the intestine after birth. The intestine is considered as one of the most complex ecosystems by the presence of at least 1000 different colonies. In addition, it is composed of native and transitional microbiota [5,6].

The microbiota consists mainly of beneficial bacteria (probiotic), such as *Bacteroides* spp., *Bifidobacterium* spp., *Lactobacillus* spp. However, in many instances, there is an imbalance in the population density of the gut microbiota (dysbiosis), condition in which pathogenic microbes as *Clostridium* spp. and *Enterobacteriaceae* may be increased in the gut [7].

Probiotics are defined as live microorganisms which, when consumed in appropriate amounts, provide human health (host) health benefits. They are found in functional dairy foods [8]. Its main properties are: protection of the microbiota against pathogenic microorganisms, stimulation of the immune system, normalization of the microbiota and reduction of intestinal permeability.

On the other hand, prebiotics are food elements used in the growth and maintenance of the intestinal microbiota, are metabolized in the large intestine, but are not digested in the small intestine. Prebiotics have the potential to transform the composition of the intestinal microbiota, making the beneficial bacteria become the dominant microbial profile [9].

In front of increase in chronic diseases, consumers are changing their eating habits, looking for foods with functional properties as fermented dairy products, infant formulas and dietary supplements. Basic research on probiotics has suggested several modes of action beneficial for the human body and clinical research has proven its preventive and curative features in different intestinal and extraintestinal diseases. In this sense, this article focused on the evidence of clinical benefits of prebiotics and probiotics toward prevention and treatment of chronic diseases.

Methodology

The present study is a systematic review article, which was based on bibliographical research. The data collection was carried out through retrospective analyzes of scientific studies published from 2001 to 2018. For this purpose, we used magazines, relevant legislation, as well as scientific papers published in the databases PubMed, Science Direct, Scielo and Other Non-Indexed Citations. A search was performed in November 2017 to identify publications from 1 January 2001 to 30 October 2017. To keep this publication as current as possible, an updated database search was performed in March 2018.

A total of 64 papers were analyzed, however, 35 scientific articles with interest characteristics were selected, including 11 articles related to prebiotics and 24 related to probiotics use to prevention and treatment of chronic diseases.

Prebiotics on Prevention and Treatment of No Infectious Chronic Diseases

Prebiotics are compounds found in foods sources of complex carbohydrates and fibers including polyols, polysaccharides such as pectin, hemicelluloses, gums, inulin and starches resistant, and oligosaccharides such as raffinose, stachyose, fructooligosaccharides, Galactooligosaccharides (GOS) and resistant dextrins which are indigestible through the human gastrointestinal tract, suffering only the fermenting action of the intestinal microflora. However, for a food rich in fiber to be considered prebiotic, it is necessary that it meet some physical criteria, such as: capacity of resistance to gastric acidity, possibility of fermentation by the intestinal microflora (use as food for this microflora) and stimulant of the activity of bacteria which are beneficial to the host. It is important to emphasize that the concept of prebiotics is new, but its existence in practice dates back to ancient periods [1].

The regular consumption of prebiotics helps regulate the human microbiota, since the fermentation of these substances is essential in the maintenance of microorganisms that are necessary to our organism, thus inhibiting the proliferation of microorganisms that are undesirable. Beneficial microorganisms play a key role in the absorption of micronutrients and other important substances in our body, being natural synthesis of antibiotics a good example [10,11].

In this context, it is necessary to highlight the GOS, these in turn are important nondigestible carbohydrates with prebiotic characteristics. These carbohydrates play a key role in preventing diseases caused by putrefactive bacteria that are in our intestinal tract, promoting the suppression of their activity. Importantly, such putrefactive bacteria are responsible for the production of toxic metabolites to our body. In addition, these carbohydrates are responsible for the increase of the population of bifidobacteria, essential to the absorption of nutrients and consequently to the human metabolism [12].

GOS is important in the treatment of irritable bowel syndrome, mainly due to the selective stimulation of the development of the intestinal microbiota, which has beneficial effects on the host organism. Such molecules reach the intestinal colon where they are fermented and assimilated by the microorganisms beneficial to our nutritional context. The author also highlighted the participation of FODMAPs (Low Fermentable Oligo, Di,

Monosaccharides and Polyol), as part of the role of prebiotics, and their importance in the production of Short Chain Fatty Acids (SCFAs) due to the beneficial effects in the fight against inflammatory diseases, diabetes and cardiovascular diseases [13].

In accordance to Souza et al., [10] and Vandenplas et al., [14] was found that the addition of prebiotic oligosaccharides in infant feeding helps the development of intestinal flora at levels close to infants who are fed breast milk.

Baucells et al., [15] reported that the use of prebiotics in the diet of infants in association with probiotics demonstrated positive effects in the combat of necrotizing enterocolitis, since such association stimulates competition by nutrients and by the prebiotics themselves in the human microbiota. Besides, the strengthening of the microbiota provides a reduction of severe infections, atopic dermatitis and allergic diseases in infants.

On the other hand, Carvalho et al., [16] addressed the use of HMOs (Human Milk Oligosaccharides) as an important source of prebiotics and probiotics for the formation of a healthy intestinal microbiota for neonates, ensuring a significant reduction of deaths in this phase as consequence of diarrhea and other infectious diseases.

Another situation in which prebiotics are presented as important tools in the fight against diseases is its use in association with probiotics, such association results in a class of foods called symbiotic. This association stems from the complementary and synergistic action of both. Its use was shown to be effective because it demonstrated an increase in the number of bifidobacteria, glycemic control, cholesterol reduction, intestinal microbiota balancing (important in the treatment of constipation and diarrhea) and finally symbiotic foods proved to be system stimulants immunological [10,11]. Besides, symbiotic foods have been used in diet therapy with the aim of improving the health status of patients with some types of cancer [17].

In general, in relation to the fight against systemic diseases, Chimenos-Kustner et al., [18] stated that many authors who deal with the subject in the contemporary literature defend the use of prebiotics in the treatment and prevention of these diseases, specifically from the use of the fecal transplantation technique, which basically consists of the transference of healthy bacterial communities. In a revision carried out by Moraes et al., [17] emphasized the relationship between the human microbiota and chronic no infectious diseases. Despite different results regarding the participation of each group of microorganisms in the composition of the microbiota, it was clear that its composition and variability is fundamental for the maintenance of the balance of the gastrointestinal tract. This characteristic was evident when the level of body adiposity was analyzed in comparison with the proportion of phyla and the variety of microorganisms. Most of the studies reviewed by these authors pointed to a relationship between weight gain and variability and composition of the microbiota, as highlighted above. What in fact could not be clarified is what role these microorganisms occupy in this process, whether cause or effect, and the extent of their participation in the process.

Still in this context Moraes et al., [17] reviewed how the consumption of prebiotics affects directly the increase in satiety and the reduction of food intake through the modulation of food behavior. Such modulation occurs in that depending on the composition of the human microbiota, this promotes the production of enzymes necessary for the metabolism of polysaccharides that are decomposed into monosaccharides and fatty acids. In addition to its energy characteristics, the production of the latter results in the production of peptides, essential hormones to the proper functioning of the digestive system, promoting the absorption of nutrients at the appropriate levels. It is important to point out that such a hormone plays a fundamental role in the CNS (Central Nervous System), inhibiting the stimuli of neurons that transmit the sensation of hunger information, inducing satiety. These data reinforce the importance of the use of prebiotics as catalysts of the activity of microorganisms that play a fundamental role in the absorption of nutrients and in the fight against unwanted microorganisms.

According to Moraes et al., [17], the authors pointed out that depending on the composition of the human microbiota, inhibition of enzymes responsible for the metabolism of fatty acids and glucose may occur, contributing to an increase in the rate of body adiposity.

Prebiotics also play a fundamental role in the treatment of patients with malnutrition, since these usually present imbalances in the intestinal barrier. The prebiotics act by releasing high levels of lactic acid with the consequent reduction of the pH of the colon. Such reduction inhibits the emergence and development of undesirable microorganisms in the human microbiota [11].

Patients with chronic pancreatitis have deficiencies of several nutrients such as calcium, magnesium and iron. The use of prebiotics reduces the symptoms of this disease in that it stimulates the specific absorption of calcium through the fermentation by the microbiota, especially the bifidobacteria, producing gases, organic acids and fatty acids of short chain. Such acids increase the concentration of ionized minerals

important in calcium solubility and diffusion [11].

Perez-monter et al., [19] found that the use of probiotics in association with prebiotics, such association has positive effects on the reduction of some of the markers used in the investigation of liver-related diseases such as liver cirrhosis.

In the treatment of diarrhea from the action of FOS (Frutooligosaccharides), prebiotics act by promoting the growth of bifidobacteria only through a mechanism of selective action, inhibiting the growth of undesirable microorganisms, aiding in the balance of the intestinal microbiota [10,11].

The use of antibiotics in excess is detrimental to the fight against diseases because it triggers the emergence of superbugs, because a process of selection and transmission of genes of bacteria resistant to our immune system and the human microbiota occurs [20].

Therefore, prebiotics as well as probiotics are important alternatives to antibiotics and disease prevention. These elements do not leave residues in the environment where they are used, either in food or in direct or sub-therapeutic use.

Probiotics on Prevention and Treatment of No Infectious Chronic Diseases

Probiotics are defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host" [21]. According to Bergmann et al., [22], in our body there is a number of microbial cells in the order of 10 to 100 times greater than the number of cells of the body itself, so that the effective functioning of the human organism depends on this microbiome. Still according to the authors, the performance of certain metabolic, immune system, and even nutritional functions is dependent on the characteristics of this microbiome.

The human intestinal microbiota is a dynamic ecosystem that is formed immediately after birth, with the GI tract (GI), a habitat for several classes of organisms, which may vary according to the environmental conditions and characteristics of the host. In general, this microbiota remains in balance, unless exogenous factors promote a disorder, which may reflect local consequences, or even reach distant organs or systems. Recent studies have indicated the influence of the microbial composition of Gastrointestinal Tract (GIT) on the occurrence of metabolic disorders and the development of allergies, inflammatory bowel diseases, rectal cancer, diabetes and obesity [7,23,24]. Because the bacterial composition of GIT is widely diverse, some authors classify these bacteria into phyla, classes, order, family, genus and species, so that it is estimated that more than 50,000 different phyla occur. However, about 90% of this population belongs to the *Firmicutes* and *Bacteroidetes* phyla. Within these phyla, the main ones belong to the classes *Bacilli*, *Clostridia*, *Mollicutes*, *Flavobacteria*, *Sphingobacterias*, *Bifidobacteriaceae* and *Enterobacteriaceae* [25-27]. Each person may present a distinct bacterial composition, depending on genetic factors, or individual and environmental characteristics, such as age and eating habits [17].

Due to the metabolic and endocrine functions of GIT, it plays an important role in maintaining the health and well-being of individuals, with the highest concentration of microorganisms and metabolic activity being found along the large intestine [28].

One of the functions of this bacterial community is protection through competition with pathogenic microorganisms, thereby regulating populations harmful to the host organism. Autochthonous bacteria (natural resident bacteria of the GIT), prevent the non-beneficial bacteria from being adhered to the intestinal mucosa, forming a kind of barrier. The production of toxic and antimicrobial metabolites as bacteriocins, form an unfavorable environment for colonization, including the population of *E. coli* [6,28,29].

The intestinal microbiota also has nutritional importance, since they use fermentable substrates to meet their energetic and plastic needs, these substrates, which are generally not digestible, but which after fermented result are molecules nutritionally important to the individual host. In the colon, the fermentation of complex polymers, such as some polysaccharides and proteins, is an essential process for the utilization of energy, since, without this process, they would be lost by excretion. The main products of microbial fermentation are short chain fatty acids, and gases such as hydrogen and carbon dioxide, as well as metabolic intermediates such as ethanol, lactate, succinate and pyruvate, which can also take metabolizable forms. In addition, B vitamins and vitamin K are also synthesized by the intestinal microbiota [6,28].

Regarding immunomodulation, according to Barbosa et al., [6], GIT is the largest lymphoid organ in the body, presenting a significant number of immunogenic molecules from the microbiota and diet. This system is activated through antigenic modulation allowing the identification of an invasion and the prompt immune response required. These immunological responses, coupled with the protection promoted by the resistance to colonization of non-beneficial bacteria, are essential for the reduction of health risks to the host [6,29]. Intestinal epithelial cells have receptors that recognize components of the bacterial cell wall, such as the peptidoglycan present in lactobacillus which are Gram-positive

and the Lipopolysaccharide (LPS), the main component of the wall of Gram-negative bacteria. The LPS is deleterious to tight junction in the intestinal epithelium while peptidoglycan can direct the anti-inflammatory immunological response reducing the intestinal permeability and improving the metabolism, immunological system, cardiovascular and renal health [24,30] (Figure 1).

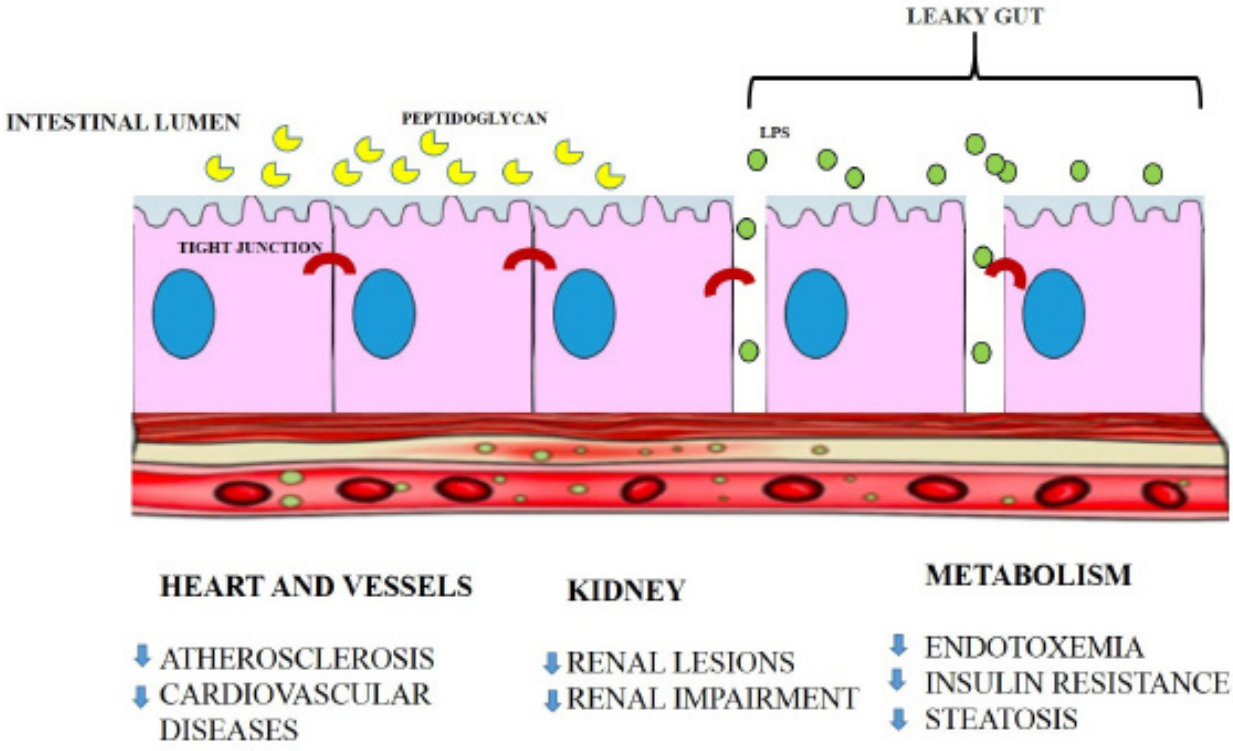

Figure 1: Action of cellular wall components of Gram-positive bacteria (peptidoglycan) and Gram-negative bacteria (lipopolysaccharide - LPS) in the intestinal permeability and on the improvement of the health.

The maintenance of adequate homeostasis of the microbial population of the GIT is necessary to guarantee the full exercise of these functions, since, in a situation of imbalance, the loss of the immunological effects can occur, being that this condition is associated with the development of diseases autoimmune and atopic. In general, the causes of these imbalances involve factors related to diet, frequent exposure to infectious agents or toxins, ingestion of antimicrobials, or even disorders of the digestive system [29,31]. Diseases such as necrotizing enterocolitis, inflammatory bowel diseases, and the development of allergies, can be induced from the intestinal microbiota disorder [32].

In this sense, it is evident the importance of the integrity and quality of the intestinal microbiota, so that this knowledge has motivated research aimed at the development of technologies aimed at the maintenance and stimulation of the microbial community of GIT, to treat and / or prevent various pathologies, through diet. In this way the interest is turned to the use of probiotics from the possibility of modulating the activity of the intestinal microbiota in a beneficial way [28,31-36].

Despite the diverse definitions of probiotics that can be found in the literature, what is currently accepted is that of live microorganisms that, when administered in adequate amounts, confer benefits to host health [37]. According to Hajela et al., [33], probiotics have been widely investigated in recent years because of their potential to improve digestive functions and contribute to the reduction of the effects caused by infectious and inflammatory diseases. These microorganisms act in a reciprocal way with the intestinal microbiota, preserving or restoring the homeostasis in the GIT [29,32].

Among the main representatives of probiotics are the lactic acid bacteria, especially the species *Lactobacillus*, *Bifidobacterium* and *Streptococcus*. The beneficial influence of these bacteria is related to the promotion of antagonistic, immunological effects or competition with harmful bacteria. It is common to apply probiotic agents mainly to milk-derived products, such as dairy drinks, cheeses and fermented milk [28,31].

Some studies have shown that probiotic ingestion increases the bioavailability of micronutrients, promotes the relief of symptoms caused by lactose intolerance, can be used to treat diarrhea, is associated with a reduction in cholesterol, promotes an increase in the immune response, prevents of colonic cancer. However, the effects are related to the characteristics of each

prebiotic strain, so that, certain probiotics can promote specific effects [28,33,38].

Studies reveal the action of probiotics in the synthesis of essential nutrients and in the increase of the digestibility and bioavailability of nutrients. Fermented foods such as kefir present an increase in the amount of folic acid, and in yoghurts larger concentrations of B-complex vitamins are found. In the intestinal lumen, probiotics produce several enzymes that play a synergistic role in digestion, improving the absorption, and increasing the bioavailability of proteins and fats, with consequent formation of free amino acids, SCFAs, lactate, propionate and butyrate. SCFAs are essential for the protection of the lumen of the colon and helps maintain the proper pH of that region. In addition, the bacteria *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, produce bacterial lactase in amounts enough to aid in the degradation of lactose in intolerant individuals [31-34,39].

The immunological effects of probiotics are pointed out in a large number of investigations, so they are reported, for example, as preventive agents and against the symptoms of viral and bacterial diarrhea by inhibiting the binding of the infectious agent to the intestinal epithelium. Certain strains may further stimulate leukocyte phagocytic activity, increase non-specific (IgA), and specific response, and promote cytokine production in the body. Some studies also demonstrate the immunological activity of strains of lactic acid bacteria in the fight against rotavirus infection in children. Probiotics can be administered as immunological enhancers in cases of pathological immunodeficiencies (AIDS, Leukemia) or caused by age, pregnancy and stress condition [31,32,34,40].

Reducing the risk of developing food allergies has also been attributed to the consumption of probiotic foods, as studies indicate the ability of these microorganisms to break down potentially allergic proteins. In addition, the production of anti-inflammatory cytokines may regulate the immune responses of hypersensitive individuals. Some studies evidence the reduction of allergic responses of children with milk allergy through the incorporation of a probiotic food into the diet [31,34,35,40].

Although not yet proven, other effects attributed to probiotics are the control of blood cholesterol levels, through the inhibition of SCFAs on the synthesis of cholesterol in the liver and / or its redistribution. Antihypertensive effects are also mentioned in the literature, and some research indicates that the consumption of probiotic food by hypertensive elderly, promoted a reduction of blood pressure, and the consumption of probiotics indicated as a prophylactic treatment against cardiovascular diseases. Prevention of colon cancer, treatment of urinary infections, and influence on diseases such as Diabetes are also possible effects of probiotics reported in various researches [28,31,32,34,40].

There is still much to be explored, problems to be solved, and technologies to be developed about the application of probiotics in food products. Studies that ensure the stability and viability of strains over the shelf-life of products, identification, characterization and even genetic manipulation of probiotics for specific applications are still being developed. Over time new probiotic foods will emerge, along with the establishment of identity and quality standards for these, allowing soon the treatment and/or prevention of diseases through diet [28,32,34,38,39].

Conclusion

In view of the analysis of the productions carried out in this work, it is evident that the satisfactory functioning of the physiological and immunological functions of the organism is related to the maintenance of a healthy and stable intestinal microbiota. The role played by probiotics in a direct way, and indirectly by prebiotics, is fundamentally important to guarantee the quality of life of the individuals, acting in a beneficial way in the control of the microbial composition of the intestine, in the performance of immunological functions, in the treatment of diseases, and in the prevention of diseases more and more common today. Studies are still being developed to optimize the performance of these components, so that soon we will have food capable of intervening in even more specific aspects, in the maintenance of consumers' health.

Conflicts of Interest

All authors declare no conflicts of interest in this article.

References

1. Sousa RCP, Santos DC, Neves LTBC, Chagas EA (2013) Tecnologia de bioprocesso para producao de alimentos funcionais. Braz J Agr Env Sci 7: 366-372.

2. Silva DC, Corso MP, Drunkler DA (2014) Produtos lácteos funcionais: perfil do consumidor e entendimento das informacoes constante no rotulo destes alimentos. Undergraduate Thesis. Federal University of Thecnology - Parana (UTFPR), Brazil.

3. Daliri EB, Lee BH (2015) New perspectives on probiotics in health and disease. FSHW 4: 56-65.

4. Jenzsch A, Eick S, Rassoul F, Purschwitz R, Jentsch H (2009) Nutritional intervention in patients with periodontal disease: clinical, immunological and microbiological variables during 12 months. Br J Nutr 101: 879-885.

5. Guarner F (2007) Papel de la flora intestinal en la salud y em la enfermedad. Nutr Hosp 22: 14-19.

6. Barbosa FHF, Martins FS, Barbosa LPJL, Nicoli JR (2010) Microbiota indigena do trato gastrintestinal. Rev Biol Cienc Terra 10: 78-93.

7. Santos TT, Varavallo MA (2011) A importancia de probioticos para o controle e/ou reestruturacao da microbiota intestinal. Rev Cien ITPAC 4: 40-49.

8. Wall R, Ross RP, Ryan CA, Hussey S, Murphy B, et al. (2009) Role of Gut Microbiota in Early Infant Development. Clin Med Pediatr 3: 45-54.

9. Stefe CA, Rebeiro Alves MA, Rebeiro RL (2008) Probioticos, prebioticos e simbiotico: artigo de revisao. Saude e Ambiente em Revista 3: 16-33.

10. Souza FS, Cocco RR, Sarni ROS, Mallozi MC, Sole D (2010) Prebioticos, probioticos e simbioticos na prevencao e tratamento das doencas alergicas. Rev Paul Pediatr 28: 86-97.

11. Flesch AGT, Poziomyck AK, Damin DDC (2014) The therapeutic use of symbiotics. Arq Bras Cir Dig 27: 206-209.

12. Cavalcante FAE, Pastore GM (2015) Galactooligossacarídeos: producao, benefícios a saude, aplicacao em alimentos e perspectivas. Scient Agro 6: 69-81.

13. Figueroa C (2015) Dieta Baja En Fodmap En El Sindrome De Intestino Irritable. Rev med Clin Las Condes 26: 628-633.

14. Vandenplas Y, Veereman-Wauters G, Greef E, Peeters S, Casteels A, et al. (2011) Probioticos e prebioticos na prevencao e no tratamento de doencas em lactentes e criancas. J Pediatr 87: 292-300.

15. Baucells BJ, Hally MM, Sanchez ATA, Aloy JF (2016) Asociaciones de probioticos para la prevencion de la enterocolitis necrosante y la reduccion de la sepsis tardia y la mortalidad neonatal en recien nacidos pretermino de menos de 1.500 g: una revision sistematica. An Pediatr (Barc) 85: 247-255.

16. Carvalho-ramos II, Duarte RTD, Brandit KG, Martinez MB, Taddei CR (2018) Breastfeeding increases microbial community resilience. J Pediatr 94: 258-267.

17. Moraes AC, Silva IT, Almeida-pititto B, Ferreira SR (2014) Intestinal microbiota and cardiometabolic risk: mechanisms and diet modulation. Arq Bras Endocrinol Metabol 5: 317-327.

18. Chimenos-Kustner E, de Luca-Monasterios F, Schemel-Suarez M, Rodriguez de Rivera-Campillo ME, Perez-Perez AM, et al. (2017) Burning mouth syndrome and associated factors: A case-control retrospective study. Med Clin (Barc) 148: 153-157.

19. Perez-monter C, Escalona-nandez L, Estanes-hernandez A, Noriega-lopez LG, Torre-delgadilho A (2018) Determinacion de la microbiota intestinal en pacientes cirroticos de poblacion mestizo-mexicana. Rev Gastroenterol Mex 2018: 1-10.

20. Diaz-lopez EA, Angel-isaza J, Angel BD (2017) Probioticos en la avicultura: una revision. Rev Med Vet 35: 175-189.

21. Koletzko S (2016) Probiotics and Prebiotics for Prevention of Food Allergy: Indications and Recommendations by Societies and Institutions. J Pediatr Gastroenterol Nutr 63: 09-10.

22. Bergmann H, Rodriguez JM, Salminen S, Szajewska H (2014) Probiotics in human milk and probiotic supplementation in infant nutrition: a workshop report. Br J Nutr 112: 1119-1128.

23. He C, Shan Y, Song W (2015) Targeting gut microbiota as a possible therapy for diabetes. Nutr Res 35: 361-367.

24. Nagatomo Y, Tang WH (2015) Intersections Between Microbiome and Heart Failure: Revisiting the Gut Hypothesis. J Card Fail 12: 973-980.

25. Huttenhower C, Gevers D, Knight R, Abubucker S, Badger JH, et al. (2012) Structure, function and diversity of the healthy human microbiome. Nature 486: 207-214.

26. Qin J, Li R, Raes J, Arumugam M, Burgdorf KS, et al. (2010) A human gut microbial gene catalogue established by metagenomic sequencing. Nature 464: 59-65.

27. Arumugam M, Raes J, Pelletier E, Le Paslier D, Yamada T, et al. (2011) Enterotypes of the human gut microbiome. Nature 473: 174-180.

28. Berdani R, Rossi E (2009) Microbiota intestinal e probioticos: implicacoes sobre o cancer de colon. J Port Gastrenterol 16: 19-28.

29. Paixao LA, Castro FFS (2016) A colonizacao da microbiota intestinal e sua influencia na saude do hospedeiro. Universitas: Cienc da Saude 14: 85-96.

30. Koppe L, Mafra D, Fouque D (2015) Probiotics and chronic kidney diseases. Kidney Int 88: 958-966.

31. Badaro A, Guttierres APM, Rezende ACV, Stringheta PC (2008) Alimentos probióticos: Aplicacoes como promotores da saude humana: parte 1. Rev Dig Nutr 2: 1-29.

32. Saad SMI (2006) Probiotics and prebiotics: the state of the art. Rev Bras Cienc Farm 42: 1-16.

33. Hajela N, Ramakrishna BS, Nair GB, Abraham P, Gopalan S, et al. (2015) Gut microbiome, gut function, and probiotics: Implications for health. Indian J Gastroenterol. 34: 93-107.

34. Parvez S, Malik KA, Ah Kang S, Kim HY (2006) Probiotics and their fermented food products are beneficial for health. J Appl Microbiol 100: 1171-1185.

35. Tsai YT, Cheng PC, Pan TM (2012) The immunomodulatory effects of lactic acid bacteria for improving immune functions and benefits. Appl Microbiol Biotech 96: 853-862.

36. Hager CL, Ghannoum MA (2017) The mycobiome: Role in health and disease, and as a potential probiotic target in gastrointestinal disease. Dig Liver Dis 49: 1171-1176.

37. FAO - Food and Agriculture Organization of the United Nations, World Health Organization (2001) Evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria. Córdoba, Argentina. Pg no: 1-34.

38. Mizock BA (2015) Probiotics. Disease-a-Month 61: 259-290.

39. Chua KJ, Kwok WC, Aggarwal N, Sun T, Chang MW (2017) Designer probiotics for the prevention and treatment of human diseases. Curr Opin Chem Biol 40: 8-16.

40. Singh VP, Sharma J, Babu S, Rizwanulla, Singla A (2013) Role of probiotics in health and disease: A review. J Pak Med Assoc 63: 253-257.