



Beneficial Effects of Post-biotics on Food Products and its Effect on Human Health: a Critical Review

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Abstract

The human intestinal microbiota is a collection of microorganisms that reside in the gastrointestinal tract and there is a direct link between the presence of beneficial microbiota and the development of immune function, the nervous system and the host metabolic pathways. Probiotics are known to be non-pathogenic microorganisms that, if taken in sufficient amounts, can have health effects. Therefore, consumption of foods or supplements containing post-biotic compounds is one of the most important strategies to balance the microbiota and to improve the health of the host. Evidence suggests that post-biotics do not require survival compared to their parent probiotic cells and can produce health-like effects similar to probiotics. Also, the production and use of post-biotics is safer, more stable and more cost-effective. Post-biotics have biological activity, including immune modulating, anti-inflammatory, antioxidant, and anti-cancer activity. Clinical studies also confirm the efficacy of probiotics as an effective factor in improving the treatment of a wide range of diseases such as ulcerative colitis, acute infectious diarrhea, antibiotic resistant diarrhea, irritable bowel syndrome, necrotic enteritis, liver disorders, and gastrointestinal cancers. In this study, a review of the concept of post-biotics and classification of post-biotics has been done based on type and chemical composition and physiological activities and promising effects on prevention or

improvement in treatment methods as well as delaying spoilage and increasing shelf life in food products.

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Introduction

The composition of human microbiota is very high and varied and is related to various factors such as age, sex and nutrition [1]. Intestinal microbiota are examples of technological breakthroughs that have potential implications for both the food and medical sciences, Nutraceutical formulations, either supplements along with drugs or stand-alone therapeutics can be developed by combining probiotics and postbiotics to restore microbial balance in the gut [2]. Postbiotics in the first place due to their unique characteristics such as stability, safety and non-toxicity and in the second place due to having biological activities and creating health effects similar to their parent probiotic cells, they can be introduced as a safe alternative to probiotics [3]. The microbiome plays an important role in both nutrient processing and the immune system [4]. Such as allergies and pathogenesis of obesity, inflammatory diseases and neurological disorders. The term "postbiotics" is also known as bacterial or biogenic metabolites [2]. These are bioactive molecules with low molecular weight or a fraction of the various components derived from the microbiome. Postbiotics are then produced during the fermentation of intestinal bacteria or may be structural components of these bacteria. Studies show that microbial postbiotics have a great impact on the physiology of the host and affect human health [5,6]. Clinical studies also confirm the effectiveness of probiotics as an effective factor in improving the treatment of a wide range of diseases such as ulcerative colitis, acute infectious diarrhea, irritable bowel syndrome, antibiotic resistant diarrhea, necrotic enteritis, liver disorders and gastrointestinal cancers [7,8]. Today, most probiotics used in food supplements or pharmaceutical products belong to lactobacilli and bifidobacteria [9]. Also from a technological point of view, maintaining the viability of probiotics in

different stages of production, storage and Distribution, selection of appropriate carriers, attempt to standardize the optimal amount of probiotics according to The various metabolic activities of each and the costs required to achieve these goals in order to achieve health effects in the host, are always of concern to researchers and manufacturers and seek to reduce costs and improve product safety and consumer health [10].

The advantages of post-biotics in terms of safety, biological effects and application in the pharmaceutical and food industries compared to living probiotic cells are as follows:

Do not invade the intestine and enter the bloodstream, especially in susceptible individuals without worrying about the transfer of resistance factor genes to other microbiota without worrying about preventing the growth and development of other intestinal microbiota, especially in infants, Exercises its health effects through proper digestion and absorption, metabolism and proper distribution as soon as possible, High durability, ease of standardization and transportation [9]. In this review study, different types of postbiotics and mechanisms of action in the host and their health impact on the host body are examined.

Methodology

Database study

A complete the databases searched for in those articles were "Google Scholar", "SID", "Scapus", "PubMed", "Science Direct", and "ISI" search engines. Search was done for articles published that included the search term containing Abiotic, Ghost probiotic, Postbiotic, Metabiotic, Supernatant, Health, Safety and benefit in their title. This study focused on published articles papers from 2011 to 2021. Exclusion criteria also included the following, articles with only

abstracts available, and studies written in languages other than English. Finally, 400 articles were found, 250 of which were discarded because they were not relevant to the purpose of the article. Then, abstracts of 150 related articles were prepared and studied. Finally, only 44 articles that were in line with the objectives and criteria of the present study were reviewed.

Definition and classification of postbiotics

A major part of the health effects of probiotic-containing products is related to the presence of post-biotic compounds in them. Postbiotics include the three major components of inactivated microbial cells (cell body), cell fractions (tocoic acid, peptidoglycan-derived morpopeptides, cell surface proteins, endo, and exopolysaccharides), as well as short-chain fatty acid cell metabolites (SCFAs). They are enzymes, bacteriocins and organic acids which are secreted when microbial cells are alive or released after they are broken down in the host intestinal environment And if received in sufficient quantities, they leave their own health effects on the host [9, 11-13]. In general, Postbiotics can be more complex due to their chemical structure (lipids, protein, carbohydrates, vitamins, and molecules). Classified potential biological activities such as anti-inflammatory, immune modulation, obesity prevention, blood pressure modulation, serum cholesterol lowering, and cessation of cell proliferation, antioxidant and anti-cancer (Figure 1) [14-18]. In addition, postbiotics have the ability to react with epithelial cells and the immune system, are metabolized by cytochrome P450 enzymes, have a good distribution, and have a high capacity to communicate with different organs and tissues in the host and can produce several physiological responses simultaneously. It is also important to note that postbiotics, like prebiotic compounds, develop probiotics in each individual's gastrointestinal tract instead of adding new species to the gut microbiota [19].

The effect of Postbiotics on health human

In recent decades, much attention has been paid to bioactive compounds such as probiotics, prebiotics and postbiotics. These compounds are closely related to the beneficial gut microbiota and promote the health status of the host. Prebiotics are indigestible food components that improve the health of consumers by stimulating the activity

and selective growth of beneficial microbiota in the gastrointestinal tract. Postbiotics are also functional parts of living probiotics that have the ability to perform the biological and physiological functions of their living parent cells [20].

Table 2. Benefits of postbiotics in human health

Probiotic organisms	Health benefits	Ref
<i>Lactobacillus</i> spp	Anti-adhesion effect against <i>E. coli</i>	[21]
<i>L. paraplantarum</i>	Antagonistic effects against MRSA	[22]
<i>L. fermentum</i>	Anti-senescence potential (alleviated senescence markers viz. p53, p21WAF1, SA-β-gal, p38MAPK, iNOS, cox-2, ROS, NF-κB, and DNA damage response)	[23]
<i>B. longum</i>	Anti-inflammatory	[24]
<i>L. casei</i>	Anti-tumour effect	[25]
<i>L. rhamnosus</i> GG	Anti-inflammatory	[26]
<i>L. brevis</i>	Anti-inflammatory and Enhancement of epithelial barrier permeability	[27]
<i>L. paracasei</i> D3-5 strain	Anti-aging	[28]
<i>L. gasseri</i>	Antibiofilm ability against methicillin-resistant <i>S. aureus</i> (MRSA)	[29]
<i>L. plantarum</i>	Anti-adhesion and antimicrobial effects	[30]
<i>L. plantarum</i>	Antibiofilm activity against <i>S. mutans</i>	[31]
<i>L. acidophilus</i> DDS-1	Increases in short-chain fatty acids (butyrate, propionate, and acetate) levels	[32]

The effect of Postbiotics on food

The possible use of postbiotics in food instead of probiotics has technological advantages since the functionality does not depend on cell viability. These functional ingredients would allow a longer shelf life, easier storage, handling, and transportation [5]. Problems with

using probiotics are: First, they do not need to prove safety or purity before marketing because they are known as dietary supplements [33]. Second, in immunocompromised patients, probiotic bacterial species such as *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Enterococcus*, and *Bifidobacterium* can enter the bloodstream and damage patients' health [34]. In addition, patients with severe acute pancreatitis have an increased risk. Mortality is achieved by using a combination of bacteria that is used as a probiotic prophylaxis. Postbiotics can have the same benefits as probiotics without the risks associated with living organisms. Also, postbiotics are easily absorbed, metabolized, and excreted by different host organs and tissues that elicit different biological responses. Other health benefits of fermented foods are related to the bioavailability of biotics, as they are related not only to ingested microorganisms but also to microbial structures and metabolites produced during fermentation. Therefore, postbiotics have a high potential for the production of fermented foods and microbial fermentation due to their biogenic composition.

In industrial use, postbiotics are more stable and safer than probiotics, Because during industrial management, many factors related to food composition such as pH, protein, fat and carbohydrate concentration, water activity, the presence of natural antibiotics as well as processing and storage conditions can help reduce the strength of probiotic cells [35]. Therefore, the use of postbiotics in food products can offer several technological advantages compared to the same microorganisms suitable for food producers [36].

Table 3. Benefits of Postbiotics in the food.

Postbiotic	Food	Benefits	Ref.
<i>Lactobacillus sakei</i> NRRL B-1917 supernatant	Grilled beef	Decrease in counts of <i>E. coli</i> and <i>L. monocytogenes</i> . There were no sensory changes	[37]
Polysaccharide extracts from <i>Lactarius volemus</i> Fr.	Yogurt	Decreased water holding capacity and reduced pH	[38]
Supernatant of <i>Lactobacillus</i>	Soy without shell	Increase shelf life	[39]

<i>Lactobacillus plantarum</i> YML 007			
<i>Lactobacillus gasseri</i> LA39 Gassericin A bacteriocin	Custard cream	Complete inhibition of four decomposition strains	[40]
Bacteriocin-like inhibitor substance of <i>Lactobacillus plantarum</i> ST16Pa	Chicken breast	Bioconservative against <i>Enterococcus faecium</i> for 7 days	[41]
Pirrol [1,2-a] and pyrazine-1,4-dione from <i>Lactobacillus salivarius</i>	Ground beef and whole milk	Biofilm removal of <i>L. monocytogenes</i>	[42]
<i>Lactobacillus rhamnosus</i> S93 enzyme	Cheddar cheese	Higher levels of soluble nitrogen in phosphotungstic acid and free amino acids	[43]

Given the above, postbiotics can be an opportunity to develop new effective treatment strategies with better safety profiles, thus avoiding the risks associated with prescribing live microorganisms. Microorganisms. This new approach to the use of postbiotics relates not only to the therapeutic benefits but also to the dilution of food and the removal of some harmful components from food during probiotic fermentation [5, 44].

Conclusion

Unhealthy lifestyle, the prevalence of chronic diseases, the prevalence of infectious and non-infectious diseases and the high cost of treatment are among the important factors that lead people to improve their lifestyle and diet. On the other hand, due to increasing consumer awareness and increasing research in the field of healthy foods, today a new concept in the field of probiotic functional food has been formed which has raised many research challenges. Postbiotics are known for their immune-boosting, anti-cancer, and antioxidant effects. As a drug supplement, they have beneficial therapeutic effects, doing so while avoiding the risk of prescribing live microorganisms to the body. In other words,

post-antibiotics, like prebiotics, develop probiotics in each individual's digestive tract, indicating the supportive role of post-antibiotics in the growth of beneficial microbiota (probiotics) in the host. Postbiotics are also used to delay spoilage, extend the shelf life of food, and promote healthy foods. Thus, postbiotics pave the way for the production of new pharmaceutical or food products with physiological effects.

Conflict of interest

The authors declare no conflict of interest.

Consent for publications

All authors approved the final manuscript for publication.

Availability of data and material

Data are available on request from the authors.

References

- Marietta E, Rishi A, Taneja V. Immunogenetic control of the intestinal microbiota. *Immunol* 2015;145(3):313-22.
- Chaluvadi S, Hotchkiss AT, Yam KL. Gut microbiota: impact of probiotics, prebiotics, synbiotics, pharmabiotics, and postbiotics on human health. *Probiotics, Prebiotics, and Synbiotics: Bioactive Foods in Health Promotion: Elsevier Inc.*; 2015: 515-23.
- Homayouni-Rad A, Fathi-Zavoshti H, Douroud N, Shahbazi N, Abbasi A. Evaluating the role of postbiotics as a new generation of probiotics in health and diseases. *J Ardabil Uni Med Sci* 2020; 19(4):381-99.
- Mato JM, Martínez-Chantar ML, Lu SC. Systems biology for hepatologists. *Hepato* 2014; 60(2):736-43.
- Hernández-Granados MJ, Franco-Robles E. Postbiotics in human health: Possible new functional ingredients? *Food Res Int* 2020; 137:109660.
- Wegh CA, Geerlings SY, Knol J, Roeselers G, Belzer C. Postbiotics and their potential applications in early life nutrition and beyond. *Int J Molecular Sci* 2019; 20(19):4673.
- Mohamadshahi M, Veissi M, Haidari F, Shahbazian H, Kaydani G-A, Mohammadi F. Effects of probiotic yogurt consumption on inflammatory biomarkers in patients with type 2 diabetes. *BioImpacts: BI*. 2014;4(2):83.
- Vaghef-Mehrabany E, Vaghef-Mehrabany L, Asghari-Jafarabadi M, Homayouni-Rad A, Issazadeh K, Alipour B. Effects of probiotic supplementation on lipid profile of women with rheumatoid arthritis: a randomized placebo-controlled clinical trial. *Health Promotion Perspectives*. 2017;7(2):95.
- Fathi-zavoshti H, Douroud N, Shahbazi N, Abbasi A. Evaluating the Role of Postbiotics as a New Generation of Probiotics in Health and Diseases. *J Ardabil Uni Med Sci* 2020; 19(4):381-99.
- Kothari D, Patel S, Kim S-K. Probiotic supplements might not be universally-effective and safe: A review. *Biomed Pharmacoth* 2019; 111:537-47.
- Aguilar-Toalá J, Garcia-Varela R, Garcia H, Mata-Haro V, González-Córdova A, Vallejo-Cordoba B, et al. Postbiotics: An evolving term within the functional foods field. *Trends in Food Sci Technol* 2018; 75:105-14.
- de Almada CN, Almada CN, Martinez RC, Sant'Ana AS. Paraprobiotics: evidences on their ability to modify biological responses, inactivation methods and perspectives on their application in foods. *Trends in Food Sci Technol* 2016; 58:96-114.
- Chuah L-O, Foo HL, Loh TC, Alitheen NBM, Yeap SK, Mutalib NEA, et al. Postbiotic metabolites produced by *Lactobacillus plantarum* strains exert selective cytotoxicity effects on cancer cells. *BMC Complement Alternative Med* 2019;19(1):1-12.
- Homayouni Rad A, Samadi Kafil H, Fathi Zavoshti H, Shahbazi N, Abbasi A. Therapeutically Effects of Functional Postbiotic Foods. *Clinical Excellence* 2020;10(2):33-52.
- Gezginc Y, Topcal F, Comertpay S, Akyol I. Quantitative analysis of the lactic acid and acetaldehyde produced by *Streptococcus thermophilus* and *Lactobacillus bulgaricus* strains isolated from traditional Turkish yogurts using HPLC. *J Dairy Sci* 2015;98(3):1426-34.
- Xavier-Santos D, Bedani R, Lima ED, Saad SMI. Impact of probiotics and prebiotics targeting metabolic syndrome. *J Functional Foods* 2020;64:103666.
- Guimarães JT, Balthazar CF, Silva R, Rocha RS, Graça JS, Esmerino EA, et al. Impact of probiotics and prebiotics on food texture. *Current Opinion in Food Sci* 2020;33:38-44.

18. Delzenne NM, Olivares M, Neyrinck AM, Beaumont M, Kjølbæk L, Larsen TM, et al. Nutritional interest of dietary fiber and prebiotics in obesity: Lessons from the MyNewGut consortium. *Clin Nutr* 2020;39(2):414-24.
19. Rad AH, Maleki LA, Kafil HS, Zavoshti HF, Abbasi A. Postbiotics as novel health-promoting ingredients in functional foods. *Health Promotion Perspectives* 2020;10(1):3-4.
20. Hajipour N, Homayouni-Rad A. Response to the paper" The effect of prebiotics on the viability of encapsulated probiotic bacteria". *LWT-Food Science Technol* 2018;90:606-.
21. Abbas HH, Abudulhadi S, Mohammed A, Shawkat D, Baker Y. Effect of *Lactobacillus* sp. crude bacteriocin (CB) and cell-free supernatant (CFS) against *E. coli* growth and adherence on vaginal epithelial cell surface. *Int J Adv Res* 2016;4(1):614-20.
22. Rishi L, Mittal G, Agarwal RK, Sharma T. Melioration in anti-staphylococcal activity of conventional antibiotic (s) by organic acids present in the cell free supernatant of *Lactobacillus paraplantarum*. *Indian J Microbiol* 2017; 57(3):359-64.
23. Kumar R, Sharma A, Gupta M, Padwad Y, Sharma R. Cell-free culture supernatant of probiotic *Lactobacillus fermentum* protects against H₂O₂-induced premature senescence by suppressing ROS-Akt-mTOR axis in murine preadipocytes. *Probiotics Antimicrobial Proteins* 2019:1-14.
24. Sang L-X, Chang B, Dai C, Gao N, Liu W-X, Jiang M. Heat-killed VSL# 3 ameliorates dextran sulfate sodium (DSS)-induced acute experimental colitis in rats. *Int J Molecular Sci* 2014; 15(1):15-28.
25. Fichera GA, Fichera M, Milone G. Antitumoural activity of a cytotoxic peptide of *Lactobacillus casei* peptidoglycan and its interaction with mitochondrial-bound hexokinase. *Anti-cancer drugs*. 2016;27(7):609.
26. Li N, Russell WM, Douglas-Escobar M, Hauser N, Lopez M, Neu J. Live and heat-killed *Lactobacillus rhamnosus* GG: effects on proinflammatory and anti-inflammatory cytokines/chemokines in gastrostomy-fed infant rats. *Pediatric Res* 2009; 66(2):203-7.
27. Ueno N, Fujiya M, Segawa S, Nata T, Moriichi K, Tanabe H, et al. Heat-killed body of *lactobacillus brevis* SBC8803 ameliorates intestinal injury in a murine model of colitis by enhancing the intestinal barrier function. *Inflammatory Bowel Dis* 2011; 17(11):2235-50.
28. Wang S, Ahmadi S, Nagpal R, Jain S, Mishra SP, Kavanagh K, et al. Lipoteichoic acid from the cell wall of a heat killed *Lactobacillus paracasei* D3-5 ameliorates aging-related leaky gut, inflammation and improves physical and cognitive functions: from *C. elegans* to mice. *Gerosci* 2020;42(1):333-52.
29. Giordani B, Costantini PE, Fedi S, Cappelletti M, Abruzzo A, Parolin C, et al. Liposomes containing biosurfactants isolated from *Lactobacillus gasseri* exert antibiofilm activity against methicillin resistant *Staphylococcus aureus* strains. *European Journal of Pharmaceutics and Biopharmaceutics* 2019;139:246-52.
30. Gao Q, Gao Q, Min M, Zhang C, Peng S, Shi Z. Ability of *Lactobacillus plantarum* lipoteichoic acid to inhibit *Vibrio anguillarum*-induced inflammation and apoptosis in silvery pomfret (*Pampus argenteus*) intestinal epithelial cells. *Fish Shellfish immunol* 2016; 54: 573-9.
31. Ahn KB, Baik JE, Park O-J, Yun C-H, Han SH. *Lactobacillus plantarum* lipoteichoic acid inhibits biofilm formation of *Streptococcus mutans*. *PLoS One* 2018; 13(2):e0192694.
32. Vemuri R, Gundamaraju R, Shinde T, Perera AP, Basheer W, Southam B, et al. *Lactobacillus acidophilus* DDS-1 modulates intestinal-specific microbiota, short-chain fatty acid and immunological profiles in aging mice. *Nutr* 2019; 11(6):1297.
33. Venugopalan V, Shriner KA, Wong-Beringer A. Regulatory oversight and safety of probiotic use. *Emerging Infect Dis* 2010; 16(11):1661.
34. Liong M-T. Safety of probiotics: translocation and infection. *Nutr Rev* 2008; 66(4):192-202.
35. Collado M, Vinderola G, Salminen S. Postbiotics: Facts and open questions. A position paper on the need for a consensus definition. *Beneficial Microbes* 2019; 10(7):711-9.
36. Danneskiold-Samsøe NB, Barros HDdFQ, Santos R, Bicas JL, Cazarin CBB, Madsen L, et al. Interplay

between food and gut microbiota in health and disease.

Food Res Int 2019; 115:23-31.

37. del Carmen Beristain-Bauza S, Mani-López E, Palou E, López-Malo A. Antimicrobial activity of whey protein films supplemented with *Lactobacillus sakei* cell-free supernatant on fresh beef. Food Microbiol 2017; 62:207-11.
38. Huang Y, Zhao S, Yao K, Liu D, Peng X, Huang J, et al. Physicochemical, microbiological, rheological, and sensory properties of yoghurts with new polysaccharide extracts from *Lactarius volemus* Fr. using three probiotics. Int J Dairy Technol 2020;73(1):168-81.
39. Rather IA, Seo BJ, Kumar VJR, Choi U-H, Choi K-H, Lim J, et al. Biopreservative potential of *Lactobacillus plantarum* YML007 and efficacy as a replacement for chemical preservatives in animal feed. Food Sci Biotechnol 2014;23(1):195-200.
40. Nakamura K, Arakawa K, Kawai Y, Yasuta N, Chujo T, Watanabe M, et al. Food preservative potential of gassericin A-containing concentrate prepared from cheese whey culture supernatant of *Lactobacillus gasseri* LA39. Animal Sci J 2013;84(2):144-9.
41. da Silva Sabo S, Pérez-Rodríguez N, Domínguez JM, de Souza Oliveira RP. Inhibitory substances production by *Lactobacillus plantarum* ST16Pa cultured in hydrolyzed cheese whey supplemented with soybean flour and their antimicrobial efficiency as biopreservatives on fresh chicken meat. Food Res Int 2017;99:762-9.
42. Moradi M, Tajik H, Mardani K, Ezati P, editors. Efficacy of lyophilized cell-free supernatant of *Lactobacillus salivarius* (Ls-BU2) on *Escherichia coli* and shelf life of ground beef. Veterinary Research Forum; 2019: Faculty of Veterinary Medicine, Urmia University, Urmia, Iran.
43. Azarnia S, Lee BH, Yaylayan V, Kilcawley KN. Proteolysis development in enzyme-modified Cheddar cheese using natural and recombinant enzymes of *Lactobacillus rhamnosus* S93. Food Chem 2010;120(1):174-8.
44. Tomasik P, Tomasik P. Probiotics, non-dairy prebiotics and postbiotics in nutrition. Appl Sci 2020;10(4):1470.