IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 2, November 2023

Unveiling the Power Within: A Review of Postbiotics as Dynamic Agents with Antimicrobial Capabilities

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Abstract*: The concept of postbiotics, representing the diverse array of bioactive molecules produced by beneficial microorganisms during fermentation or metabolic processes, has emerged as a promising avenue in the field of antimicrobial research. These dynamic biological molecules, derived from the byproducts of probiotics or the microbial communities inhabiting the human body, exhibit considerable potential in modulating and enhancing the host's immune response. This abstract delves into the multifaceted role of postbiotics as potent agents with antimicrobial activity, elucidating their mechanisms of action and therapeutic implications. By exploring the intricate interplay between postbiotics and host microbiota, this review aims to shed light on the evolving landscape of postbiotic research and its implications for developing innovative strategies in combating microbial infections and promoting overall health.*

Keywords: Dynamic biological molecules, Antimicrobial activity, Bioactive compounds

I. INTRODUCTION

Postbiotics were just discovered, making probiotics hard to get. Postbiotic supplements should include unique postbiotics, such as short-chain fatty acids [1], which may replace some nutrients in diets. Human gut microbiotas are diverse, and postbiotics may maintain their balance [2].

Probiotics are beneficial microorganisms that may benefit health. Probiotics in food or the host body may create postbiotics, which cause most of these health effects. However, probiotic function's molecular pathways are complex and unknown [3]. Despite probiotics' beneficial role in the gut, absorption, infection risk, and antibiotic resistance gene transfer remain concerns [4]. Optimizing probiotic therapy involves increasing probiotic survivability in fermented food and as they transit through the human gastrointestinal tract to the colon, their main action site, to 107 cfu/g or ml. Probiotics support prebiotics during fermentation, which may be a byproduct of postbiotics, and may help keep the stomach healthy by avoiding unwanted microbes [5]. Studies suggest postbiotics may prevent type 1 diabetes in pre-diabetics [6]. A parenthetically unbalanced microbiota may cause pre-diabetes or metabolic resistance [7].

Muramyl Dipeptide (MDP), a postbiotic, has been proven to diminish affront resistance even after weight reduction or gut flora changes during obesity [8]. Schertzer concluded that microbial imbalance and postbiotic synthesis disturbances contribute to diabetes [9]. Changing the number and diversity of indigenous bacteria in the gastrointestinal tract may affect type 2 diabetes [10]. The gut bacteria's blood sugar-lowering mechanism is well recognized [11]. Karim et al. (2017) evaluated how inulin RG14 and postbiotics affect development, cecal smaller-scale biota, unstable greasy volatile fatty acids, and optimum cytokine explanation in broilers [12].

The study found no difference between Interleukin 8/Chemokine (C-X-C motif) value and slim down. In aviculture, inulin (prebiotic) and postbiotics (produced from probiotics) may replace antimicrobial development boosters [13]. Konstantinos et al. [14] concluded that postbiotics may be safer than live bacteria for colonic health. Tsilengiri et al. suggested using postbiotics in therapy and anticipation with gut-relevant illnesses like provocative intestine illness [16]. Studies have shown that probiotics that produce post-antibiotics like exopolysaccharides can improve gastrointestinal health and prevent colon and rectal cancer [15].

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An effective 2017 assessment reviewed randomized, controlled human studies with any clinical outcome that included a butchered probiotic as a mediation [17]. Audit questions numbered forty. These 40 proposals differed in organism, target population, and end purpose (preventing or curing a cluster of illnesses). However, creators say thoughts were probably not aroused to notice a change. Dead probiotics outperformed live ones in two therapeutic tests [18]. One avoidance approach said life was better than murder. The audit also looked for dead organism side effects. As usual, most ponders unsuccessfully gathered or described competing circumstances to avoid a conclusion [19].

After biotics

Postbiotics are beneficial bioactive complexes that are created in a fermentation environment and may be used to enhance consumer health. In the fermentation environment, a wider variety of postbiotics are created the more prebiotic carbohydrates that probiotics have access to [20]. According to some research, probiotics may not always be able to support and sustain intestinal health on their own, but the postbiotics they create may be able to do so successfully [21]. Probiotics create many postbiotics, such as lactospin, indole, lipopolysaccharide, exopolysaccharide, teichoic acid, and muramyl dipeptide. Acetic acid, butyric acid, and propionic acid are examples of short-chain fatty acids that are among the most important and well studied postbiotics [22]. These fats are essential to the intestines' physiological and digestive processes. Maintaining gut health is mostly dependent on taking part in certain metabolic processes as well as food digestion and absorption [23]. As probiotic postbiotics, short-chain carbohydrates improve health by promoting the growth or activity of one or more gut microbiota and are unaffected by human stomach-related proteins [23–24]. These substances, which come from Lactobacillus species, operate as a stand-in for live probiotic cells in food and the body when there are insufficient probiotics [18]. A probiotic bacteria may produce postbiotic, a metabolic byproduct that affects the host's organic capacity [25].

Stout people with pre-diabetes may benefit from the aid of bacterial by-products, sometimes known as postbiotics, in decreasing their blood sugar levels [26]. Researchers hypothesize that postbiotics might help overweight people with pre-diabetes avoid developing type 2 diabetes [26–27]. Postbiotics are now thought to be helpful prebiotics that, in addition to their own positive effects, nourish and boost the efficacy of probiotics as a rich supply of carbohydrates [28]. The pH is lowered and the environment for the development and activity of pathogenic bacteria are restricted by the synthesis of postbiotics, particularly short-chain fatty acids [29].

Postbiotics are essential for promoting Lactobacillus and Bifidobacterium bacterial growth and activity [30]. It was previously believed that the existence and activity of bacteria increased blood sugar and inflammatory responses. Nevertheless, it is now shown that probiotic bacteria and postbiotic substances lower blood sugar and enhance insulin action in obese individuals [31]. In a study where scientists genetically modified fat mice, they discovered that postbiotics boost the effects of insulin [32–35].

Antimicrobial Activity of Postbiotics

Postbiotics address the bacterial risks of live cell probiotics by arguing that bacterial life is not essential for human health [36]. Despite little study, postbiotics may have antimicrobial properties [37]. Research has demonstrated that postbiotic compounds have antibacterial (pathogenic and spoiler) effects that prevent food spoilage and infectious diseases. These compounds prevent intestinal problems including diarrhea and irritable bowel syndrome by inhibiting gut bacteria [38]. Postbiotics improve human health by changing the body's microbial ecology, limiting antimicrobial growth, replacing invading gut bacteria, and changing environmental pH [39]. By maintaining intestinal microbiota balance and starting fermentation and post-antibiotic production, intestinal infections and other gastrointestinal tract problems are considerably reduced [40, 41]. Postbiotics connect to bacterial receptors to limit the development of toxic pathogens like E. coli and Clostridium and remove them from the intestinal lumen [42, 43].

Recent research on postbiotics' positive benefits and relevant ingredients has shown that they may prevent surviving microbes or premature babies from replacing and causing illness [44, 45].

Microbial Strains Used as Postbiotic Sources

This may be important to avoid the creation of safe antibacterial microbial strains that might damage humans [46]. Lactobacillus strains connected to people must be employed as postbiotics in animals, whereas Bifidobacterium strains from humans were used [47]. Bacillus strains have been used to make postbiotics in most countries, notably Europe, for decades [48]. The main end products of postbiotics are exopolysaccharides and short-chain volatile fatty acids synthesized in the lab. Most postbiotics used in breeding are synthetic and given to birds, pigs, and ruminants [49, 50, 51]. These compounds may also be found in pig, ruminant, and chick feces [53, 54, 55]. Bacillus subtilis When Mind 588 is separated from ocean water, E. coli may thrive [56].

Giang et al. recovered lactic acid bacteria (LAB) from sound stuffing pig interiors. Postbiotics such Pediococcus pentosaceus, L. acidophilus, L. plantarum, and Enterococcus faecium helped weaned pigs develop [56–57]. Silages from humid and hot environments have isolated Pediococcus pentosaceus, P. lolii, L. pentosus, L. plantarum, L. buchneri, L. rapi, and L. rhamnosus [58, 59]. Some study suggests that L. murinus, L. salivarius, and L. johnsonii from young feces calves may become bacteriocins [60].

Some investigations have identified postbiotic strains different from newly found aquatic and marine organisms [61]. L. salivarius from bottlenose porpoises may prevent human and marine Salmonella enteritidis strains from spreading [62]. Pig small intestines yielded particular Lactobacillus strains, mostly L. salivarius [63]. These organisms showed potential postbiotic traits such pH 3 tolerance, auto-aggregation, and E. coli K88 manifestation [64].

Leuconostoc mesenteroides was found in Nile tilapia and snakehead fish intestines [65, 53]. Common octopuses Leuconostoc cremoris and Weissella cibaria of Atlantic salmon fish provided postbiotics [66].

Sarkono et al. found that L. paracasei from the normal condition resists bile and acidic environments and kills pathogenic bacteria including E. Coli, Bacillus cereus, and Staphylococcus aureus [67].

Leuconostoc mesenteroides strains have been obtained from the intestines employing new water angles such Nile tilapia [69–71] and snakehead fish [68].

Table Some bacterial activities species of postbiotics.

Competition with pathogen	References
Lactobacillus plantarum I-UL4	[61]
Lactobacillus rhamnosus [66]	
Lactobacillus paracasei [68]	
Faecalibacterium prausnitzii	[68]
Lactobacillus brevis [70]	
Lactobacillus pentosus [70]	
Lactobacillus gasser [71]	

Postbiotics as Antimicrobial Agents in Food Products

LAB are confirmed safe, active, and useful food components with a long history of usage [72]. They may also employ their metabolic byproducts, such as lactic acid and bacteriocin, as conventional viewpoint and bactericidal agents to prevent food rotting [73].

LAB prevents urogenital infections [74], controls inflammatory bowel diseases [75], modulates the immune system [76], regulates serum cholesterol [77], and inhibits certain cancers [78]. Bio-preserving cell-free supernatant from L. plantarum YML 007 increased unshelled soybean shelf life by two months [79]. Exopolysaccharide from L. rhamnosus boosted cheddar cheese production by 8.2% when coupled with L. lactis [68]. Bifidin from Bifidobacterium lactis Bb-12 increased minced beef shelf life to three months at -18¯C by decreasing E. Coli O157:H7 by 100% [80].

Many practical issues hinder good bacterial cell effects [81]. However, undefined terms like "postbiotic" or "paraprobiotic" imply that dead microorganisms, microbial divisions, or cell lysates may indicate physiological preferences for bioactivity [82]. Numerous investigations on LAB postbiotics have demonstrated that each genus and species produces a different soluble postbiotic. Many of these bacteria develop mucoid colonies and films in the culture medium [83]. L. plantarum, the main LAB strain, produces PM with unique postbiotic effects [84]. More is known about LAB's anticancer activities, but less about PM from L. plantarum's cytotoxic and anti-proliferative actions. Research has been done on the cytotoxicity of PM produced by six L. plantarum strains on normal and malignant cells [85].

Antimicrobial mechanisms of postbiotics

It has been examined and shown that postbiotic metabolites have a good potential to substitute in-feed antimicrobials in animal nutrition [86]. Postbiotics aim to mimic the viable restorative effects, predicting the risk of preserving living bacteria in prematurely born infants with immature intestinal barriers or impaired immune systems [87]. Many microbes in the gastrointestinal system have the ability to catabolize indigestible carbohydrates to create significant quantities of volatile short-chain fatty acids and butyrate [89].

Here are some of the health-promoting effects of postbiotics:

Due to poor carbohydrate fermentation, water is retained in the gastrointestinal tract, causing constipation. The colon's capacity to absorb fibrous foods boosts stool output and bacteria [90]. In an aged study, inulin, an indigestible carbohydrate/prebiotic, reduced constipation and increased feces [91]. Carbohydrate postbiotics like exopolysaccharides operate similarly.

Postbiotics lower animal blood lipids, according to research. But further study is needed to confirm this effect on humans [92]. Postbiotics affect triglyceride activity and fatty acid synthesis, although human studies have not been done [93].

Postbiotics change and strengthen gut flora, boosting the body's and gastrointestinal tract's immune systems and lowering the risk of inflammatory illnesses, especially intestinal inflammation [94].

Human and animal studies have indicated that postbiotics improve iron, calcium, magnesium, and zinc absorption [95]. Human experiments have revealed that digestible oligosaccharides improve calcium absorption during adolescence and menstruation. Increase intestinal lumen calcium, potassium, and magnesium ions to control and inhibit cellular transformation [96].

Effect on cancer: As probiotics in the gut expand, the body creates more postbiotics such butyrate and oligosaccharides, which prevent cancer and cell deformation [97]. Postbiotics may increase Lactobacillus and Bifidobacteria activity, causing them to bind and destroy carcinogens [98]. Postbiotic highlights' appropriate inhibitory effect is crucial to their mechanical growth. Bacitracin synthesis under controlled aging has occurred for decades [99].

Future Perspectives of Postbiotics

Postbiotic antibacterial properties and microbial resistance are discussed in this article. Due to antibiotics' strengthening effects, co-administration of antibiotics and postbiotics may help combat germ resistance. This idea needs further laboratory and clinical animal and human study [100, 101]. The most notable distinction between postbiotics and probiotics is that probiotics must be active [102]. Live bacteria or dead and damaged cell components secrete postbiotics. Postbiotics are particularly interesting because of how much simpler fabrication, packaging, packing, transportation, and caring are without the organism. Since probiotics' active nature may cause infection concerns, inactive and dead organisms are a safer alternative. Post-biotics have been demonstrated to improve health in several research. Postbiotics may be microencapsulated to improve effectiveness and survivability like probiotics [103, 104].

II. CONCLUSION

These days, probiotic effects ascertained by means of microbial metabolites regarded as bioactive postbiotic metabolites are receiving more and more attention. Using living microorganisms, postbiotics are defined as dissolvable agents (items or metabolic by-products) that are released after bacterial lysis, such as proteins, teichoic acids, peptides, peptidoglycans, cell surface proteins, polysaccharides, and natural acids. The self-evident chemical features, security dosage items, long shelf life, and the content of various signaling particles that will have anti- (inflammatory, obesogenic, immunomodulatory, hypertensive, proliferative, oxidant) hypocholesterolemia applications have drawn interest in these postbiotics. Even though the specifics are still unclear, these targeted benefits of postbiotics may contribute to the advancement of wellbeing by boosting the execution of particular physiological wants.

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