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Mini Review

Industrial Applications Of Lactic Acid Bacteria – A Review

Rose Mary Sunny, P. Sreelakshmi, M. Shanmugavadivu*

Department of Biotechnology, Dr. N.G.P. Arts and Science College, Dr. N.G.P. Nagar, Kalapatti Road, Coimbatore, Tamil Nadu – 641048

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ABSTRACT

Lactic acid bacteria (LAB) belongs to a diverse category of Gram-positive bacterial species that generate several antibacterial chemicals. They can be found in different habitats, ranging from soil, water, the gastrointestinal and urogenital tracts of mammals, fermented dairy products, meat and vegetables. Many substances, for example, organic acids, reuterin, hydrogen peroxide, phenyllactic acid, diacetyl, and bacteriocins, are produced by LAB species and have antibacterial activity against both bacterial and fungal species. Among these substances, bacteriocins are employed as natural and safe preservatives in food to extend its shelf life. LAB can be utilised as starter cultures in fermented foods to boost antioxidant activity and lower the amount of anti-nutritive chemicals, in addition to their utility in food preservation. LAB species are also used as probiotic cultures to improve people's general health and intestinal health. Thus, these bacterial cultures and the antimicrobial substances they produce provide a substitute for chemical food preservatives.

INTRODUCTION

Food safety and quality are the top concerns for consumers worldwide, particularly in developed nations. The quality standards of food items are related to its shelf life from production until consumption and safety attributes to the absence of toxic substances or pathogenic microorganisms. The nutritional value and the concerned health benefits are also of high demand among the consumers. Chemical preservatives used in food can be extremely hazardous to humans and lead to health problems. The production of nitrosamines in food that can cause cancer is one of the drawbacks of utilising chemical preservatives. Therefore, it is suggested that using natural and biological components to bio preserve food items is a safer solution than trying to stop microbiological deterioration of food and food products and the resulting financial loss. Additionally, it will help lower the prevalence of foodborne infections (Anwaar et al., 2002). Fungi is the major food and feed spoiling microorganism

***Corresponding Author:** M. Shanmugavadivu
Address: *Department of Biotechnology, Dr. N.G.P. Arts and Science College, Dr. N.G.P. Nagar, Kalapatti Road, Coimbatore, Tamil Nadu – 641048*
Email : shanmugavadivu@drngpasc.ac.in
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that destroys crops and agricultural products which leads to economical loss worldwide. Fungi releases mycotoxin which is a threat to human health as it may lead to death even in acute cases. Mold spoilage of bread is the largest known spoilage caused by fungal species like Penicillium and Aspergillus and is estimated to cause huge economic losses. Fusarium spp. is found to cause spoilage in cereal grains and Penicillium spp. is the major reason for spoilage of food stored under cold conditions. Yeast belonging to Candida spp. cause spoilage of yoghurt and other fermented dairy products. Hard cheese undergoes spoilage by P. roqueforti and P. commune. Since their spores can withstand high temperatures, spore-forming bacteria are the main factors behind food degradation in heat-treated environments. Other food-spoilage bacteria include Gram positive thermophilic bacteria and Pseudomonas, Enterobacteriacea, etc which are Gram negative (Schnürer and Magnusson., 2005).

LAB belong to a diverse group of rod- or cocci-shaped, non-sporulating, Gram positive, non-catalase producing bacteria that are present naturally in vegetables, dairy products, and meat products. The main by-product of the fermentation of carbohydrates is lactic acid, which is produced by LAB (Ayivi et al., 2020). These are significant industrial microbes that are mostly utilised as starter cultures to produce fermented goods like cheese, yoghurt, sausage, bread, beer, and wine. They belong to Generally Recognised As Safe (GRAS) status and shows probiotic qualities which makes them highly desirable as biopreservatives (Zapaśnik et al., 2022). LAB species like Lactobacillus acidophilus produce antifungal compounds that inhibit fungal growth. Lactic acid bacteria produce different kinds of antifungal metabolites, such as organic acids, hydrogen peroxide, proteinaceous substances, reuterin, fatty acids, and phenyllactic acid. Bacteriocins are low molecular weight, ribosomally synthesised chemicals that actively inhibit spoilage bacteria and fungi, generated by LAB species. The three main bacteriocins that are produced by LAB species are nisin, pediocin, and plantaricin. Due to their easy hydrolysis by the digestive enzymes found in the human stomach, bacteriocins are regarded as safe for ingestion by humans (Reis et al., 2012). The conventional chemical preservatives can be substituted with these inhibitory metabolites. The metabolites produced by the LAB species can be isolated and added to food products to extend their shelf life, or they can be utilized as starting cultures in fermentation (Kalhoro et al., 2023).

Applications of Lactic acid bacteria

As Starter Culture In Fermented Foods

LAB has the ability to ferment specific sugars, resulting in the production of pickled vegetables, dairy products including yoghurt, cheese, and fermented milk, as well as meat and fish products (Bintsis, 2018). These lactic acid bacteria-developed products improve gastrointestinal system performance and offer health benefits to users (Raphael D. Ayivi et al., 2020). Because lactic acid fermentation is acidic, more microbial enzymes are active, which lowers the amount of anti-nutritive substances like tannins and phytic acid. The bioavailability of nutrients may be increased by LAB and is also found to possess antioxidant activity (Agnieszka Zapasnik et al., 2022).

Probiotic Activity

Microbial cells and their constituents that are beneficial to the health and general well-being of the host are known as probiotics. LAB species such as Lactobacillus, Bifidobacterium, and Propionibacterium are frequently used in foods that have probiotic properties. The several health-promoting advantages of LAB include cholesterol assimilation, immune system activation, pathogen control, allergy management, and the management of bacterial, viral, and related illnesses (Bintsis,

2018). The mode of action of probiotics can be categorized under three types:

- Alter the host's defence mechanism, in order to manage chronic gastrointestinal tract inflammation and avoid infectious illnesses.
- They have the ability to directly affect other bacteria, which is advantageous for therapy and the general restoration of the gut's microbial equilibrium.
- They play a role in the gastrointestinal tract's toxin's inactivation.

The ability of LAB probiotics to stick to and colonise the colon, as well as to tolerate and survive in the acidic and alkaline conditions of the gastrointestinal tract, are linked to their therapeutic effects (Ayivi et al., 2020).

Bioprotective Cultues

Some LAB species synthesise polypeptides, such as bacteriocins ribosomally, and these compounds can either cause bactericidal activity or bacteriostatic effects on other bacteria. By preventing the formation of cell walls or by causing poration in the cell membrane, bacteriocins have the ability to mediate cell death. Bacteriocins play a crucial role in food preservation because they can suppress food pathogens or stop food from spoiling. Nisin is the most well-known bacteriocin and is widely utilised in the food sector. It is frequently added to processed cheese, dairy products, and canned foods in many different nations (Delves-Broughton et al.,1996). Lacticin from Lactococci, macedovicin from Streptococcus macedonicus, reuterin from Lactobacillus reuteri, sakacin M from Lactobacillus sake, curvacin A, curvaticin and lactocin from Lactobacillus curvatus, pediocin from Pediococcus acidilactici, plantaricins from Lactobacillus plantarum are some examples of useful bacteriocins that the lactic acid bacteria produces. The bacteriocins mentioned above have shown efficacy in managing food deterioration and found effective against harmful bacteria (Parada et al.,2007). Fungal mycotoxins are lowered by the anti-mycotoxinogenic metabolites produced by LAB strains. In addition to having a variety of other physical and biochemical qualities, LAB must be able to produce an adequate number of antimicrobial metabolites in order to be employed as bio-protective starter cultures (Bintsis, 2018).

4. Biofertilizers

LAB species are frequently found in compost (Partanen et al., 2010), silage, and methogenic anaerobic digestion systems. They are engaged in the breakdown of various organic compounds utilised in the processing of agricultural waste. According to some studies, LAB was found to be the most prevalent and abundant group (Ahn et al., 2014) among the consortium of useful microorganisms that included actinomycetes, yeast, mould fungus, photosynthetic bacteria, and LAB (Higa, 1991).

Antimicrobial Substances Produced By LAB

1. Organic Acids

The two main organic acids that LAB species produce as end-metabolites during fermentation are lactic acid and acetic acid. Acetic acid as compared to lactic acid is reported to have a wider range of antibacterial action (Stoyanova et al., 2011). Propionic acid is produced only in trace amounts by heterofermentative LAB, whereas acetic acid is produced in large amounts in the presence of external electron acceptors. The electrochemical proton gradient is neutralised by these organic acids through interactions with the cell membrane. At lower pH levels, propionic acid affects fungal membranes and acts against some specific fungal species (Schnürer and Magnusson., 2005).

2. Reuterin

Lactobacillus reuteri produces reuterin, a low molecular weight inhibitory molecule with a broad antibacterial range. The active reuterin produced under anaerobic conditions from glycerol is an equilibrium combination of the

monomeric, hydrated monomeric, and the cyclic dimeric forms of 3- hydroxypropionaldehyde (3-HPA) (Talarico et al., 1988). It was discovered to be effective against a variety of both Gram positive and Gram negative bacteria, yeast and fungal species including Candida, Saccharomyces, Aspergillus, Fusarium, etc (Chung et al.,1989).

3. Phenyllactic acid

Phenyllactic acid is a metabolite produced during phenylalanine metabolism where P-hydroxyphenylpyruvic acid is the precursor. It demonstrates antibacterial action against microscopic fungi, Gram positive bacteria, and Gram negative bacteria (Stoyanova et al., 2011). It was shown that L. plantarum could make phenyllactic acid and 4-hydroxy-phenyllactic acid, which have antifungal properties against a variety of filamentous fungal species (Schnürer and Magnusson., 2005).

4. Hydrogen peroxide

When NADH oxidase and superoxide dismutase activities are introduced to Lactic acid bacteria, hydrogen peroxide is produced by them. Hydrogen peroxide builds up when heme is not present in the environment because LAB is unable to produce catalase. The ability of Lactococcus and Lactobacillus species to accumulate peroxides resulted in the prevention of growth of food-contaminating bacteria, such as Pseudomonas spp. (Stoyanova et al., 2011).

5. Bacteriocin

Bacteriocins are ribosomally synthesized peptides which are biologically active proteins with antimicrobial activity. Based on their molecular weight, thermal stability, and chemical structure, bacteriocins have been classified into four classes. Foods that include bacteriocins are more naturally preserved and have superior nutritional qualities because they can decrease the amount of chemical preservatives added, the degree of heat treatment, or both. This can be done alone or in conjunction with other traditional treatments (Abd El-Salam et al., 2004). Bacteriocins provide several advantages when it comes to food preservation, such as a lower risk of food-borne pathogen transmission, a decrease in food losses from spoiling, a decrease in chemical preservatives, and enhanced food qualities (Reis et al., 2012).

6. Diacetyl

Diacetyl is produced by LAB when citrate is transformed into pyruvate. It is effective against Gram positive bacteria from the genera Bacillus as well as Gram negative bacteria like Salmonella, Yersinia, Aeromonas, and Escherichia (Stoyanova et al., 2011).

CONCLUSION :

The ability of LAB to preserve foods was used historically as the fermentation reduces carbohydrate content and produces some organic compounds that had antimicrobial activity. It has been found and generally accepted that bacteriocins generated by LAB is a natural or food grade protein and can be used to preserve food. As an antimicrobial substance, bacteriocin is found to be effective against bacteria and is non-toxic to people or animals. They work well at low concentrations and do not alter the nutritional makeup of meals. They have a consumer friendly and environmentally-friendly nature and are active when stored in a refrigerator. The prevention of infectious diseases and food borne pathogens in order to assure food quality and safety is important for consumer satisfaction and reduce the economic and health losses. The antimicrobial compounds produced by LAB provide promising potential as good natural preservative agents. In the current perspective only limited data is available in terms of the ability of LAB to destroy pathogens. The future studies focuses on the isolation of psychrophilic and thermophilic probiotic bacteria capable of producing antimicrobials against a variety of bacterial species. Bacteriocin treated plastic films can be used as an effective packaging

material for the preservation of foods especially seafood products. Current studies focuses on the development of preservative releasing packaging material to ensure the quality and safety of foods.

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