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Application of bacteriocins in food industry: A Review article

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Abstract

The current article describes how bacteriocin is used in the food industry and explains the term in scientific and microbiological terms. It draws attention to the unique properties of bacteriocin, a bio-preservative substance derived from gram-positive bacteria. It also discusses the role that bacteriocin has played in the food sector as a possible pathogen killer and tool for extending product shelf life. Additionally, it describes how bacteriocin works to safeguard food against pathogens as well as practical application techniques. It also includes topics including inadequate physical circumstances, the chemical makeup of food, and its efficacy and regulatory mechanisms, all of which have an impact on the application of bacteriocin. Last but not least, it briefly discusses the main issues that have been widely publicized while employing bacteriocin as bio-preservative mechanisms.

Keywords: bacteria bacteriocin, biopreservative, nisin, pathogen,pediocin

1. Introduction

Nature has given many types of foods to mankind. Everybody expects that the food they eat is wholesome, and safe for consumption. The greatest threat to quality and safety of our food comes from the microbial spoilage (Pal, 2013). The food spoilage is wasteful, and costly; and can adversely affect the economy, and erode the confidence of the consumers. It is well established that food is a valuable source of nutrients for certain microbes such as molds, bacteria and yeasts. As they grow on the food, they may cause problems such as bad taste, unpleasant smell, and poor appearance. More importantly, the growth of microbes may lead to dangerous levels of toxins in the food. This makes the food unfit to be eaten by the people, and hence it leads to food scarcity (Orji, J. O.,et al., 2021).

Preservatives are a type of food additive which are added to food to prolong shelf life, and keep the products from being broken down by microorganisms (Pal, 2014). Most preservatives today are actually fungistatic in their action. That means they prevent the growth of fungi, moulds and yeasts. They have little effect on bacteria but using a combination of preservatives, with antibacterial properties can give good protection. Food preservatives help to control the spread of bacteria which can cause life threatening illnesses such as *salmonellosis* or *botulism*. Preservatives are commonly used in these foods such as low fat spreads, cheeses, butter, mayonnaise and dressing, bakery products, and dried fruit preparations (Pal, 2014).

Among bio-preservatives, bacteriocin has caught the attention of food scientists to be used as a natural food bio-preservative due to its antimicrobial activity against food spoilage, and pathogenic bacteria. Bacteriocins are peptides or complex proteins produced by bacteria, biologically active with antimicrobial action against other bacteria, active against food borne pathogens and food spoilage bacteria, principally closely related species (Nath, S., et al., 2014). It is a bio preservative method in which antagonistic effects of microorganisms and their metabolic products are used to remove undesired microorganism for food preservation and increasing shelf life of the food.

Different bacteriocin producing strains of lactic acid bacteria as well as *Bacillus* spp. have been isolated for food preservation purpose but the keen interest towards bacteriocin of lactic acid bacteria worldwide is due to their essential role in majority of food fermentation, flavor development and preservation of food products along with proving safer for health. Therefore, this paper reviews about the nature of bacteriocins and its application in food industry (dairy food industry, meat and meat product, fish),factors affecting its production and effectiveness, mode of application, methods of application and its role in hurdle technology in detail.

2. Nature of bacteriocins

These proteins are produced by most lineages of bacteria which are playing key roles in recognition and possess a cognate immunity system for self-protection as well as host protection from infections.Most bacteriocin producing microorganism is obtained from different sources depending on the nature of that microorganisms and adaptability to environment. This adaptability caused the superiority of one microbe over the other on the product they give. Based on these, it is basically divided into archaea, gram negative bacteria and gram positive bacteria.

The Archaea synthesize their own distinct family of bacteriocin-like antimicrobial peptides named as archaeocins during stationary phase (Najjari, A., et al., (2021). The producer strain lyses the target cells by secretion of archaeocins and reduces the competition in the local environment. However, bacteriocins are initially isolated from Gram-negative bacteria. A colicin from *E. coli*, identified as an antimicrobial protein was the first described for the bacteriocin family and dominated many of the related studies up to the recent past (Preciado, G. M., et al., 2016). Bacteriocin producer strains are not only restricted by *E. coli* but also the fact that many species of Gram-negative bacteria have production ability for colicin-like proteins. Klebicins of *Klebsiella pneumonia*, marcescins of *Serratiamarcescens*, alveicins of *Hafniaalvei*, cloacins of *Enterobacter cloacae* and pyocins of *Pseudomonads* are important representative examples for bacteriocins of other Gram-negative bacteria.

Most bacteriocins of this group are relatively large and consequently heat-labile peptides. An exception, microcins such as microcin V of *E. coli* breaks this rule. It characteristically contains only a few peptides and shows heat-stable property. The narrow antimicrobial activity spectrum is the main disadvantage for the bacteriocins of Gram-negative bacteria that limits their industrial-scale uses. This property calls attentions towards to the more suitable types of bacteriocins produced by Gram-positive bacteria (Cleveland, J., et al 2001).

Gram-positive bacteria also produce a wide variety of bacteriocins. Their non-toxic property on eukaryotic cells and much broader inhibitory spectra make Gram-positive bacteriocins a unique useful tool for many industrial and medicinal applications. In this respect, lactic acid bacteria (LAB), a group of phylogenetically diverse Gram-positive bacteria characterized by some common morphological, metabolic and physiological properties, have attracted much interest due to their GRAS (generally regarded as safe) potential for human consumption (Balciunas EM et al 2013). LAB is characterized by production of lactic acid in their fermentation pathway, thereby earning the name “lactic acid bacteria”. In this process, a member of LAB converts at least 50% of the carbon from sugars into two isomers of lactic acid. This group of bacteria shows a great variety depending on many physiological and morphological properties. Members of LAB can be cocci, bacilli or coccobacilli shaped Gram-positive bacterial strains with various physiological characteristics. Due to their safe nature and valuable metabolic products (such as organic acids, diacetyl, acetoin, hydrogen peroxide, reuterin, reutericyclin, antifungal peptides, and bacteriocins), these have a great importance in medicinal and food applications.Bacteriocins can mainly isolated from dairy, vegetables and meat products and a few obtained from fish products.

3. Application of Bacteriocin In food industry

One of the most concerned issues in food industry is food pathogen which causes spoilage of food and finally illness due to food borne disease (Newell et al., 2010). The use potential of bacteriocins in various technological applications is fundamentally depending on their antimicrobial effects. In this regard, the rapid rise and spread of multi-resistant bacteria pathogens state expressly the importance of the research studies purposing to find alternative methods combating of infections. Bacteriocins with broad-scale antimicrobial activity can be thought as promising natural antimicrobials for many industrial applications in this manner (Gulluce, M., et al., 2013).

Although technology is on developing stage day to day, food preserving from microbial contamination is at infant stage and resulted in huge economic losses and undesirable human healthy. However, latter investigation shows that bacteriocins are a biological protective method of pathogen from food spoilage and mostly used in food industry (LahiriD., et al., 2022).These bacteriocins are produced by lactic acid bacteria and have a great potential to meet this request in the food industries. In food preservation, the bacteriocin produced by lactic acid bacteria is generally recognized as safe substances, inactive and none toxic on eukaryotic cells. They become inactivated by digestive proteases, little influence on gut micro biota, heat and pH tolerant, relatively broad antimicrobial spectrum against many food-born pathogenic and spoilage bacteria (Galvez, A., et al., 2014).They also shows bactericidal mode of action which is usually acts on the bacterial cytoplasm membrane and no cross resistance with antibiotics and have the capacity to genetic manipulation. Preservation action of lactic acid bacteria is due to production of lactic acid, acetic acid, hydrogen peroxide as well as bacteriocin resulting from metabolic activity of organism (Reis, J. A., et al., (2012).The use of bacteriocins with these properties in the food industry can increase the shelf life of foods, offer additional protection during temperature abuse conditions, reduce the risk of food-borne pathogens spreading through the food chain, reduce the use of chemical preservatives, and ameliorate economic losses caused by food spoilage (Singh, T. P., et al., 2021), permit the application of less severe heat treatments without compromising food safety: better preservation of food nutrients and vitamins, as well as organoleptic properties of foods, permit the marketing of novel types of foods (Galvez A., 2007).

Bacteriocins have different function in food industry. Those are in dairy foods, meat and poultry products, fish and sea foods, vegetables and drinks and have been dominating food safety and preservation (Verma, D.K., et al., 2022; Galvez A et al., 2008). Nisin and pedocin is commercially available bacteriocin preparation for food applications and their uses drastically increasing from time to time (Biscola V., 2013). According to many scientists, Nisin which is commercially named as Nisapline is the most prominent Class I bacteriocin, internationally accepted as biopreservative in certain industrial application.

4. Bacteiocin in meat and poultry product application

Microbial contamination causes serious safety and quality problems in meat industry. Meat and meat products, particularly fresh meat, contain adequate amount of water and abundance of proteins and essential nutrients with favorable pH for supporting microbial growth (Woraprayote, W.,et al., 2016). The microorganisms present on meat and its products are in broad spectrum, ranging from bacteria to yeasts, molds and viruses, depending on type of the products. The main bacteria that cause meat spoilage are:- *Pseudomonas*, *Acinetobacter*, *Brochothrixthermosphacta*, *Moraxella*, *Enterobacter*, *Lactobacillus*, *Leuconostoc*, and *Proteus* (Odeyemi, O. A., et al., 2020). Upon a substantial growth of those spoilage organisms, proteins and lipids of meat and meat products undergo degradation, adversely changing appearance, texture and flavor of the products as suggested by Jayasena and Jo (2013).

In addition to microbial spoilage, meat and its products are also prone to contamination by pathogenic microorganisms. Nine major pathogenic bacteria associated with meat and meat products include *Salmonella spp.*, *thermophilic Campylobacter jejuni*, *enterohemorrhagic Escherichia coli O157:H7*, *Clostridium perfringens*, anaerobic *Clostridium botulinum*, *Listeriamonocytogenes*, *Staphylococcus aureus*, *Bacillus cereus*, and *Yesinia enterocolitica*, causing illness or even death in humans (Hui, 2012; Bhunia, A. K. (2018). In order to protect those microorganisms, physical, chemical and biological treatments are important during meat processing. However, both physical and chemical treatments are harmful to human healthy and decrease the quality of food. Consequently, biological treatment is the best food preservative mechanism and increase shelf life of the meat(Qu, P., et al., 2022)

The LAB bacteriocins exhibit qualities that make them acceptable for use as food preservatives when preparing meat. The only commercial bacteriocin among hundreds of others permitted for use in meat, poultry, ready-to-eat meat products and banger casing is nisin (Calo-Mata, P., et al., 2008). Despite no official approved use, pediocin has been widely studied and applied in meat and meat products (Barcenilla, C., et al., 2022). In meat applications, nisin andpediocin PA-1/AcH are usually used to decontaminate or to control the growth of *L. monocytogenes*, one of themost pathogen of concern, especially in RTE meat products. Although anti-Listeria efficiency of nisin and pediocin significantly differed depending on the producing or indicator strains, the sample preparation method, and the bacteriocin assay conditions, pediocin is likely to have higher activity and acts more specifically against L. monocytogenes than nisin(Barbosa, A. A. T., et al., 2017).Additionally, unlike nisins A and Z, pediocin PA-1/AcH has the capacity to suppress Listeria without affecting other bacteria, including helpful ones. Therefore, pediocin PA-1/AcH is a strong contender for the treatment of L. monocytogenes in meat and meat products (Woraprayote, W., et al., 2016).

5. Roles of Bacteriocin in Milk and Dairy Products

Bacteriocins can be applied to dairy foods on a purified/crude form or as a bacteriocin-producing LAB as a part of fermentation process or as adjuvant culture (Silva, C. C.,et al., 2018). A number of applications of bacteriocins and bacteriocin-producing LAB have been reported to successful control pathogens in milk, yogurt, and cheeses. It reduces microbial growth in raw milk. It also inactivates mesophilic bacteria in milk in combination with PEF or with HHP (Amenu, D. (2013).

In fermented milk products it is used in inhibition of gas formation by *C.tyrobutricum* on semihard and hard cheeses. It also inhibits pathogenic and toxicogenic bacteria *(L.monocytogenes, B.cereas, S.aurus*) in cheeses and on the surfaces of cheeses. Over acidification of yoghurt and other fermented products produced by mesophilic bacteria and endospore former could be inactivated by combination of bacteriocin with HHP (Arqués, J. L., et al., (2005). Uses of bacteriocin producer strain as starter culture is used to inhibit adventitious nonstarter lactic acid microflora in cheese. It also used in inhibition of post process contamination by *C.botulimum*. To date, few studies have investigated the effectiveness of incorporating bacteriocins and/or bacteriocin-producing LAB in coatings and films applied to dairy products inhibit the growth of pathogenic microorganisms in foods packed. However, the effectiveness of incorporating purified bacteriocins in edible coatings show a limited reduction of pathogens such as *L. monocytogenes*. Specially, cheeses, particularly fresh cheeses, are highly perishable due to their high content in caseins, lipids, and water. The complexity of cheese composition and its manufacture support the development of pathogenic and deteriorating microorganisms that increase the risk of food borne illness and reduce cheese quality and acceptability (Ramos et al., 2012).

By acting as additional hurdle, the application of edible coatings and films with incorporation of bacteriocins may overcome problems associated with post-process contamination, therefore enhancing the safety and extending the shelf-life of the cheese. According to the findings of Cao-Hoang et al. (2010), they incorporated nisin in films of sodium caseinate applied in semi-soft cheese and observed a small reduction in *L. innocua*counts (1.1 log cfu g) after a week of storage at 4°C. Similar findings also reported that the application of a coating in Port Salut cheese, consisting of tapioca starch combined with nisin and natamycin, reduced *L. innocua*counts above 10 cfu ml during storage, acting as a barrier to post-process contamination (Resa et al., 2014). Lately, Marques et al. (2017) used a biodegradable film incorporated with cell-free supernatant (CFS) containing bacteriocin-like substances of *Lactobacillus curvatus*P99, to control the growth of *L. monocytogenes*in sliced “Prato” cheese. These films containing the bactericidal concentration of CFS were able to control *L. monocytogenes*for 10 days of storage at 4°C.

6. Application of bacterioicn in fish industry

There are various traditional and advanced ways of eradicating bacterial fish diseases; hence, the need of the control search for novel antibacterial compound preferable proteins with therapeutic potential for which the pathogens may not have resistance is important. Aquatic animals have been successfully tested with probiotics and bacteriocins, antimicrobial peptides produced by some species of lactic acid bacteria (LAB), as alternatives to control bacterial illnesses (Pereira, W. A., et al., 2022). Bacteriocins do not act equally against target species, but researchers have examined that affinity of bacteriocins to specific species and strains. Numerous characteristics of bacteriocins make them desirable as antibiotic substitutes. They are a secure substitute for conventional antimicrobials because they have been proved to be non-toxic to eukaryotic cells and are GRAS (Galvez et al., 2008). It has also been demonstrated that pure bacteriocins are stable up to a salt concentration of 10% and do not affect the sensory attributes of seafood. Additionally, bacteriocins' comparatively limited killing range when compared to typical antibiotics minimizes the pressure on bacteria to develop resistance to these antimicrobials, which in turn lowers the prevalence of pathogens that are resistant to medication (Bakkal, S., et al., 2012). Generally, the phospholipid composition of the target strains and environmental pH influences the minimal inhibitory concentration (MIC) values.

7. Methods of application and mode of action

The application of bacteriocins for biopreservation of foods usually includes the following approaches: inoculation of food with the bacteriocin-producer strain; addition of purified or semi-purified bacteriocin as food additive; and use of a product previously fermented with a bacteriocin-producing strain as an ingredient in food processing

Bacteriocins have distinct mechanisms of action and can be divided into those that promote a bactericidal effect, with or without cell lysis, or bacteriostatic, inhibiting cell growth (Da Silva Sabo et al., 2014). Most of the bacteriocins produced from LAB, in particular those inhibiting Gram-positive bacteria; exert their antibacterial effect by targeting the cell envelope-associated mechanisms (Cotter et al., 2013). Several antibiotics and some class II bacteriocins target Lipid II, an intermediate in the peptidoglycan biosynthesis machinery within the bacterial cell envelope and, by this way they inhibit peptidoglycan synthesis.Other bacteriocins use Lipid II as a docking molecule to facilitate pore formation resulting in variation of the cytoplasm membrane potential and ultimately, cell death. Nisin, the most studied lantibiotic, is capable of both mechanisms (Perez-Ramos, A.,et al., 2021; Cotter et al., 2013). Some bacteriocins damage or kill target cells by binding to the cell envelope-associated mannose phosphotransferase system (Man-PTS) and subsequent formation of pores in the cell membrane (Eissa, S. A., et al., 2018; Cotter et al., 2013). Other bacteriocins can kill their target cells by inhibition of gene expression (Vincent and Morero, 2009) and protein production.

8. Factor affecting the bacteriocins production and its effectiveness

Bacteria spontaneously loss the ability to produce the bacteriocin, the producer strain can be infected by bacteriophages, or the indigenous biota can inhibit the bacteria. The effectiveness of bacteriocins in food depends on many factors; the interaction with the food matrix and or with the target bacteria and the action of the microbiota presents in the food (Galvez A, et al., 2007). As an example, addition of divalent cations such as Ca2+, or Mg2+ led to a reduction of nisinactivity since they were bounded to anionic phospholipids making the cytoplasmic membrane more rigid and thus reducing the affinity of the bacteriocin towards the cytoplasmic membrane (Kumar, M., &Srivastava, S. (2011). Regarding the action of the microbiota present, the presence of competing microorganisms can be an environmental factor stimulating bacteriocin production such as divercin. In other cases, microbiota can compete for nutrients with the bacteriocin producing strain inhibiting its growth and therefore bacteriocin production (Galvez A.et.al. 2007).

Moreover, there are also numerous factors which affect the production of bacteriocin in food industry (Cleveland. J., et al 2001). Those are: inadequate physical conditions and chemical composition of food (pH, temperature, nutrients, etc.), spontaneous loss in production capacity, inactivation by phage of the producing strain, and antagonism effect of other microorganisms in foods (Hamad, S. H. (2012). Similarly the effectiveness is also adversely inhibited by: resistance development of pathogens to the bacteriocin, inadequate environmental conditions for the biological activity, higher retention of the bacteriocin molecules by food system components (e.g. fat), inactivation by other additives (Ananou, S.,et al., 2007) ; slower diffusion and solubility and/or irregular distribution of bacteriocin molecules in the meat matrix. In contrary several factors, such as the presence of salts, other food ingredients, poor solubility and the uneven distribution of the bacteriocin, have all shown to affect the efficacy of bacteriocins in food.The composition of the food and the interaction with other preservation factors affect bacteriocin production and its antimicrobial activity (Campos, C. A., et al., 2013).

Bacteriocins are added into food processing applications as *ex situ* produced preparations, or by inoculation with the bacteriocinogenic strains (Galvez, A., et al., 2008). Then these antimicrobial agents can be ready to show their specific activity in the food matrix. However, the matrix, the processing steps and the natural microbiota have a fairly complex and non-stable nature in many cases. Thus the bacteriocins have to pass all limiting factors to exert their activity. Galvez A., et al. 2007, reviewed the limiting factors of bacteriocins for food applications and presented as below.

Groups	Limiting factors
Food related factors	Food processing conditions
	Food storage tempreture
	Food pH, and bacteriocinunstablity to pH changes
	Inactivation by food enzyme
	Interaction with food additives/ingridients
	Bacteriocin adsorption to food component
	Low solubility and uneven distribution in food matrix
	Limited stability of bacteriocin during shelf life of food
Food microbiota	Microbial load
	Microbial diversity
	Bacteriocin sensitivity
	Microbial interaction in the food system
The target bacteria	Microbial load
	Bacteriocin sensitivity (Gram-type, genus,species, strains)
	Physiological stage (growing, resting, starving or viable but non-culturable cells, stressed or sub-lethally injured cells, endospores, etc.)
	Protection by physiochemical barriers(microcolonies,biofilms,slime)
	Development of resistance/adaptation

Sources: - Galvez A., et al. 2007

9. Regulation mechanism biosynthesis of bacteriocins

Competition among the members of microflora in an environment with limited substrates or nutrients plays a key role in the regulation of bacteriocin production.the induction factors (IF or pheromone), bacteriocin-like peptides with 19-26 amino acid residues length, low molecular weight and cationic nature, have a great importance in the regulation mechanism (Johnson, E. M., et al., 2018). Different researcher stated that the role of induction factors and proposed two models to explain bacteriocin induction. The first one was the quorum sensing model, which refers that the IF is constitutively produced and accumulated in low concentrations during bacterial growth. Then, induction of the bacteriocin genes occurs when IF concentration reaches the threshold for IF auto induction level. Therefore, this model relies on a control mechanism depending on the cell density of the cultures Microbial pathogens and strategies for combating them: science, technology and education (Mesquita, C. S.,et al., 2013). According to the second model, an alternative for the quorum sensing model, the IF concentration never reaches the threshold by itself and requires unidentified environmental signals or modification in environmental conditions such as changes in nutrient levels or physicochemical growth conditions. Besides, more recent studies pointed out that the regulating system is composed of three components in many cases: an inducing peptide (or pheromone-activating factor), the transmembranehistidine kinase (pheromone receptor) and a response regulator (Gulluce, M., et al., 2013). Apart from these, it is also known that regulation of the production of lantibiotics such as nisin and plantaricin is directly controlled by the bacteriocin itself, which acts as a pheromone inducing their production at high levels(Jonson. E,M., et al., 2018). In the mode of action, all types of bacteriocins show their effects on the target cell surface via various mechanisms as mentioned in the classification section. This generally results in deficiencies in the cell wall synthesis, changes in the membrane permeability and/or formation of pores causing the death of the target cells. As an example, lantibiotics inhibit target cells by forming pores in the membrane, depleting the transmembrane potential ($\Delta\psi$) and/or the pH gradient, resulting in the leakage of cellular materials. In this phenomenon, a positively charged bacteriocin molecule with hydrophobic patches binds to negatively charged phosphate groups on target cell membranes via electrostatic interactions. Thus, hydrophobic portion of the bacteriocin inserts into the membrane, causes pore formation and consequently cell death.

10. Hurdle technology

Bacteriocins have a great potential for filling the gaps in food industry applications as natural antimicrobial agents. Besides their conventional use methods, recent research efforts have routed the attentions toward development of different antimicrobial combinations to get more effective responses. Basically, this process is a combination of multiple antimicrobial factors called as “hurdle technology” (Khan, I., et al., 2017). To date, more than 60 potential hurdles have been described and the application of bacteriocins as part of this technology has received great attention in recent years (Malik, R. K., &Kaur, G. (2011); Woraprayote, W., et al., 2016). In a hurdle technology application, a bacteriocin may combine with another bacteriocin, other types of natural antimicrobials, chemicals or physical treatments (Castellano, P., et al., 2017; Biscola V *et al* 2013). The most researched hurdle technology uses for bacteriocins in this context include combining them with chemical compounds (sodium chloride; organic acids and their salts, such as acetic acid, sodium lactate, and sodium citrate; chelating agents, such as disodium pyrophosphate, trisodium phosphate, and hexametaphosphate; ethanol); and natural antimicrobials (essential oils, their active ingredients, and phenolic compounds, such asand phenolic compounds such as carvacrol, eugenol, thymol, terpineol, caffeic acid, *p*-coumaric acid; bacteriocins; non-bacteriocin antimicrobial proteins or peptides (BenBraiek, O., &Smaoui, S. (2021) and physical treatments (heat treatments, modified atmosphere packaging, pulsed electric fields, high hydrostatic pressure and other non-thermal treatments). Moreover, many recent efforts have given promising results to develop novel hurdles with high efficiency for the near future (Biscola V. *et al*2013).

11. Challenges

Lactic acid bacteria have the ability to create bacteriocins, which give them the power to fight off a variety of common diseases like Salmonella enteritis, Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus thuringiensis, and Escherichia coli (Ahsan, A., et al., 2022).Bacteriocins have been identified by Huang, F., et al. (2021) as prospective clinical antimicrobials or immune-modulating agents to combat the worldwide threat to human health. Bacteriocins have been shown to inhibit a variety of clinically harmful and multidrug-resistant bacteria due to their broad- or narrow-spectrum antibacterial activity, hence reducing infections caused by these bacteria in the human body. The selectivity and safety profile of bacteriocins have been highlighted as superior advantages over traditional antibiotics. However, bacteriocins' use as food additives may be constrained by a number of reasons, such as their low efficacy in eradicating pathogens or their high cost (Silva, C. C., et al., 2018). Purified bacteriocins are only occasionally used in the food sector, despite recent improvements in bacteriocin research for food applications. When it comes to microbial contamination of meat, fish, vegetables, fruits, and dairy products, applying a bacteriocin alone is frequently insufficient (Batiha, G. E. S., et al., 2021). The commercial development of new bacteriocins is further hampered by the high cost of bacteriocin isolation and purification (Silva, C. C., et al., 2018). Additionally, the FDA and EFSA's tight food regulations prevent the approval of new bacteriocins as food preservatives; as a result, only two bacteriocins (nisin and pediocin) are now accessible on the market (Oztekin, S., et al., 2022).

12.Conclusion

The natural means of selective microbial inhibition called bio-preservative is very interesting over Chemical preservative. Because, foods produced using these non-thermal technologies usually have better sensory, and nutritional qualities compared with products produced using conventional thermal processing methods. So, this should better to encourage in future food industry. According to different research findings, different microbes have potential to use as bio preservative; however, few microbes have being considered and need further study for future use.The bacteriocins have a high specificity thereby inhibiting strains closely related to the producer. Consequently, it is thought that these peptides assist the producers to compete within their specific ecological niche, but some bacteriocins seize a broad spectrum of inhibition, such as nisin, which is active against numerous gram-positive targets and better to popularize in the application of food industry. Inactivation of several foodborne pathogens by bacteriocins may differ greatly depending on the food matrix used. Therefore, the effectiveness of different bacteriocins to foodborne pathogens must be tested in all food systems. Finally, Contamination can occur in later stages of food product processing, hence, post packaging into consideration is important.

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