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A review on the production of bacteriocin by lactic acid bacteria from dairy products.

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ABSTRACT

Antimicrobial peptides or proteins produced by bacteria are known as bacteriocins. Lactic acid bacteria (LAB) are ubiquitous bacteriocin makers that are frequently used in fermented food preparation. These bacteria and the bacteriocins they make can stop germs from spoiling food and causing foodborne illness. Isolating bacteriocin-producing LAB from food is time-consuming and labor-intensive. Lactic acid bacteria (LAB) are a diverse collection of microorganisms that create lactic acid as the primary end product of fermentation. Gram-positive bacteria with significant biotechnology potential in the food business are known as LAB. They can manufacture bacteriocins, which are proteinases antimicrobial compounds with a variety of genetic origins that can assist the producer organism in outcompetingete other bacterial species, whether post-translationally modified or not. The many varieties of bacteriocins found as well as the organization and regulation of the gene clusters responsible for their production and biosynthesis are discussed in this review, as well as the food applications of the prototype bacteriocins from lactic acid Bacteriocin.

KEYWORDS: bacteriocins, Lactic Acid Bacteria, food preservatives, Microbiota

INTRODUCTION

Bacteriocins are secondary metabolites produced by bacteria via their ribosomes. Bacteriocins are bactericidal or bacteriostatic antimicrobial peptides or proteins. Bacteriocins are practically harmless to humans compared to chemical agents because they induce less change in nutritional and organoleptic qualities of foods and have lower toxicity. Bacteriocins, unlike antibiotics, induce less bacterial resistance, implying that target microorganisms have evolved further. Bacteriocins are natural defense weapons created by bacteria to attack other related (narrow spectrum) or unrelated (broad-spectrum) microbiota (Gálvez *et al.*,2007). They are a strategy for preserving the population of bacteriocin-producing bacteria while reducing the number of competitors to gain more resources and a living place. *Lactococcus*, *Streptococcus*, *Pediococcus*, and *Lactobacillus* are important bacteriocin makers and are widely utilized in the creation of fermented foods, indicating that bacteriocins are protected. To identify safer and more effective ways to combat diseases, it is vital to study the antibacterial properties of bacteriocins and isolate bacteriocin-producing bacterias**.**

Bacteriocins are extracellularly produced proteins or peptides that have antibacterial activity against specific microorganisms, usually those that are linked to the bacteria that produce them. Bacteriocins have a lot of promise for use in the food business right now. Their use can reduce the use of synthetic preservatives and/or the severity of heat treatment during food manufacturing, while still satisfying the consumer's desire for safe, fresh, and minimally processed food. It is required to understand the nature of bacteriocins, their production methods, controls, and activities, as well as the influence of external factors on their antimicrobial activity, to fully realize this potential. The stability and activity of added bacteriocins can be influenced by the food's composition, or its properties (pH, temperature, ingredients and additives, types and numbers of epiphytic microbiota), as well as the actual technological procedure employed in production (Riley *et al*., 1998).

Lactic acid bacteria (LAB) play a critical part in the fermentation of foods. They regulate ripening processes by their metabolic activity, resulting in beneficial sensory qualities while limiting the growth of undesirable microbes. LAB have been certified as "safe microbiota" because of their major function during fermentation and a long record of use. The production of non-specific (lactic acid, acetic acid, and other volatile organic acids, hydrogen peroxide, diacetyl, and other metabolites) and specific (bacteriocins) metabolites protects LAB as a naturally present and/or selected and purposely inserted microflora (Dobson *et al*., 2012).

LACTIC ACID BACTERIA AS A "SAFE MICROBIOTA"

Lactic acid bacteria (LAB) have been responsible for the fermentation of a wide range of foods, including fruits and vegetables, for ages. There is now some interest in using LAB as a biocontrol agent to ensure the safety of minimally processed, refrigerated (MPR) foods that are not acidified. LAB applications in meat and dairy products have been extensively researched, but only lately have they been considered for use in MPR fruit and vegetable products. Microflora, including possible pathogens, can be found in MPR fruits and vegetables. Depending on kinetic parameters for growth, formation of inhibitory metabolites, and other aspects, LAB cultures may be used to determine the shelf life and safety of MPR products. Bacteriocins produced by LAB cultures or added separately may help to ensure that these products are safe. Compatibility with the product and the culture's ability to dominate over natural microflora and any infections are factors to consider when choosing a LAB culture. The successful implementation of such biocontrol approaches could result in a larger market for MPR fruit and vegetable good (Breidt *et al*.,1997). Lactic Acid Bacteria (LAB) are ancient organisms that cannot biosynthesize functioning cytochromes and cannot obtain ATP through respiration. They developed electrogenic decarboxylation and ATP-forming determination in addition to sugar fermentation (Pessione *et al.,* 2012). The empirical application of microbes and/or their natural metabolic products dates back to the Neolithic period, 10,000 years BC, in human history (Ross *et al*.,2002, Prajapati *et al*., 2003). The notion of biological preservation, or the reduction of consumer health hazards, is based on the action of particular microbes and their metabolic products against undesired spoilage bacteria or food poisoning bacteria while maintaining the product's quality. Today's global food and beverage sector offer a diverse range of commercial fermented products (over 5,000), many of which rely on microbes for manufacturing and sustainability (Vesković-Moračanin *et al*.,2010).

It is common knowledge that the wine, beer, and alcohol industries would be unable to operate without the use of specific yeasts. Similarly, lactic acid bacteria (LAB) play an important part in the creation of a wide range of goods based on lactic fermentation (milk, meat, and vegetable industries) (Holzapfel *et al*.,1995).

Weak organic acids, diacetyl, acetone, hydrogen peroxide, reuterin, reutericyclin, antifungal peptides, and bacteriocins are among the antimicrobial compounds produced by LAB (Naidu *et al*.,2000, Magnusson *et al*.,2001). the role and method of action of LAB in the majority of final metabolic products were characterized, and it now has its place in natural food protection (Caplice *et al*.,1999), While the significance of LAB bacteriocins is still a hot topic of debate (Vesković *et al*.,2009).

LAB BACTERIOCIN AND THEIR APPLICATION IN FOOD PRODUCTION

Bacteriocins are extracellularly distributed proteins or peptide atoms that have antibacterial effects against specific types of microbes that are generally friendly to the microscopic creatures that deliver them (Tagg *et al.*,1976). Bacteriocins, or LAB bacteriocins, are antimicrobial peptides or proteins having a wide range of potential applications in the food industry as protectors (Cleveland *et al*.,2001), safeguarding people's health while improving food's sustainability (Turcotte *et al*.,2004, Vuyst, *et al.*,1994). Hurst referred to bacteriocins as "natural food additives," and that name has been widely accepted (Hurst *et al.*,1981).

LAB provides a variety of antibacterial compounds that are thought to be useful in the maturation and preservation of food. A few strains produce antibacterial compounds known as bacteriocins in addition to metabolic end products. Bacteriocin producers were discovered in both lactococci and lactobacilli during routine LAB separation from handmade cheeses (Cotter *et al.*,2005).

TABLE 1. FERMENTED FOOD AND BEVERAGES AND THEIR ASSOCIATED LACTIC ACID BACTERIA

Sr.no	Type of fermented product	Bacteria that produce Lactic acid
I	Hard cheeses don't eyes	*Lactococcus lactic ssp. lactic, Lactococcus lactis ssp. cremoris*

II	Swiss and Italian Style cheese	*Lactobacillus delbrueckii ssp. lactis, Lb. helveticus, Lb. casei, Lactobacillus delbrueckii ssp. lactis, Lactobacillus delbrueckii ssp. lactis, Lactobacilli, Streptococcus thermophilus, Lb. delbrueckii ssp. bulgaricus*
III	Buttermilk and butter	*L. lactis ssp. lactic, L. lactis ssp. lactis var. diacetylactis, L. lactis ssp. cremoris, Ln. mesenteroides ssp. cremoris*
IV	Yogurt	*Lb. delbrueckii ssp. bulgaricus, S. thermophilus;*
V	Probiotic fermented milk	*Lactobacillus casei, Lactobacillus acidophilus, Lactobacillus rhamnosus*
VI	Sausages fermented (USA)	*P. pentosaceus* is a species of pentosaceous plant
VII	Vegetables fermented	*P. acidilactici, P. pentosaceus, Lb. plantarum*
VIII	Fermented olives	*Ln. mesenteroides, Lb. pentosus*
IX	Wine	*Oenococcus oeni* (malolactic fermentation)
X	Rice wine	*Lb. sakei*

L. = Lactococcus, Lb. = *Lactobacillus*, Ln. = *Leuconostoc*, S. = *Streptococcus*,

B. = *Bifidobacterium*, P. = *PediococcuS*

DIFFERENCE BETWEEN BACTERIOCINS AND ANTIBIOTICS

These bacteriocins are ribosome-combined polypeptides with bactericidal action that are swiftly digested by human intestine proteinases. (Vesković *et al*.,2014). Because of their reported antibacterial effects, they are usually compared to anti-microbials. Because of their reported antibacterial effects, they are usually compared to antimicrobials (Hansen *et al*.,1993, Hurst *et al*.,1981). However, unlike therapeutic antimicrobials, their use, when in question, does not rule out the possibility of unwanted adversely sensitive reactions in persons. In the same way that Alexander Fleming's discovery of penicillin in 1929 had immediate implications for humanity, the discovery of bacteriocins has far-reaching implications for convention medical services and sanitation. Anti-infection agents and "natural anti-microbial substances"-bacteriocin are discussed from a similar standpoint of union, movement, antimicrobial rangeoisonousness, and opposition (Cleveland *et al*.,2001).

TABLE 2. BACTERIOCIN AND ANTIBIOTICS- SIMILARITIES AND DIFFERENCES

Characteristics	Bacteriocins	Antibiotics
Application	Food	Clinical
Synthesis	Ribosomal	Secondary metabolite
Activity	The narrow scope of activity	The spectrum is diverse
Immunity Of the host cell	Yes	No
Resistance or tolerance mechanisms in target cells	Adaptation is usually the case. influencing the cell membrane composition	A genetically transferable trcan can be passed down from generation to generation. a factor that has an impact on a variety of things sites that are dependent on the method of action
Interaction requirements	Sometimes docking Molecules might be difficult at the time	Specific goal
Mode of action	Pore formation is the most common, but cell wall biosynthesis is also possible in a few cases	Cell membrane or intracellular targets
Toxicity effects	None known	Yes

CLASSIFICATION OF BACTERIOCINS

Many Gram-positive and Gram-negative bacteria produce bacteriocins, but those produced by the LAB are the most interesting for the food business. Furthermore, the majority of bacteriocin-producing LAB are natural isolates, making them appropriate for usage in the food industry (Obradović *et al*.,2007). LAB produces a variety of bacteriocins that can be classified into one of the Klaenhammer classes proposed in 1993. The majority of LAB bacteriocins used in food preservation methods nowadays are classified as Ia, II, or IV (Helander *et al*.,1999).

TABLE 3. CLASSIFICATION OF BACTERIOCINS

Class	General characteristics	Bacteriocins from LAB
I - Antibiotics *Ia - Linear* antibiotic *Ib - Globular* *Ic - Multi-component*	***Heat-stable, <15 kDa Cationic***, pore-forming There are no cationic enzyme inhibitors	Nisin, Lacticin 481, and Plantaricin C., Plantaricin W, Lct314
II – Unmodified peptides *IIa - Pediocin-like* *I - Miscellaneous* *Ic - Multi-component*	***Heat stable, <15 kDa*** Tail-to-head peptide bond	Enterocin A, Sakacin A, Pediocin PA1/ACH Carnobacteriocin A, Enterocin B, L50 Plantaricin S, Lactococcin G, Lactacin F
III - Large proteins *IIIa - Bacteriolytic IIIb - Non-lytic*	***Heat labile, >30 kDa Degradation*** of cell walls, cytosolic targets.	Enterolysin A, Lcn972 Colicin E2-E9
IV – Circular peptides	**Heat stable,** Tail-to-head peptide bonds	AS-48, Gassericin A, Acidoticn B

ENVIRONMENTAL FACTORS AND BACTERIOCIN EFFICIENCY IN FOOD SYSTEM

Food is a complex ecosystem whose microbiological profile is influenced by factors such as the type of food, the type of warm treatment used during handling, the style of handling, storage conditions, and so on. Because there can be significant differences in the microbial population depending on whether the food is industrially clean, raw, or fermented (Kozacinski *et al*.,2008).

In other words, the properties of the food system, such as its structure, buffer capacity, composition (nutrients, additives, antibiotics), processing conditions (freezing, cooling, high pressure, and temperature exposure, homogenization, etc.), pH, and others, indirectly damage the producing cell or result in reduced bacteriocin synthesis. The action of the added bacteriocins is directly influenced by the quantity and kind of microorganisms or potential pollutants present in the meal. Simultaneously, more bacteriocins are required to inactivate more microbe cells and vice versa. Microbiological interactions can also have a significant impact on the microbiological balance and/or the proliferation of beneficial and harmful bacterial strains (Galvez *et al*.,2007).

Food-borne bacteriocin efficacy: limiting factors

I. Factorstor related to food: Food processing conditions; food storage temperature; food pH; bacteriocin pH stability; Food enzyme inactivation; food additive/ingredient interactions; bacteriocin adsorption to food components; low solubility and uneven dispersion in the food matrix; bacteriocin stability during the shelf life of the food microbiome, part two: Microbial diversity, bacteriocin sensitivity, and microbial interactions in the food chain are all factors to consider.

II. Bacteria should be targeted: Bacteriocin sensitivity (Gram-type, genus, species, strains); microbial load Physiological stage (developing, resting, starving, or living but non-cultivable cells, stressed or sub-lethally wounded cells, endospores, etc.) Physico-chemical barriers (microcolonies, biofilms, slime) provide protection. Resistance/adaptation development (H.C *et al*., 2003).

CONCLUSIONS

For the benefits of bacteriocins have been utilized in human progress. However, Nisin is the only bacteriocin that has been traced down in today's food industry as a food preservative and that has authority, and legal approval in countries all over the world. After learning that there are additional productive bacteriocins besides Nisin that can be used efficiently in a variety of food sources, one could wonder why their use in the modern food industry, beginning now, is absent. The primary motivations for this could include issues with various government regulatory organizations, as well as financial difficulties in the fields of development, detailing, and the state of new bacteriocin commercial preparations on the global food market. Overall, those difficulties are mostly to the application of bacteriocins available on the market, despite the scientific proofs of justifiability and benefits of their use being readily available., The demonstrated efficacy of bacteriocins, as well as the cost-effective and not overwhelming way of fusing them into food, makes them an exceptional option when combined with other common additives. If the aforementioned difficulties are ignored, we are left with a plethora of large-scale applications for their use in the food sector. However, it would be naive to believe that bacteriocins are the only and final solution to the existing food-handling problems.

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