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Short Communication

Bacteriocin-Producing Starter and Non-Starter Lactic Acid Bacteria in Food Industry

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Abstract

The antimicrobial activity of industrially important lactic acid bacteria as starter cultures and probiotic bacteria is the main subject of this review. This activity has been attributed to the production of metabolites such as organic acids (lactic and acetic acid), hydrogen peroxide, ethanol, diacetyl, acetaldehyde, acetoine, carbon dioxide, reuterin, reutericyclin and bacteriocins. The potential of using bacteriocins of lactic acid bacteria, primarily used as biopreservatives, represents a perspective, alternative antimicrobial strategy for continuously increasing problem with antibiotic resistance. Another strategy in resolving this problem is an application of probiotics for different gastrointestinal and urogenital infection therapies.

Key words: antimicrobial activity, bacteriocins, lactic acid bacteria, probiotics, starter cultures

Introduction

Lactic acid bacteria (LAB) are Gram-positive, non-spore forming, catalase-negative bacteria that are devoid of cytochromes and are of nonaerobic habit but are aero-tolerant, fastidious, acid tolerant and strictly fermentative; lactic acid is the major end-product of sugar fermentation (Axelsson). They are the most widely used bacteria as starter cultures for the industrial processing of fermented dairy, meat, vegetable and cereal products. Despite the starter culture addition, non-starter lactic acid bacteria (NSLAB), originating from the raw material and environment, grow out during fermentation and may reach higher numbers than the starters. Reduction of pH and conversion of sugars to organic acids are the primary preserving actions that these bacteria provide to fermented food. However, many kinds of food are still fermented naturally, without the use of starter cultures, by autochthonous lactic acid bacteria, which form the characteristic properties of the products. These natural isolates of lactic acid bacteria from spontaneous fermentations could be used as specific starter cultures or as adjunct strains, after phenotypic and genotypic characterization and they represent a possible source of potentially new antimicrobial metabolites (Topisirovic et al.,2006). In addition, the application of lactic acid bacteria and their antimicrobial metabolites in the prevention of food spoilage and the extension of the shelf life of food that is ready to eat, fresh-tasting, nutrient and vitamin rich minimally processed and biopreserved are the major challenges for the current food industry .The use of bacteriocin-producing lactic acid bacteria as protective strains or bacteriocins in form of purified or concentrated compounds as biopreservatives to control undesirable bacteria remains a primary focus of researches related to food safety and quality (Havelaar, et al., 2009).

Besides the well-known biopreservative effects of antimicrobial metabolites of lactic acid bacteria such as lactic acid, acetic acid, hydrogen peroxide and diacetyl, bacteriocins have the most immediate potential in food application as biopreservatives and they can be readily introduced into food without any concentration or purification (Cotter, 2005). Since lactic acid bacteria are generally regarded as safe (GRAS) according to the FDA, they could be used in food production and food biopreservation.

Bacteriocin-producing starter cultures

The main antimicrobial effect of starter LAB, responsible for biopreservation, is the rate of acidification, but in slightly acidified products or to eliminate undesirable microorganisms that display acid tolerance, such as *Listeria monocytogenes*, the bacteriocinogenic activity could play a crucial role. The use of bacteriocin-producing starter cultures may not only contribute to food safety, but also prevent the growth of undesirable autochthonous lactic acid bacteria that produce off-flavour. This property may improve the competitiveness of the starter cultures and lead to a more controlled and standardized fermentation process as it has been shown in sourdough, fermented sausage, fermented vegetables and olives, and cheese production (Leroy et al., 2006).

Bacteriocin-producing adjunct cultures

Bacteriocin producers can be delivered to a food product as an adjunct culture, together with the starter culture. In this case, the ability of starter adjunct to grow and produce bacteriocin in the product is crucial for its successful use. The bacteriocin-producing adjunct cultures are mostly isolated from raw milk, vegetables, cereals and other natural sources of lactic acid bacteria that are believed to contain strains essential not only for the characteristic flavour of traditional fermented products, but also with promising and useful properties such as bacteriocinogenic activity, which will make them applicable as starters. For example, *Lactococcus lactis* strain, which produces both nisin and lacticin 481, isolated from raw ewe's milk, might be used as adjunct culture to the commercial starter in the manufacture of dairy products to inhibit or destroy undesired microorganisms (Bravo et al.,2009). Adjunct culture does not need to contribute to the flavour but it is important that the starter culture is resistant to bacteriocin produced by the adjunct culture. One of the exceptions is the controlled lysis of starter culture during cheese manufacture caused by bacteriocin-producing strain, with the aim to release intracellular enzymes, needed for accelerated ripening and improvement of product flavour (Leroy et al., 2006).

Bacteriocin-producing protective cultures

Bacteriocinogenic protective cultures alone can be used to inhibit spoilage and pathogenic bacteria during the shelf life of non-fermented foods by producing bacteriocin *in situ* or previously cultured in growth medium and after that applied as an ingredient in food processing. Two preparations are already present on the market: ALTATM 2341, containing pediocin PA1 produced by *Pediococcus acidilactici*, and MicrogardTM, a commercially available fermented milk product containing antimicrobial metabolites. In the literature different milk-based preparations such as lacticin 3147 are described (Guinane et al.,2005). The addition of purified or semi-purified bacteriocins as food preservatives requires approval from legislative point of view. There is also a problem of costly production because of low production rates, instability and expensive downstream processing of bacteriocins.

If immobilized or microencapsulated bacteriocin or bacteriocinogenic strain is applied on the food surface, much lower concentration is needed compared to the application in the whole food volume .Other advantages of immobilized bacteriocins are the possibility of gradient-dependent, continuous supply of bacteriocin and the protection against food components and enzymatic inactivation. The use of antimicrobial films containing immobilized bacteriocins for the development of antimicrobial packaging is a recently developed technique (La et al ., 2008).

Use of bacteriocins in combination with other antimicrobial factors

The antimicrobial spectra and activity of bacteriocins can be extended through the synergy between different antimicrobial factors such as inorganic salts (especially sodium chloride), organic acids and their salts, chelating agents (such as EDTA), essential oils and their active components, phenolic compounds, as well as other natural antimicrobials. Application of bacteriocins together with different physicochemical treatments, like heat treatment, modified atmosphere packaging, high hydrostatic pressure, pulsed electric field, pulsed magnetic field and gamma irradiation, has received great attention in recent years (Ross et al ., 2003). The effectiveness of bacteriocins in combination with hurdle technology will depend on the type of food and its natural microflora. Thus with acidification of the food acidotolerant bacteria may be selected, while heat treatment may favour bacterial endospores, but in combination with bacteriocins higher sensitization may be achieved after optimization of doses and conditions. Furthermore, the Gram-negative bacteria could become sensitive to bacteriocin activity upon exposure to hurdles such as chelating agents that destabilize the bacterial outer membrane (Omar et al ., 2003).

Application of nisin, the most famous bacteriocin, in food industry

So far, nisin is the only bacteriocin licensed as food preservative (E234). Commercial production of nisin by *Lactococcus lactis* ssp. *lactis* began in England in 1953, and international acceptance of nisin was given in 1969 by the Joint Food and Agriculture Organisation/World Health Organization (FAO/WHO) .In 1988, it was approved by the US Food and Drug Administration (US FDA) for use in pasteurized, processed cheese spreads and since then, as a food additive in over 50 countries. Nowadays, the most established available form of nisin for use as a food preservative is NisaplinTM. Applications of nisin have been developed for processed cheese, dairy desserts, milk, fermented beverages, bacon, frankfurtersombination with hurdle technologies to achieve better inhibitory effect.

Its use extends shelf life of the food by inhibition of Gram-positive spoilage bacteria such as *Listeria*, *Staphylococcus* and *Mycobacterium*, and spore-forming bacteria *Bacillus* and *Clostridium.* The spores of these bacteria are more sensitive to nisin than their vegetative cells, so nisin is often applied in heat-processed food such as canned vegetables. The spectrum of its activity can be successfully broadened when it is applied in combination with chelating agent such as EDTA .Very few variants of six naturally occurring nisin molecules are described with enhanced activity against Gram-positive pathogens.

Conclusion

The potential of using bacteriocins of lactic acid bacteria, primarily used as biopreservatives, represents a perspective, alternative antimicrobial strategy against the continuously increasing problem of antibiotic resistance. Another strategy in resolving this problem is an application of probiotics in prophylaxis and therapy of different gastrointestinal and urogenital infections. Characterization of lactic acid bacteria and their beneficial mechanisms allows progress in their use in the food industry and their potential in promoting human and animal health and nutrition.

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