Bioprotection

Food preservation has been a key concern since the earliest days of humanity. Among the numerous empirical processes that have been developed and passed down, fermentation is one of the oldest preservation techniques and still widely used in various food matrices. Fermentation produces beneficial effects in foods that undergo chemical changes caused by microorganisms such as bacteria or yeasts[2]. Bioprotection is a natural way to protect against spoilage and harmful contamination in food. This helps keeping food products fresh and safe throughout shelf life, opening for the possibility of reducing food waste[9].

The food industry is presently looking for means of producing safe food products with an extended shelf life thus reducing food waste and meeting the consumer demands for natural, low salt, low sugar foods and reduced use of chemical preservatives. Fermented food products have a longer shelf life and are less prone to spoilage than non-fermented food products of the same matrix. There have been advances in the understanding of food microbiology and ability to screen for microbial food cultures with better ability to stabilize food provide microbial food cultures with bioprotective effect[4].

Microbial food preservation to keep food fresh and safe: bioprotection

The microbial stability and safety as well as the sensory and nutritive quality of foods are achieved by applying a combination of several different preservative factors called hurdles. The most important hurdles for keeping food fresh and safe are temperature (high or low), water activity (a_w), acidity (pH), redox potential, preservatives (food additives), competitive microorganisms (bacteria, moulds and yeasts) and their metabolites. The competitive microorganisms with enhanced protective effect can be indigenous or be added as specifically selected food cultures[5].

Bioprotection refers to enhanced food safety and extended shelf life of foods by indigenous and/or intentionally added microflora, with their microbiological competition and production of antimicrobial metabolites to help inhibit the growth of pathogens and spoilage microorganisms. Among the different species of microbial food cultures, lactic acid bacteria have a major potential for use as bioprotection supported by their long history of safe use, proven antimicrobial properties, their capacity to naturally dominate the microflora and occupy the ecological niche during storage[4].

Microbial food cultures for bioprotection are metabolically active preparations. While the traditional use of cultures in fermented foods refers to their positive action on product properties (texture, aroma, digestibility, …), the use of microbial food cultures with the appropriate bioprotective properties for a given application can inhibit the spoilage microflora and improve food safety.

The biological mechanisms of microbial food cultures

Fermentation and the resulting protection can be ascribed to several biological mechanisms including the ability of the cultures:

- To control acidity of the food material as a natural consequence of fermentation

- To produce metabolites, enzymes and various naturally occurring compounds or degradation products from the food product such as peptides derived from proteolysis of food proteins

- To compete with other microorganisms, e.g. through ecological competition for limited nutrients, oxygen, space in the food product or head space in the food container.

The selection of the appropriate microbial food culture for bioprotection for a certain food matrix is based on detailed analyses on the performance of the culture in these three areas throughout the shelf life of the food.

Reviews of many scientific papers point to important findings that the amounts of individual compounds produced by lactic acid bacteria are insufficient to explain the full protective effect[7]. Hence, microbial food cultures with bioprotective effect work through a combination of the mechanisms described above.

Bioprotection as one out of several hurdles

Bioprotection enhances the effectiveness of a food management system but is never an alternative to good cleaning practices, hygienic design of the production and cold chain conservation[6]. Food cultures with bioprotective effect create an extra protective hurdle against specific pathogens and/or spoilage microorganisms in the product during processing and/or after the product has left the manufacturing facility, e.g. during transport, storage, retail display and even after opening of the packaging by the consumer[1].

The selection and application of protective microbial food cultures must comply with the same safety criteria as for all microbial food cultures used in the food industry.

Selection of suitable and safe food cultures

Food cultures are chosen for their ability to control and reduce foodborne pathogens and spoilage microorganisms by exploiting microbial competition and dominance phenomena. Isolation, selection, detailed characterization and validation of cultures are a way to take advantage of the natural way microorganisms compete with each other in a complex environment, in order to assure the added bioptotective culture has the specific characteristics that will consistently inhibit a specific pathogen or a spoilage organism(s) in specific food matrix(es) at specific condition(s). This allows more control over the process than with spontaneous fermentation. New analytical tools make it feasible to identify and characterise microorganisms present in a given environment. These enable the selection of the best candidates from a very high number of food cultures to protect against pathogenic and spoilage microorganisms.

Individual food culture strains within the same species have different fermentation properties that can create variations in taste, aromas and texture/viscosity. For example, by selection of individual strains within the two well-known yogurt culture species (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) it is now possible to produce yogurt with very different viscosity/ mouth feel and high or low acid taste to a degree that was not seen some decades ago. A similar careful selection of individual strains is also possible with well-known and commonly used species regarding properties contributing to fit for purpose of bioprotective effects.

What is the food industry doing?

Application of bioprotective microbial food cultures as part of hurdle technology to improve food quality, safety and security has gained great attention since the late 1990's.

Consumers are becoming increasingly aware of the human health risk posed by the use of chemical preservatives in foods. In contrast, the increasing demand by the dairy industry to extend shelf life and prevent spoilage of dairy products has appeal for new preservatives and new methods of conservation. The combination of bioprotection with already applied physical treatments (heat treatment, high pressure processing, membrane filtration…) offers good opportunities for safer food with longer shelf life. The effectiveness of bioprotection is often dictated by environmental factors like pH, temperature, food composition and structure, as well as the natural food microbiota. Food is a complex ecosystem in which

microbial interactions may have a great influence on the microbial balance and proliferation of beneficial or harmful bacteria. In ready to eat products seen as non-fermented the natural food microbiota may result in a fast spoilage. Use of bioprotection can compete with the natural microbiota and prevent fast spoilage. Recent developments in molecular microbial ecology can help to better understand the global effects of bioprotection in food ecosystems.

The research in dairy has been focused lately on the ecological competition of traditional used cultures with spoilage (moulds and yeasts) and pathogenic (*Listeria monocytogenes*) species of concern[3,8].

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