Innovative technologies for the natural biopreservation of meat

by Dr S. Talukder, Arvind, Lalchamliani and Tarun pal Singh, Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar, Bareilly-243122, Utter Pradesh, India.

Meat has long been considered as a highly desirable, nutritious and protein rich food, but at the same time, unfortunately, it is also highly perishable because it provides the nutrients needed to support the growth of many types of micro-organisms. Due to its unique biological and chemical nature, meat undergoes progressive deterioration from the time of slaughter until consumption.

The main process of quality degradation of fresh and processed meat is initiated by spoilage or pathogenic microbial proliferation, and it should be controlled to guarantee the microbial safety of foods. A combination of factors can be an efficient way to warrant food safety keeping their organoleptic and functional properties.

Meeting consumer demands

Modern technologies associated with food processing and microbiological food safety standards have reduced but not eliminated the likelihood of food-related illness and product spoilage in industrialised countries.

Food spoilage refers to the damage of the original nutritional value, texture, flavour of the food that eventually render food harmful to people and unsuitable to eat. During the last few decades, investigation on food preservation has focused on meeting consumer demands for more natural and healthier food. In order to achieve improved food safety against pathogenic and spoilage micro-organisms, the food industry have used chemical preservatives or physical treatments (for example high temperatures).

These preservation techniques have many drawbacks which includes the proven toxicity of the chemical preservatives (nitrites), the alteration of the organoleptic and nutritional properties of foods, and especially recent consumer demands for safe but minimally processed products without additives.

To harmonise consumer demands with the necessary safety standards, traditional means of controlling microbial spoilage and safety hazards in foods are being replaced by combinations of innovative technologies that include biological antimicrobial systems such as lactic acid bacteria (LAB) and/or their metabolites.

The harmful side effects of chemical preservatives made the negative perception and this, along with the increasing demand for minimally processed foods with long shelf life and convenience, has stimulated research interest into finding natural and effective preservatives.

The use of micro-organisms and their natural products for the preservation of foods (biopreservation) has been a common practice in the history of mankind.

Biopreservation refers to the extension of the shelf-life and improvement of the safety of foods using micro-organisms and/or their metabolites.

Among alternative food preservation technologies, particular attention has been paid to biopreservation to extend the shelf-life and to enhance the hygienic quality, minimising the impact on the nutritional and organoleptic properties of perishable food products. Biopreservation rationally exploits the antimicrobial potential of naturally occurring (micro-) organisms in food and/or their metabolites with a long history of safe use. Bacteriocins, bacteriophages and bacteriophage-encoded enzymes fall in this concept.

Biopreservatives

Biopreservation, as commented above, can be defined as the extension of shelf life and food safety by the use of natural or controlled microbiota and/or their antimicrobial compounds.

One of the most common forms of food biopreservation is fermentation, a process based on the growth of micro-organisms in foods, whether natural or added.

These organisms mainly comprise lactic acid bacteria, which produce organic acids and other compounds that, in addition to antimicrobial properties, also confer unique flavours and textures to food products.

Traditionally, a great number of foods have been protected against spoiling by natural processes of fermentation.

Currently, fermented foods are increasing in popularity (60% of the diet in industrialised countries) and, to assure the homogeneity, quality, and safety of products, they are produced by the intentional application in raw foods of different microbial systems (starter/protective cultures).

Moreover, because of the improved organoleptic qualities of traditional fermented food, extensive research on its microbial biodiversity has been carried out with the goal of reproducing these qualities, which are attributed to native microbiota, in a controlled environment.

Microbial metabolites

One of the few possible solutions of biopreservation is based on the concept of using food-grade micro-organisms in food itself. These mechanisms are part of the natural balance in complex microbial ecosystems.

By exploiting the fittest of the naturally occurring micro-organisms in organoleptically appealing food products, it is conceivable to design preservation systems that ensure an adequate safety and shelf life while maintaining the desired quality of the food product.

The biopreservation principles from food-grade micro-organisms can be categorised according to the antimicrobial compound

Continued on page 9

Continued from page 7
(bacteriocin, other metabolites, bacteriophages, enzymes) as well as product format (purified antimicrobial, fermentate, protective culture).

Not all microbial inhibitory mechanisms are fully understood and not all antimicrobial metabolites from food grade micro-organisms have yet been discovered. It is highly likely that the near future will bring new understanding and discoveries, which will further expand the options for natural food biopreservation systems.

Nisin

Nisin is a cationic, amphiphilic peptide produced by various strains of Lactococcus lactis, which has a relatively broad target spectrum that inhibits a wide range of Gram-positive bacteria. It belongs to the lanthionine-containing bacteriocins and has a long history of safe use in food.

Nisin is a linear lantibiotic that exerts its antibacterial action through inhibiting cell wall formation as well as forming membrane pores. Effective use of nisin has been demonstrated both for shelf-life and safety purposes in various types of food, including processed meats.

Natamycin

Natamycin is classified as a macrolide polyene antifungal and is characterised by a macrocyclic lactone-ring with a number of conjugated carbon-carbon double bonds, it is being produced by Strepyomyces natalensis.

Natamycin has a low solubility in water, but the activity of neutral aqueous suspensions is very stable. Natamycin is stable to heat and it is reported that heating processes for several hours at 100°C lead to only slight activity losses.

Natamycin is active against almost all foodborne yeasts and moulds but has no effect on bacteria or viruses. Natamycin acts by binding irreversibly with ergosterol and other sterols, which are present in the cell membranes of yeasts and vegetative mycelium of moulds.

Bacteriocin

Micro-organisms produce a diverse range of microbial defence molecules, including the classical antibiotics, numerous types of protein exotoxins, lytic agents, metabolic byproducts, and bacteriocins.

Bacteriocins are ribosomally synthesised, extracellularly released antimicrobial peptides that have a bactericidal or bacteriostatic effect on other micro-organisms. Bacteriocin production is a common feature of food-grade lactic acid bacteria (LAB). They are generally active against Listeria species, and against some species of Clostridium, Enterococcus, Carnobacterium, Lactobacillus, Pediococcus and occasionally Streptococcus and Leuconostoc. These bacteriocins have thus primarily been tested in foods for their antilisterial properties.

In meat products: Lactobacillus sakei together with 50% carbon dioxide prevented outgrowth of L. monocytogenes in bologna-type sausage without an unacceptable pH drop. Pediococcus acidilactici was efficient in reducing L. monocytogenes in dry-fermented Spanish sausages. L. sakeii prevented listerial growth in a pork meat system while enhancing protein hydrolysis.

Use of essential oils

Preservative agents are required to ensure that manufactured foods remain safe and unspoiled. Antimicrobial properties of essential oils (EOs) reveal that Gram-positive bacteria are more vulnerable than Gram-negative bacteria.

A number of EO components have been identified as effective antibacterials, for example carvacrol, thymol, eugenol, cinnamaldehyde and cinnamic acid, having minimum inhibitory concentrations (MICs) at higher dilutions in vitro.

EOs comprises a large number of components and it is likely that their mode of action involves several targets in the bacterial cell. The potency of naturally occurring antimicrobial agents or extracts from plants, ranges of microbial susceptibility and factors influencing antimicrobial action and their antioxidative properties, aimed at food preservation are all important. Methods employed for estimation of inhibitory activity, mode of action and synergistic and antagonistic effects and the potential value of these agents as natural and biological preservatives should be considered.

A high fat content appears to markedly reduce the action of EOs in meat products. It is generally supposed that the high levels of fat and/or protein in foodstuffs protect the bacteria from the action of the EO in some way. For example, if the EO dissolves in the lipid phase of the food there will be relatively less available to act on bacteria present in the aqueous phase.

One study found that encapsulated rosemary oil was much more effective than standard rosemary EO against L. monocytogenes in pork liver sausage, although whether the effect was due to the encapsulation or the greater percentage level used was not further elucidated.

Certain oils stand out as better antibacterial than others for meat applications. Eugenol and coriander, clove, oregano and thyme oils were found to be effective at levels of 5-20µl/g in inhibiting L. monocytogenes, A. hydrophila and autochthonous spoilage flora in meat products, sometimes causing a marked initial reduction in the number of recoverable cells.

The activity of oregano EO against Clostridium botulinum spores has been studied in a vacuum packed and pasteurised minced (ground) pork product. Active packagings with the packaging materials delivering antimicrobials can play an important role.

Conclusion

Bio-preservation can provide the potential to extend the storage life and food safety using the natural microflora and (or) their antibacterial products.

Shelf life of meat and meat products can be extended and safety ensured by the use of natural or controlled microbiota and/or their antimicrobial compounds.

This food preservation process can be effectively used in combination with other preservative factors (called hurdles) to inhibit microbial growth and achieve food safety.

Application of hurdles is not only economically attractive; it also serves to improve microbial stability and safety, as well as the sensory and nutritional qualities of a food.

The principle hurdles employed in food safety are temperature (higher or lower), water activity (aw), pH, redox potential (Eh), chemical preservatives, vacuum packaging, modified atmosphere, HHP, UV and competitive flora (LAB producing antimicrobial compounds).

A crude bacteriocin-like substance can be applicable to meat and products to determine its preservation action on endogenous microflora and on added B. cereus. However, the application of biopreservation technology to these products should be integrated as part of an overall good manufacturing practice program and, in combination with refrigeration, is a promising approach for maintaining product safety. ■

References are available from the authors on request