The use of food preservatives and preservation

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There are conflicting views in consumers' minds regarding food preservation and the use of preservatives. On the one hand there are demands to remove 'chemical preservatives' from foods, but almost in contradiction, a demand for a longer, safer shelf-life, whilst retaining 'freshness'. These consumer-led concerns have resulted in a renewed interest in the development of more 'natural' preservatives for extending the shelf-life while maintaining food safety.

Nature has certainly developed ways and means of reducing microbial attacks and other degradations of plants' and animals' tissues, some of which could potentially be used in food preservation.

One example is sorbic acid, found naturally in rowan berries (fruits of the mountain ash tree), which has been used as sorbate salts for many years to inhibit mainly yeasts and moulds in several different foods. However, in recent decades many yeasts and moulds have developed resistance to it.

Health scares

Whilst chemical preservatives are cheap and effective, a number of different health scares have been linked to the use of these preservatives.

For example, in the 1970s and '80s there was considerable concern about the formation of nitrosamines (known carcinogens) from nitrite during the cooking of cured meats (for example bacon).

However, detailed research showed that omission or reduction of nitrite in cured meats could lead to growth and toxin production by Clostridium botulinum.

Only later was it shown that nitrite has a very specific effect on the energy producing metabolism of clostridia, hence preventing growth and toxin production.

The presence of sodium benzoate was linked to the formation of benzene (another carcinogen) in the presence of ascorbic or citric acid, and the consumption of mixes of certain artificial food colours preserved with sodium benzoate was linked to an adverse effect on children's behaviour.

Role of salt and sugar

Less obvious is the role of salt and sugar as preservatives through their effects in reducing water activity, although considerable efforts are being made by the health authorities and manufacturers to reduce sugar as one of the causes of obesity, and salt as a hypertensive (resulting in high blood pressure).

Although there is considerable concern by both consumers and the health and food safety authorities regarding such issues, little seems to have been done to identify any alternative solutions. Many companies are seeking alternatives to 'chemical' preservatives, and reducing salt and sugar for health reasons, while at the same time maintaining safety or extending shelf-life provided by these additives.

Reductions in salt and sugar will increase the water activity of a food, an important parameter in preservation of salted meats and fish, and conserves, jams and jellies, preserved by high levels of sugar.

Thus, reduction of salt below approximately 3.5% salt-on-water in a meat or fish product combined with prolonged chilled storage could result in botulinal growth and toxin production.

Levels of total sugar in jam or conserves below approximately 65% w/w could allow growth of osmophilic yeasts or moulds, some of which are mycotoxin producers; hence labels on some jams and conserves now advise chilled storage after opening, with a stated shelf-life.

Substitution of an intense sweetener for sucrose in hazelnut flavouring for yoghurts, led to the growth and toxin production of Clostridium botulinum. However, low water activity increases heat resistance of microbes, often very considerably, and conversely, increasing water activity by reducing the levels of salt and sugar, may allow a reduction in the severity of a thermal process.

Pickling in salt and vinegar, for example vegetables, requires certain minimum levels of both ingredients for safety and shelf-life. Traditionally, but often forgotten, is that salt, sugar and acetic acid, in the form of vinegar, are in certain foods not just for taste but are essential ingredients contributing to preservation. At the concentrations used, each of these components would not be sufficient for preservation, but together, act in synergy to achieve a safe and stable product, usually referred to as the 'Hurdle Effect'.

Specific mixtures of salt, acetic acid, sugar and final pH value, is critical for the safety and shelf-life of pickles, sauces and mayonnaises (mathematical prediction by application of the CIMSCEE code).

Changes in levels or replacements of these components must not be made without considering the consequences to shelf-life or safety, for example reductions in salt or sugar must be compensated by reducing the pH and increasing the level of acetic acid.

The exchange of acetic acid by, for example citric or lactic acids in mayonnaises or pickles for reasons of taste, should not be undertaken lightly, as these acids are much less active as antimicrobials and will markedly reduce the preservation index.

'Natural' preservatives

Simple chemical preservatives have been used for many years, often back into prehistory, and can be effective in a variety of situations.

However, in the case of 'natural preservatives', plant or animal products or extracts, it is necessary to understand the nature of the active ingredient(s) and each application on an individual basis. As many of these natural preservatives would be novel in their application, they will be subject to legislative approval systems.

In terms of definitions of 'natural', the UK and France are similar, but the French definition appears quite wide as 'any product that can be found in nature', whereas the UK definition appears more restrictive in limiting these to recognised food or plant sources.

The USA takes a very different approach in that any additive/preservative that would not normally form part of that food, will not

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be regarded as 'natural' and are therefore being much more restrictive in the potential use of 'natural preservatives'.

Many antimicrobial compounds from plant, animal and microbial sources have been reported, but their potential for use as natural food preservatives has not yet been fully explored or exploited.

A plethora of papers describing the antimicrobial properties of lytic enzymes, bacteriocins and plant extracts are submitted for publication in peer reviewed journals almost on a daily basis.

Most of these 'natural antimicrobials' are parts of plants or their extracts often used in traditional medicine, and/or form part of the Mediterranean range of herbs and spices used in traditional foods.

However, most of these reports suffer from a rather random experimental plan and obvious lack of end-point application; only a very few studies have attempted to investigate the impact of those extracts or compounds on the sensory characteristics of foods, while lack of toxicological data does not encourage consideration for further use.

Most of the herb and spice extracts possess very strong aromas and flavours, and on analysis seem to consist of similar phenolics and long-chain unsaturated compounds, in varying proportions, for example carvacrol, limonene, cinnamic acid and esters.

There are many natural antimicrobials to choose from, so which types of compounds and their sources should be investigated?

Essential oils

The most widely studied according to the literature, are the essential oils from plants, especially those from the warmer countries around the Mediterranean basin, and more recently from Africa and India.

However, most of these essential oils possess a strong odour and flavour, for example Rosemary oil has a very strong odour unless de-odorised, and while the de-odorised oil still has antioxidant properties, the antimicrobial activity may be lost or severely reduced. The antibacterial efficacy of this oil has been extensively studied, but there are few studies of its antifungal activity. Other plant extracts have been less well studied and there is little detailed information regarding activity and the specific antimicrobial compounds responsible.

Specific criteria

Before developing research projects on plant materials, there are some specific criteria regarding the plant and its habitat, which must be considered in choosing materials for study:

- Can you rely on local knowledge about a plant used in local culinary practice or folk medicine?

Plant species	Reported activity
Acer nikoense	Used as medicine, Japan
Bauhinia racemosa	Used as an antibacterial, India
Biphora radians	Used to treat infections, Turkey
Buchholzia coriacea	Used against infections, South Africa
Datura innoxia	Documented antibacterial activity/toxic
Hymenodictyon parvifolium	Traditional use against infections
Hyssopus officinalis	Traditionally used in medicine/strong flavour
Juglans manshurica	Documented antibacterial activity through coumarins
Lagerstroemia speciosa	Used as medicine, Asia

Table 1. Some traditional uses of plants and their activities (Leatherhead Food Research, Food Safety internal database).

- Do you have the 'correct' plant? For scientific reports and publications, the plant must be carefully identified, often not easy, and given its recognised Latin name.
- What is the availability of the plant? If a food application is successful, many hundreds of kilos may be required.
- Will permission be granted to take the plant for commercial use, or to remove it from its native habitat? Perhaps to grow it in another country? Can it be grown easily?
- What part of the plant is used – roots, stem, leaves, flowers or seeds? When is it harvested for maximal yield?
- How is it extracted – water extract, steam-distilled or solvent extracted? Will this affect its 'natural' designation?
- Are there any reports on toxicology?

Finally, determination of antimicrobial activity – is it soluble in water? Should the Minimal Inhibitory Concentration (MIC) be determined in broth or on agar, using viable counts, optical density measurements, etc?

In Table 1 are some traditional uses of plants that might be useful as indicators for initial investigations into antimicrobial activities. Indeed, extracts of these plants have recently shown promising antimicrobial activities.

Activities of these extracts have been determined to result from the contents of tannins, flavonoids and glycosides, so other plants rich in these types of compounds might also be good sources of antimicrobials and therefore subjects for investigation.

Although most of the reported activity is against bacteria, some show activities against yeasts and fungi, and with quite low MICs.

However, as indicated above, much work remains to characterise and identify the active compounds, test for a wider range of antimicrobial activities and effects of food matrices and pH, toxicity and, of course, acceptability criteria of aroma and flavour at effective antimicrobial concentrations.

A few antimicrobials from animal sources have also been well studied, for example chitosan (derived from chitin present in crustacean shells) is especially active against yeasts and fungi (a European Commission research project was developed on this and other antimicrobials).

Although there are several antimicrobial peptides known from animal and insect sources, these have been difficult to either synthesise or extract in sufficient quantity for use in experimental food systems.

The enzyme lactoperoxidase (LP) is naturally present in milk, but its activity is difficult to exploit as its substrates (thiocyanate and hydrogen peroxide producing the hypothiocyanite ion) are limited in milk, but it is very effective when these substrates are added.

The LP system has been approved for use in countries where it is difficult or impossible to control microbial growth by chilling.

Bacteriocins, peptides generally produced by Gram positive organisms, typically lactic acid bacteria (LAB), have been well studied in several different food matrices, and more producer organisms are being reported every year; they are generally active against closely related organisms.

There has been a considerable emphasis on activity against Listeria monocytogenes in lightly preserved foods, for example lightly cured, smoked sausages and fish, often with considerable success.

Most successful experimental systems have not used purified bacteriocins, but incorporated the active producer organism(s).

These have generally been isolated from samples of the same product, since they are native to, and have characteristics that allow growth in that product.

The use of nisin

Nisin is the only purified bacteriocin permitted to be added to a limited range of foods. However, as the conventional preservatives are phased out and salt and sugar are reduced, the use of nisin or bacteriocin producing strains of LAB in lightly preserved chilled foods, such as high pH cheeses, cold-smoked fish, lightly fermented and smoked sausages, may become more general.

For inhibition and destruction of certain pathogens, for example salmonella, Listeria monocytogenes, Campylobacter spp., on poultry, the use of specific phages has been proposed and investigated.

Generally, as with any predator-prey relationship, an irreducible minimum level of the prey (the pathogen) seems always to remain. ■

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