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Food preservation inspired by nature

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breakthrough research has recently shed light on the molecular mechanisms responsible for how probiotic ingredients work. a group of international researchers has discovered how helpful bacteria interact with the human gut where they confer their health giving properties. this new study has opened up a whole new field of research that clarifies the mode of action of live microorganisms contained in probiotic foods. good news, perhaps, for the manufacturers of probiotics in the light of recent rejection of some of their claims by the eu.

the european food safety authority’s (efsaa) dismissal of 171 of the 181 dossiers submitted to them by probiotic food manufacturers (who were looking to have product health claims endorsed) came as a big disappointment. the dossiers submitted by some of the world’s biggest suppliers of probiotic foods were rejected on the grounds that the probiotic strain in question had not been sufficiently characterised. according to efsaa, the microorganisms involved in the health giving (probiotic) benefits of a product should be sufficiently characterised at the strain level by internationally accepted genetic methods. efsaa has also shown its preference for human studies to validate any health claims (rather than in vitro cell models). in particular, efsaa has stated that claims need to be “sufficiently defined” in order that the effect of the probiotic ingredient could be subjected to tests and measurements using generally accepted techniques.

the results of the international study may well provide some support to probiotic companies struggling to get their products validated. the research team led by scientists at the university of helsinki and incorporating researchers from the finnish dairy company valio, started by sequencing the whole genome of the most frequently used and studied probiotic lactobacillus rhamnosus gg (lgg), as well as other closely-related bacteria. the researchers then went on to isolate the genetic sequences (and hence the proteins) responsible for lgg binding to mucus in the human intestine. the proteins identified form the ‘pili’ of the bacteria; long ‘hairlike’ appendages 1-10 nm in diameter that stick out from the cell surface and are used in host-cell attachment. one of the proteins forming a subunit of the pili was shown to provide a clear interaction with the human gut. this binding mechanism is thought by the scientists to be responsible for the health promoting effects of lgg and other probiotic bacteria.

the results, which have been published in the respected pnas research journal, not only illustrate how probiotics may be involved in gut/protein interactions but, it is hoped, go on to promote product development in the food industry. however, the first hurdle is to get the health claims of probiotics approved at the european level. studies such as this, which provide a positive example of cooperation between the food industry and academia are a good start. by knowing the full genetic sequence of a probiotic bacteria, manufacturers will have more tools in their arsenal to provide the genetic markers that can be used to identify bacteria in a product. and having a better idea of how probiotics work at the molecular level can only help to bolster any new product dossier submitted to efsaa. in addition, this new knowledge will help companies refine their scientific arguments when they finally come to resubmit their dossiers to the food authority.
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Going natural
the potential of antimicrobial
preservatives derived from nature

Preservatives in general have been on the receiving end of some very negative publicity in recent years to the extent that the phrase “contains no preservatives” has become a positive selling point for some foods. Consumers and hence retailers have become increasingly unwilling to accept products containing synthetic preservatives. As a result, pressure for ‘clean-labelling’ of food products is driving a trend towards so-called ‘natural’ additives. Researchers have been studying antimicrobials derived from nature for many years, but interest is now stronger than ever and is driving the development of a number of potentially marketable natural alternatives.

Extracts from herbs, such as oregano, which possess natural antimicrobial properties could be used as additives for food.
On the face of it, the current trend for clean-labelling of foods is driven not by science, but by ignorance and lack of understanding. Many perfectly serviceable food additives are now seen as undesirable simply because of unfounded negative publicity, or on the basis of an unattractive ‘chemical’ name. For example, it is ironic that the ‘E-numbers’ assigned to permitted additives are now widely seen as unfavourable on an ingredient list, despite that fact that the number means that the additive has been thoroughly assessed for safety and is strictly controlled as to how it can be used. The same cannot be said of some natural alternatives. Taken to its extreme, this clean label trend can become ridiculous. For example, last year one UK product was promoted on the basis that it was “100% chemical free”. This prompted the Royal Society of Chemistry to offer a prize of £1 million for anyone who could prove that they had such a material. So far, the prize remains unclaimed.

Food manufacturers may be faced with demands to reformulate products without synthetic additives that are at best unscientific and at worst unreasonable, but in many markets such action is now necessary to maintain sales. This is particularly true of synthetic preservatives such as sodium benzoate, which has been used safely and successfully for many years, primarily to prevent fungal spoilage in acid foods. Recent UK research on the effect of synthetic colours on child behaviour found that a cocktail of colours together with sodium benzoate could be linked to hyperactivity in some children. Despite the fact that there was no evidence for any causal effect, there is now considerable pressure for benzoic acid and benzoates to be removed from foods and beverages. It therefore comes as no surprise that many manufacturers are looking for alternatives from natural sources, which can maintain product safety and quality, but which look less unfriendly on a label.

A wide spectrum of natural antimicrobials
Natural substances with antimicrobial action have been identified from a very wide range of sources, including herbs and other edible and medicinal plants, microorganisms and animals. Many of these have been investigated, but few have yet been exploited as food preservatives on a commercial basis. Some examples are given in the table on the next page.

Antimicrobials from plants
Plants need to protect themselves from microbial infection just as animals do and the defences of many species are boosted by the presence of antimicrobial compounds in their leaves, fruits, buds, bulbs and seeds. Many of these compounds have already been identified and investigated by researchers, though it is certain that a great many more remain undiscovered. Not surprisingly, most attention has been given to herbs and other edible plants and to plants known for their medicinal qualities – in other words, plants known not to be toxic to humans – but it is mainly herbs and spices that are of interest as sources of antimicrobials for use in food preservation.

Many researchers have focused on extracts from herbs, such as oregano, rosemary and thyme. It is the essential oils derived
from these plants that contain most of their antimicrobial activity. These oils contain a variety of individual components that seem to be able to kill or inhibit the growth of microorganisms. Antimicrobial components include phenolic compounds, terpenes, alcohols, aldehydes, ketones and isoflavonoids, but there are four individual compounds that seem to occur most frequently and at the highest levels. These are carvacrol, citral, eugenol and thymol, but other compounds too, such as borneol, cinnamaldehyde and thujone have been identified as important. Essential oils from different plants show activity against different types of microorganisms. In general, most are more active against Gram-positive bacteria, such as Bacillus species, than against Gram-negatives like E. coli and Salmonella, but a few, notably oregano, clove and cinnamon, have been found to be effective against both, and these therefore have the greatest potential for food use.

In other plants, different chemical compounds provide protection against attack. For example, in garlic and other members of the Allium family, such as onions, precursors and enzymes are present, which together generate an antimicrobial called allicin, but only when the plant is physically damaged or stressed. The antimicrobial and medicinal properties of allicin have been widely studied. Other plants, including mustard, horseradish and wasabi, use a similar mechanism to produce various isothiocyanates, one of which, allyl isothiocyanate, is a powerful antimicrobial and has antifungal as well as antibacterial activity. Green tea extracts containing catechins have also been found to show activity against a wide range of pathogenic bacteria.

Many natural antibiotics are completely unsuitable for use in food preservation. However, compounds produced by lactic acid bacteria – sometimes known as lantibiotics – are of most interest for food manufacturers.

Antimicrobials from microorganisms
Many microbes produce chemicals that inhibit the growth and development of other microbial species and this has been known for many years. Some therapeutic antibiotics, including penicillin, were originally derived from microbial cultures. It is thought that producing antimicrobial compounds may give microbes in complex and diverse environments like soil a competitive advantage over their neighbours. Many natural antibiotics are completely unsuitable for use in food preservation, but there is one group of compounds that has great potential. Bacteriocins are antimicrobial proteins produced by both Gram-positive and Gram-negative bacteria, but it is the compounds produced by lactic acid bacteria – sometimes known as lantibiotics – that are of most interest for food manufacturers. The reason for this is that lactic acid bacteria are generally harmless and are often present in foods, especially in products like cheese and fermented meats. Furthermore, lactic acid bacteria tend not to cause detectable spoilage of foods unless they are present in very large numbers. This means that food manufacturers can safely exploit the ability of some strains to produce bacteriocins by using them in starter cultures, or even adding them to certain foods. Furthermore, lantibiotics are not generally used as therapeutic agents and so the development of antibiotic resistance is not an issue.

A wide range of bacteriocins has been discovered, but the most important from a food preservation point of view is nisin, which is currently used commercially. Nisin has a 40-year history of use and is approved for use in food in the EU (E234), the USA and many other countries. It is a stable polypeptide compound produced by...
some strains of *Lactobacillus lactis* and is quite effective against many Gram-positive bacteria. It works mainly by damaging the cell membrane. It is used in a number of applications, but is particularly useful for preventing the spoilage of cheese by the bacteria *Clostridium tyrobutyricum* and *Cl. butyricum*, which cause ‘late blowing’ during ripening. Nisin has other applications in canned foods, dressings, bakery products and cooked sausages, but is somewhat limited by its comparatively narrow spectrum of activity – it is not effective against Gram-negative bacteria or fungi – and by the fact that it is most effective at low pH. However, the effectiveness of nisin against Gram-negative bacteria can be improved if chelating agents, such as EDTA, are present. These work by increasing the permeability of the bacterial cell wall to nisin. Nisin is marketed under the trade name Nisaplin by Danisco.

Other bacteriocins of special interest include pediocin, a stable protein produced by strains of *Pediococcus acidilactici*, which is generally recognised as safe (GRAS) and is active against many Gram-positive bacteria over a wide pH range. Pediocin-producing bacteria are used in starter cultures for fermented sausage products, where their presence helps to inhibit both spoilage bacteria and pathogens, including *Listeria*. Other bacteriocins produced by lactobacilli, but not yet exploited commercially, are attracting interest. These include acidophilin, bulgaricin, lactacin and plantaricin. Reuterin, a non-protein bacteriocin produced by certain strains of *Lactobacillus reuteri*, has also been widely investigated. It has a wide spectrum of activity and is effective against both Gram-positive and Gram-negative bacteria, yeasts and moulds. It is watersoluble, works over a wide pH range and is quite stable, making it potentially a very useful food preservative.

**Antimicrobials from animals**

Antimicrobials derived from animals are the least studied, but potentially the most interesting and useful from a food preservation point of view. Some, such as lysozyme found in egg white, the lactoperoxidase system in milk and chitosan from the shells of crustaceans and arthropods, are well known, but researchers are finding that antimicrobial peptides (AMPs) are widespread in the animal kingdom and can be found in insects, fish, amphibians, birds and mammals. These compounds are currently attracting a lot of attention. Most of them seem to act by rapid general destruction of the microbial cell membrane so that even fast-growing bacteria are unlikely to develop resistance to them.

Lysozyme is a bacteriolytic enzyme naturally present in the albumen of birds’ eggs, which helps to protect the developing egg from microbial attack. Like nisin, lysozyme has been found to be effective against the clostridia that cause late blowing in cheese and has been shown to help prevent spoilage of wine by lactobacilli. It can also inhibit growth of Gram-positive spoilage organisms and pathogens, including *Listeria* and *Bacillus cereus*. Lysozyme has been commercialised and is available in purified preparations like inovapure marketed by Neova Technologies. The lactoperoxidase system relies
Lysozyme is a natural bactericide present in the albumen of birds’ eggs.

Lysozyme is a natural bactericide present in the albumen of birds’ eggs.

on reactivating the enzyme lactoperoxidase, naturally present in raw milk, by adding thiocyanate and a source of peroxide. The effect is to block bacterial metabolism and inhibit growth, so extending the shelf life of raw milk, and it is approved by Codex for this purpose. The lactoperoxidase system is effective against both bacteria and fungi, but Gram-negative bacteria seem to be the most susceptible. Chitosan is a polymer, but in low molecular weight form it has been shown to be effective in controlling growth of both bacteria and fungi.

Researchers have only scratched the surface when it comes to investigating the huge numbers of AMPs that are thought to be present in animals, but some of them have already shown promise as food preservatives. Lactoferrin for example, found in cows’ milk, is a glycoprotein that binds iron and has antimicrobial activity against bacteria and fungi. It has an application as a preservative in meat, and has recently received USDA approval for use in beef products. Pleurocidin is an AMP found in the skin of a fish called the winter flounder and has antimicrobial activity against both Gram-positive and Gram-negative bacteria. It is also heat stable and salt tolerant and has been shown to be effective at quite low concentrations against some important foodborne pathogens and spoilage bacteria, including *Listeria* and *E. coli* O157:H7. It appears not to be toxic to human cells and so its potential as a preservative is clear. Another promising group of AMPs are the defensins found in the epithelial cells of mammals and birds. They are present as part of the animal’s protection against infection and are reported to be effective against a wide range of microorganisms. Other AMPs currently under investigation include protamine, salmine and clupeine from fish and magainin from frogs, all of which are active against important foodborne bacteria and show potential as natural preservatives.

**Turning potential into reality**

There is no shortage of candidates to become the food preservatives of the future, but there is still a long way to go before syntheptics can be phased out entirely and there are many obstacles on the road to all-natural preservation.

One obvious problem is that there are few natural antimicrobials that can be used as direct replacements for existing preservatives. Either they are not as effective, prove too costly, or cause product quality problems. Replacing proven preservatives like sodium benzoate with a natural alternative needs to be very carefully researched and tested before it can be implemented, especially where there are safety concerns. One approach that might make this easier is to use natural antimicrobials in combination or with other technologies in a multi-hurdle preservation system. For example, nisin in combination with carvacrol has been shown to be more effective than nisin alone. Much research has focused on using blends of essential oils from different herbs to preserve foods and in some cases definite synergies can be obtained. Bacteriocins work better in combination with chelating agents, whilst non-thermal processing technologies like ultrasound, high pressure processing and ozonation have all been found to enhance the performance of bacteriocins.

Even if a natural antimicrobial system with potential as a food preservative can be shown to be sufficiently effective, it will still need to be approved before it can be used as a food additive. Ironically, this is likely to mean acquiring one of those E numbers that consumers are so wary of. This has already happened to nisin, which is proven to be both effective and safe, but must be declared as an additive on the label if it is used as a preservative. The problem is that consumers may not recognise which additives are natural and which are not and may reject declared additives wholesale.

A possible answer to this is for natural preservatives to be included as ingredients. For instance, it may be possible to formulate products flavoured using herbs that also have significant antimicrobial action, such as oregano and thyme, or to source herbs bred specifically for high levels of antimicrobials. Using bacterial starter culture strains known to produce bacteriocins is also an option. Another possibility would be to look at classifying some natural antimicrobials as processing aids if they are not detectable in the product at point of retail. These options may provide a way round the stumbling block of the approval process and labelling, but they are not a long term answer. If natural antimicrobials are to be successfully exploited as food preservatives it will probably require changes in legislation and better consumer education. We have only just begun to tap the huge potential of natural preservation and, in the future, it could even relegate conventional processing technologies like pasteurisation to niche applications, as well as replacing synthetic preservatives. It is an exciting field, but one that demands a lot more research before it can make a real contribution to safer, fresher food.

**Reference**


**More information:**

The Danisco natural preservation web site Care4U: http://www.daniscocare4u.com

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Sustainable production has become a highly desirable goal for the food industry, not only for environmental reasons, but also because it has the potential to deliver significant business value. This is especially true for food and drink packaging. But while sustainable packaging may carry the potential for substantial benefits, achieving those benefits is a far from simple task that cannot be undertaken in isolation. The packaging industry is beginning to address the sustainability issue seriously, but there is still some way to go before food manufacturers can implement truly sustainable packaging solutions.

It would be easy to dismiss sustainability in food production as just another fad, designed to appeal to green-minded consumers and soon to be replaced by the
next environmentally friendly-sounding, but rather vague, idea. However, many in the food industry are beginning to realise that the basic principles of sustainable production provide a route to some significant benefits for manufacturers. Even in its simplest interpretation, sustainable production involves minimising the use of non-renewable resources and energy, and that has clear parallels with an efficient business model. But the basic tenets of sustainability also include a lot more of the elements that go to make up a successful business. As a result these tenets are emerging as a source of guiding principles for managing organisations in a rapidly changing world.

Nowhere is this more so than in the packaging sector, where sustainability is set to become essential, rather than simply desirable. Packaging has, perhaps unfairly, become the focus of attention for environmental campaigners, consumer groups, major retailers and legislators. The reason is simple – packaging looks at first glance like a very obvious source of waste. Disposing of it is seen as an environmental problem and it has become a common belief that the food industry uses too much packaging. The pressure to reduce the environmental impact of packaging is growing.

Packaging under pressure
A recent Datamonitor survey of consumer attitudes to packaging in 15 countries found that 39% of consumers were influenced in their purchasing decisions by packaging design, and in the UK, 40% said they would look for alternatives if they thought a product carried excessive packaging. These figures illustrate a shift in consumer attitudes away from bulky, over-packaged products with built-in waste and disposal problems towards much more environmentally sensitive options. Consumers are becoming increasingly aware of the need to cut the amount of waste going to landfill and to increase recycling and re-use. They expect food packaging to reflect this and in future are likely to favour products packed sensitively. Consumer attitudes are also reflected in European legislation in the form of the EU Packaging and Packaging Waste Directive (Directive 94/62/EC), which has a clear aim of reducing the environmental impact of packaging.

Pressure is also coming from some of the food industry’s biggest customers, the major retailers. Take the world’s biggest retailer, US-based Wal-Mart, for example. In 2006 Wal-Mart instituted its ‘Packaging Scorecard’, which is used to rate suppliers’ packaging according to a range of environmental attributes, including greenhouse gas (GHG) production, product/package ratio, transport, recycled content and renewable energy use. These are all criteria that fit well into the sustainability concept. Wal-Mart has good business reasons for this initiative – it aims to cut overall packaging by 5% by 2013 and make direct savings of more than $3 billion. Other retailers are looking at similar initiatives and it will become increasingly difficult for any business to supply a major retailer without first considering the environmental impact of its packaging.

Against this background it is not surprising that many manufacturers of packaged food and drink are looking seriously at ‘sustainable packaging’ as a means of meeting the expectations of their customers and the requirements of legislation. In fact, a recent report by Pike Research in the US predicts that sustainable packaging will grow from 21% of the total global packaging market in 2009 to 32% by 2014. But what exactly does the term sustainable packaging mean in practical terms?

Defining sustainable packaging
The idea of sustainability was first identified and defined clearly by the UN Brundtland Commission in its report ‘Our Common Future’, first published in 1987. The Commission defined Sustainable Development thus: “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This involves addressing economic, social and environmental factors and their interdependence in an organisation’s decision-making and activities.” In packaging a widely accepted definition of sustainable packaging has been developed by the Sustainable Packaging Coalition, a US-based international industry working group with almost 200 member organisations, including large food and beverage businesses like Unilever, Cadbury, Kraft Foods, Coca-Cola, General Mills and Heinz as well as major packaging manufacturers such as Tetra Pak. The Coalition defines criteria for sustainable packaging as follows;

Sustainable packaging:
• Is beneficial, safe & healthy for individuals and communities throughout its life cycle
• Meets market criteria for performance and cost
• Is sourced, manufactured, transported, and recycled using renewable energy
• Optimises the use of renewable or recycled source materials
• Is manufactured using clean production technologies and best practices
• Is made from materials that do not endanger health in all probable end of life scenarios
• Is physically designed to optimise materials and energy
• Is effectively recovered and utilised in biological and/or industrial closed loop cycles

It is this ‘closed loop’ principle that characterises sustainable packaging most clearly, implying a packaging cycle that involves no net consumption of resources or energy, delivers economic benefits and doesn’t produce any harmful by-products or safety issues. This sounds like a real ‘win win’ scenario, but of course there is a catch. At present, packaging that meets all these criteria and can be considered truly sustainable does not exist. As Ed Klein, Vice President Environmental Affairs, Tetra Pak North America, wrote recently, “… currently there is no packaging solution in the marketplace that is 100% sustainable.”

Others agree with that view and also argue that the sustainability of packaging should not be considered in isolation. A recent report called ‘Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers’, produced jointly by EUROPEAN (The European Organisation...
The life cycle approach is set out in the ISO 14040 series of international standards – themselves part of the broader ISO 14000 series relating to environmental management systems. These standards set out the key requirements for the main tool used to measure the environmental impact of packaging, the Life Cycle Assessment, or LCA. A detailed LCA is a rigorous and complex process that identifies and evaluates all the inputs and outputs of the product life cycle as well as the possible environmental impact. These are likely to include GHG emissions, the environmental effects of any pollutants produced, energy consumption, raw material sourcing and use and waste production. A full LCA can take many weeks to complete and the results will only be as credible as the data used to conduct the analysis.

Industry makes progress
It is clear that the objective of sustainable packaging is not an easy one to reach, but it should be applauded that Europe’s food and drink industry has already made progress towards it. According to the latest CIAA sustainability report the EU food and drink industry accounts for about two thirds of total packaging waste by weight. However, the total amount of packaging waste sent for final disposal went down by more than 20% between 2001 and 2004, even though packaging consumption grew significantly over the same period.

The drive towards sustainability is also aided by improvements in energy efficiency, greater availability of renewable energy, waste reduction initiatives, better packaging design and the development of new recyclable and biodegradable packaging materials made from renewable resources. As the technology to produce bioplastics from cornstarch and other natural polymers advances, the green packaging options grow. Many large packaging manufacturers are developing products designed to fit into sustainability strategies. International paper and packaging group Mondi, for instance, recently launched a range of biodegradable packaging under the brand name Sustainex.

There is still some way to go before any food manufacturer can claim to be using 100% sustainable packaging, but progress over the last ten years has been dramatic. Driven not only by the demands of consumers, retailers and legislators, but also by the realisation that sustainability is a good way to do business, food manufacturers are expected to make rapid progress in the pursuit of total sustainability over the next few years.

Towards sustainable packaging
What most experts in the field agree on is the need to look at the entire life cycle ‘from cradle to grave’ of a packaged product when considering sustainability. There are also a number of tools available to packaging designers which can be used to help estimate the environmental impact of different pack designs in real time. One such, an on-line software package called COMPASS, has been developed by the Sustainable Packaging Coalition. COMPASS will produce “comparative profiles of packaging design options” and uses a set of metrics derived from the Coalition definition of sustainable packaging. Some large food manufacturers have developed their own tools for assessing the environmental impact of packaging and designing new packs. For example, Kraft Foods uses its own Eco-Toolbox to help build sustainability into each design and an Eco-calculator tool to measure environmental performance.

While it is the environmental impact aspect of sustainable packaging that will require the most time to assess, it should not be at the expense of addressing the economic and social impacts, which are equally important. Factors such as logistical efficiency, product availability, impact on health and safety of staff and, last but not least, profitability all need to be considered when developing a sustainability strategy for packaging. There is little point in achieving a very low environmental impact if the business cannot survive the economic consequences.

Sustainable packaging may not actually exist at present, but there is plenty of advice and help for food businesses wanting to move towards it.

Environmental Sustainability in the European Food and Drink Industries’. This report stresses the importance of reducing the environmental impact of packaging without compromising product safety and quality and makes the important point that insufficient packaging can result in more food waste.

So it seems that sustainable packaging is far from the simple concept it may at first appear and cannot be achieved just by switching to biodegradable or recyclable materials. Sustainability is a long term goal that can only be achieved by a continuous programme of small steps and improvements. That being the case, what can be done on a practical level to reduce the environmental impact of food packaging?
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The demand for materials from renewable resources is increasing. Hemicelluloses are a group of polysaccharides found in plants that are, at present, not fully exploited in a commercial sense. In this article, we describe our work on targeting hemicelluloses from wood for food packaging applications, in particular film wrapping. Nanoscale fillers generated from wood pulp are introduced as reinforcement, resulting in coherent, easy-to-handle films with improved mechanical properties. The oxygen permeability of these novel composite films is similar to that reported for high-barrier materials such as polyvinyl alcohol (PVOH) and ethylene vinyl alcohol (EVOH).

**Polymers from renewable resources**
As we look to a future in which the oil on which we have depended for the last 100 years starts to run out, sustainable sources of raw materials for industrial and consumer products are increasingly of interest. Biodegradable materials are therefore attracting more attention from a research perspective, as well as from the viewpoint of manufacturers. In this context, there is a considerable history in the field of biopolymers obtained from marine or land-based biomass or indeed from animal sources. Such biopolymers include those that are already on the market, such as polylactide (PLA), produced at present from corn, and the polyhydroxyalkanoates (PHAs) generated in-situ by certain bacteria grown under controlled conditions. In addition to these are starch-based thermoplastics and chitosan, obtained by deacetylation of chitin derived from the shells of marine crustaceans (e.g. shrimps). One can also add the now rapidly developing biomass-derived polyethylene, generated, for example, by dehydration of bioethanol.

**Hemicelluloses**
Most biomass is composed of cellulose, lignin and hemicellulose sugars and, although there has been a long history of research and development on new chemicals and materials from cellulose and lignin, the hemicelluloses have remained relatively unexplored until quite recently. While cellulose has a unique structure, the
Hemicelluloses comprise a group of non-crystalline hexose and pentose sugars. Four main groups have been defined according to their primary structure: xyloglycans (xylans), mannoglycans (mannans), β-glucans and xyloglucans. The hemicelluloses in the plant cell wall are bound to cellulose and lignin. Detailed isolation procedures are required in order to separate these components from the plant raw material. A number of methods are used to isolate hemicelluloses from plant sources including extraction with alkali, dimethyl sulfoxide or methanol/water, as well as steam or microwave treatment. The composition of the hemicelluloses varies between different feedstocks, as well as between sources, depending on factors such as origin and growth stage.

Hemicelluloses as a source of new biopolymer films and coatings
Films and coatings from renewable materials have numerous potential applications in the food industry, medicine and related industries. In the food industry, a number of researchers have explored the feasibility of producing new biopolymer films based on hemicelluloses with packaging in mind. Hemicellulose biopolymers are hygroscopic in nature and films, and as a result, do not behave well under conditions of high humidity. Previous research, largely aimed at overcoming such drawbacks, can be broadly broken down into categories based on the approach adopted: 1) formation of composite films or films with additives and hemicellulose as the major component, 2) coating of a hemicellulose film on a support layer, 3) chemical modification of hemicellulose prior to film casting, 4) chemical modification of previously formed hemicellulose films.

The formation of films from hemicellulose acetates was reported as early as 1949 by Smart and Whistler. Since that time there have been many reported studies [1]. Composite films based on xylans from wood have been formed by mixing this compound with other biopolymers such as alginate and carboxymethyl cellulose to form good oxygen barriers. The water vapour barrier properties of xylans extracted from maize bran have also been greatly improved by mixing with emulsified lipids. The addition of plasticisers such as glycerol, sorbitol and xylitol in the correct amounts has been a route adopted to create more practical, flexible films from hemicelluloses. Similarly, edible glucan coatings have been used to form moisture barriers on fruit. In the field of chemical...
modification, ethers with improved barrier properties have been formed by the reaction of hemicelluloses with benzyl chloride. Grafting of fluorinated moieties to xylan-based films has also been shown to be effective in reducing water uptake and creating a hydrophobic surface. A similar effect has been demonstrated by grafting stearyl methacrylates on to hemicellulose films, which also provided for reduced water permeability.

New directions in improving hemicelluloses as a raw material for food packaging

The work on enhancing hemicelluloses at Risø DTU started with an interest in exploring higher value uses for hemicelluloses generated as by-products from bioethanol production. However, we now know that these by-products are significantly degraded and we have therefore taken a more fundamental approach in which we target developments in the use of films from xylans, which can be derived from biomass by a variety of processes.

One of the research strategies has been to investigate the use of microfibrillated cellulose (MFC) from wood pulp as a way of producing reinforced xylan films. We have focused our attention on commercially available xylan extracted from birch wood and MFC provided by research partners at The Royal Institute of Technology (KTH) and Innventia AB in Stockholm. Our past research formed part of the EU Sixth Framework programme Sustainpack project (http://www.sustainpack.com) and included work on films cast from MFC as well as the potential use of this nanofiller to reinforce and upgrade starch-based films. The scientific literature on MFC utilisation includes a high proportion of studies aimed at MFC in combination with hydrophilic polymers because of obvious compatibility advantages. By using a polysaccharide such as xylan, this potential advantage is maintained and significant difficulties with mixing and dispersion can be avoided.

We have generated films from xylan/MFC mixtures containing up to 50% MFC by casting from alkaline solution followed by drying under controlled conditions. In some cases we also added glycerol plasticiser. Although it was not possible to cast films from pure xylan, the addition of MFC, especially at loadings over 10%, gave films which were at least 20-30 microns in thickness and could be handled and tested for various properties [Image 1]. As an example, the tensile strength of such films as a function of their MFC content is illustrated in Figure 1.

The tests showed that MFC has a positive effect on xylan film tensile properties and, since elongation is also increased, MFC may be acting as a reinforcing plasticiser. The addition of glycerol as a plasticiser had the expected effect of decreasing tensile strength while increasing the measured strain at break. The measured oxygen permeability of unplasticised xylan/MFC films gave promising values of ~ 1 cm³ 25µm m² 24h·1 bar·1. While these oxygen permeability values for unplasticised xylan/MFC films are considered to be quite low (and comparable with literature values cited for polymers such as PVOH and EVOH, which are generally regarded as high barrier materials), there was a clear and expected increase in permeability when plasticiser was added. For example, the permeability of films containing 30% glycerol was approximately 40 times greater than that of the corresponding unplasticised films.

Future developments

We will be continuing our research on nanoparticle-reinforced hemicellulose films with a view to fuller characterisation and a better understanding of properties in relation to potential food packaging applications. The direction described here is complemented by another strategy in which we are synthesising esterified xylans in ionic liquids with the objective of identifying new and more easily processable bioplastics for packaging and other uses.

Reference


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Comments on this article?
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Over 1.5 billion Tetra Pak cartons to go FSC

Tetra Pak has announced that many of its UK and Irish customers will now be able to use the Forest Stewardship Council (FSC) label across the nation’s favourite brands. The majority of Tetra Pak cartons in the UK and Ireland can now use paperboard sourced from FSC certified forests and other controlled sources, demonstrating the company’s ongoing commitment to responsible forest management. This development is a first in Europe, where a major liquid food and drink packaging manufacturer is now able to embark upon a wide-scale roll out. It means iconic brands of household milk, juice and liquid food will be able to sport the FSC logo across many, if not all, of their packs within the next 12 months. This development will see supply increase from 200 million FSC-certified packs available globally in 2008, to over 1.5 billion packs, in the UK & Ireland alone.

Slider closures a clear favourite

Zip-Pak, the global leader in resealable packaging solutions, has announced the results of an independent research study, which shows that 91 per cent of German consumers surveyed selected the ZIP-PAK Slidergrip closure as the easiest way to open and close a package. Respondents also said they valued the durability and perceived quality of the seal and would consider paying a premium of 4.9 euro cents on average for packages that incorporated slider technology. The study was commissioned by Zip-Pak and asked consumers to compare three types of resealable closures: single press-to-close, double press-to-close and slider. While Slidergrip was the first choice of respondents, the study also indicates that consumers prefer double zipper profiles over single press-to-close solutions due to perceived strength, robustness, durability and seal quality. The Slidergrip was described by 35 per cent of respondents as the most convenient option because it is easy to use. While the closures are ideal for a variety of applications, 60 per cent of respondents indicated a strong desire to use slider technology on cheese packages. Meat products, fresh and frozen fish, confectionery and pet food were also identified by consumers as desirable products for resealable packaging.

Sustainable packaging wins award at PACK EXPO

This year marks the fourth annual PACK EXPO Selects awards program—a display and electronic voting program that allows packaging professionals at PACK EXPO, North America’s largest packaging show, to reward innovative packaging designs, structures and processes by voting for their favorite project. Whilst the first two prizes were given to non-food containers, the third place was taken by Lloyd’s Barbecue Pork, Chicken and Beef, submitted by Airlite Plastics. Lloyd’s Barbecue is a leader in the fully cooked, refrigerated, microwaveable, heat-and-eat barbecue meat (beef, pork, and chicken) category. The primary innovation is the conversion to an IML (in-mold labelled) container and lid. The conversion allowed Lloyd’s to eliminate the paperboard sleeve that was part of the original package since all dietary and product information is now printed directly on the container and lid. This correlates to significant sustainability benefits as the elimination of the throwaway sleeve saved 973 tons of paper, according to the company. In-Mold Labeling injection molded packaging has been a standard in Europe for over 20 years but only now is it being embraced in the United States.

ScanStar for soup packaging

Faerch Plast is the first company to develop a unique packaging solution for serving soups onboard aircraft. The company’s solution has been rewarded with one of the much sought after ScanStar awards. The judges are packaging experts, appointed by the four Nordic countries’ packaging industries. In making their decision, the judges praised the attractive simplicity and functionality of the solution. Moreover, the packaging solution addressed a problem that the judges were not even aware of. Past heating of sealed soup packs produced caused the pack to ‘balloon’ and in some cases ‘explode’. The solution consists of a soup bowl and snug fitting lid that is tight enough to contain the soup, while allowing excess pressure to escape. This is achieved via the unique design of the vent-holes on the edge of the packaging. A fill level indicator in the wall of the pack, prevents the soup overflowing through the vent-holes during heating.
Modified Atmosphere Packaging (MAP) of fresh produce has posed difficult challenges for a packaging industry accustomed to barrier packaging designed to exclude atmospheric oxygen. Fresh-cut produce has been successful in the market place, in part because of the value added to the product through its preparation and delivery in a ready-to-eat condition. However, because fresh fruits and vegetables are still living, and still require oxygen for their metabolism, barrier flexible packaging has not been appropriate in most cases. The best way to reduce respiratory metabolism and thus conserve the plants stores of carbohydrate, acids and moisture, is to reduce temperature. When excellent temperature control is in place, MAP can be used to further reduce respiration rate, loss of moisture, production of metabolic heat, colour change, decay and sensitivity to ethylene.

Modified atmosphere packaging is the process by which it has become possible to optimise the atmosphere inside packaging units in such a way that the quality of the product is prolonged for an extended period of time. As the term implies, MAP involves film packaging containing a modified atmosphere. The modification process often requires reducing the amount of oxygen (O₂), decreasing it from 20% to 0% in order to slow down the growth of aerobic lifeforms and the speed of oxidation. The displaced oxygen can be substituted with nitrogen (N₂), commonly acknowledged as an inert gas, or carbon dioxide (CO₂), which can lower pH or inhibit the growth of bacteria.

In the fresh produce segment of the retail food market, MAP’s market share has risen significantly over the past few years. For MAP, barrier films and/or composite films are used, which can be rigid or soft films depending on the properties required. To ensure the gas does
not escape, barrier films, with a barrier effect tuned to the specified shelf life, are needed. Alongside high-transparency, outstanding anti-fog properties are required to keep water drops from forming inside the film and causing fogging. The modified atmosphere inside the packaging creates a gas-filled space that counteracts atmospheric pressure to such an extent that even pressure-sensitive products with long shelf lives can be packaged without risk of damage – and without the addition of preservatives.

The protective atmosphere
Nitrogen serves as a supporting gas, filling the voids and ensuring pressure compensation between inside and outside. This means the merchandise rests loosely in the packaging and is protected against deformation, slices do not stick to each other and release of liquids is minimised. Carbon dioxide (CO₂) dissolves in water and forms carbonic acid (H₂CO₃). During the packaging process a slightly acidic, preserving film forms on the surface of aqueous products, protected by CO₂. This acid atmosphere inhibits the growth of most bacteria and mould fungi. The carbon dioxide evaporates as soon as the packaging is opened or the product is heated. A high oxygen concentration prevents meat surfaces from turning brown by de-oxidation under vacuum. This means the fresh colour is retained and foodstuffs – like fruit and vegetables – can ‘breathe’. In addition, this selective supply of oxygen enables a substantially longer shelf life for many products because it prevents fermentation and minimises anaerobic bacteria counts.

MAP, therefore, facilitates a longer shelf life for packaged products, reduces waste, makes products look more appetising and renders the use of preservatives superfluous. This means it can increase productivity – and open up new markets. Products like red meat, seafood, minimally processed fruits and vegetables, pasta, cheese, bakery goods, poultry, cooked and cured meats, ready meals and dried foods can be packaged utilising MAP. The three major commodity groups are fruit and vegetables, meat and meat products, and seafood. It has been estimated that 25–40% of all fresh produce harvested will fail to reach the consumer, due to spoilage and mishandling occurring during distribution.

Effectiveness of MAP
Preserving fresh produce through packaging has been the subject of a great deal of research over the decades. Fresh-cut fruit products, both retail and for food service applications, have appeared with increasing frequency in the marketplace. In coming years, it is commonly understood that the fresh-cut fruit industry will enjoy unprecedented growth. For this reason, many leading fresh-cut salad manufacturers have targeted the development of fresh-cut fruit products as part of their long-term business plans. Fresh-cut kitchen vegetables are the largest segment of the fresh-cut produce industry. Fresh-cut salads are another important category since consumers perceive them as being healthy. A study has been conducted by Lee et al. to design a modified atmosphere package for a mixed vegetable salad, which includes 75 g of cut carrot, 55 g of cut cucumber, 20 g of sliced garlic and 50 g of whole green pepper [1]. A pouch-formed package (made of 27 mm low density polyethylene) containing a modified atmosphere of 2.0–2.1% O₂ and 5.5–5.7% CO₂, was beneficial for all components and provided better quality retention than other test packages. The performance of modified atmosphere packaging has also been evaluated for a mixed, prepared food i.e. Korean braised green peppers with dry anchovies [2]. The impact of MAP on product quality with different CO₂ concentrations at 10°C was also studied. MAP conditions of 60% CO₂/40% N₂ extended the shelf life at 10°C by 130% (to 18.4 days) relative to that achieved with stretch-wrap air packaging (7.9 days). The study was based on the time taken to reach the degredation limit of an aerobic bacterial count of 10⁵ CFU/g. It demonstrated that the relative extension of shelf life achieved with MAP was greater at lower temperatures.

Food safety qualities
The hygienic and sensory qualities of MAP have been evaluated by analysing microbial growth and atmosphere composition at the moment of packaging [3]. It has been found that the hygienic quality was comparable across all packaging systems used. However, the vegetables packaged in perforated film kept their sensory characteristics better than those packaged in air or under a modified atmosphere. The effect of a modified atmosphere of 20% CO₂, 80% N₂ on the microbial development and visual shelf life of a mayonnaise-based vegetable salad has also been reported [4]. The shelf
life of the product was increased from 40 to 54 days at 4°C storage, 12 to 22 days at 10°C storage, and 5 to 12 days at 15°C storage. A study has also been carried out to characterise the changes that occur during refrigerated storage of six salad vegetables both individually and in a mixture [5]. Salad-cut and whole lettuce, carrot, celery, radish, green onion and endive, and a salad mixture were stored at 4.4°C in packages made from a film having low gas permeability. After two weeks of storage, organoleptic evaluation indicated that the chemical treatments were generally of no value and in some cases were even detrimental, however the modified initial headspace was beneficial.

A total of 116 commercial samples of mixed vegetable salads, packaged in plastic bags, were examined for the presence of Listeria monocytogenes during storage at 4°C [6]. The results showed that the modified atmosphere did not greatly inhibit Listeria monocytogenes. Carbon dioxide concentration, Lactobacillus casei inoculum size and the storage temperature were also varied according to a central composite design in order to assess the effects of these variables and their interactions on the growth of Aeromonas hydrophila and lactic acid bacteria in ready-to-use mixed salad vegetables packaged under modified atmosphere [7]. It has been observed that the use of these hurdles may increase the shelf life and microbiological safety of ready-to-use vegetables.

Fresh-cut products often require significantly different packaging from the complete product. For whole produce, packaging is primarily designed to avoid bruising during post-storage handling. The MAP technique consists of the enclosure of respiring produce in polymeric films, in which the gaseous environment is actively or passively altered to slow respiration, reduce moisture loss and decay and/or extend the shelf life of the products. Many of the films used in MAP do not offer, on their own, all of the properties required to contain a modified atmosphere. To provide packaging films with a wide range of physical properties, many of these individual films are combined through processes like lamination and co-extrusion. There are several groupings in MAP films. Polyethylene is most commonly used to provide a hermetic seal and also as a medium of control for characteristics like anti-fogging abilities, peelability and the ability to seal despite a degree of contamination.

A look to the future

The flexible packaging industry has become increasingly responsive to the specific atmospheric requirements of fresh produce and are now providing films specifically designed for given produce items. Films for low, medium and high respiration rate commodities are now available from many package vendors and the process of matching the oxygen transmission rate (OTR) to product is being constantly refined. This has allowed fresh-cut processors to begin providing a much greater diversity of products, including artichoke hearts, baby salad greens, sliced strawberries, stir fry mixes and many others. High respiration rate commodities such as broccoli, asparagus and mushrooms have always presented a challenge to packagers. New technologies are now allowing the manufacture of very high OTR (> 15000 cc/m2-day) films for these applications.

Although much work has already been undertaken on the benefits of MAP, more research into the influence of storage temperature and atmosphere on prepared salads and fresh cut fruit needs to be done. The use of intelligent packaging systems also needs to be evaluated. In addition, the antimicrobial effect of super atmospheric O₂ in the fresh-cut produce, and the impact of antimicrobial compounds which can be incorporated into the coating need to be investigated. One area of research that is currently growing is the area of edible films for use in MAP systems.

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Comments on this article?

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www.fei-online.com/comment/MAP_research
Solidifying unsaturated oils without trans or saturated fats: the hardstock of the future?

by Michael A Rogers

Hardstock lipids, including trans and saturated fats, have been shown to have serious deleterious health effects. However, it is these ‘heart unhealthy’ lipids which impart the solid elastic properties to foods. It is the intention of this review to examine new technologies which present the first viable alternatives to structuring lipid products without the use of saturated or trans fats.

Traditional high-fat foods such as ice cream, margarine, butter, lard, and chocolate attain their semi-solid structure from hardstock lipids, which rely on trans and saturated fats to supply their desired elastic properties. Although these ingredients contribute a highly desired physical structure to food products, they are often associated with deleterious health factors such as adverse effects on lipoprotein (cholesterol) profiles, increased incidence of heart disease and metabolic syndrome. It is estimated that around 20-25 percent of the world’s adult population suffers from metabolic syndrome. Sufferers are three times more likely to experience a heart attack or stroke compared with non-sufferers. In addition, patients with metabolic syndrome have a five fold greater risk of developing type 2 diabetes. 230 million people worldwide have been diagnosed with diabetes, one of the most common chronic diseases worldwide and the fourth or fifth leading cause of death in the developed world [1]. The negative health implications associated with diets high in trans and saturated fats may be reversed by reducing the intake of these ‘heart unhealthy’ fats and replacing them with polyunsaturated fats.

In an attempt to curb this new epidemic, governments across the globe including the United States, Denmark and Switzerland have passed aggressive legislation limiting (and in certain cases banning) trans fats in foods. This move has been mirrored by numerous multi-national foodstuff corporations struggling to reduce even further trans and saturated fats in their products. Despite herculean efforts by both governments and corporations, the major challenge is not one of willingness but the lack of suitable ingredient technology.

A look at lipids
Lipids, as an ingredient, supply flavour, mouthfeel, satiety and structure. Lipids that are solid at room temperature have
Butter relies on the trans and saturated fats for its desired elastic properties.

very straight fatty acid backbones the most common being mystic, palmitic, and stearic acid. However, polyunsaturated fats with the same number of carbons as stearic acid (i.e., oleic acid (18:1), linoleic acid (18:2) and linolenic acid (18:3)) are solid at much colder temperatures. For example stearic acid will crystallise at approximately 65°C, while oleic acid crystallises around 10°C and linoleic acid at -10°C. Hence the inclusion of polyunsaturated lipids into semi-solid food products is constrained by their temperature range. Typically, hardstock lipids are soft, plastic materials with different levels of structure which influences their macroscopic properties. Upon cooling, saturated and trans lipids have limited solubility and, via nucleation, assemble and grow into small spherical crystals interacting via non-covalent forces, thus forming a continuous network of lipid crystals. Lipids, below their melting point exist as a 3-dimensional colloidal fat crystal network, which confers their desirable physical properties. Upon crystallisation, hardstock lipids aggregate to form fat crystals. These in turn interact to form clusters which eventually aggregate into flocs. Weak links develop between flocs to form the final macroscopic network. These hardstock fats have been central in the development of solid-based lipid products. However, given legislative and consumer pressure to reduce saturated fat levels, the food industry is at a cross roads; how to go forward in order to reduce the amount of traditional hardstock fats in foods?

**The search for lipid replacers**

With this in mind, researchers have been actively researching novel lipid replacements. In order to be effective, these ingredients should provide sufficient elastic properties and a solid appearance. Self-assembled fibrillar networks (SAFiNs) have been central over the past five years to this exhaustive research effort. SAFiNs, as opposed to colloidal fat crystal networks, produce 1-dimensional crystals from low molecular weight compounds (as opposed to spherulitic crystals produced from higher molecular weight compounds (i.e., triacylglycerides)). Numerous new technologies have been developed and studied; however, major complications have presented an obstacle to their introduction into the food industry. Examples of such limitations include; stearic acid gels - due to the unhealthy connotation of saturated lipids; span and tween gels - due to the high concentrations required; lecithin gels - due to their instability; and hydroxylated fatty acids, - due in part to their laxative effect. However, three promising new technologies are currently under development and these may have an impact on reducing the amount of trans and saturated fats in complex food products. The first has been developed at the University of Guelph, Canada. Here researchers have exploited the application of L<sub>α</sub> liquid-crystalline lamellar phase of monoglycerides in water and oil emulsions [2]. Cooling the emulsion causes the droplet wall previously coated with the L<sub>α</sub> liquid-crystalline lamellar phase to crystallise, thereby efficiently entraining the liquid oil. From a nutritional stand-point this fat-like material contains no trans fats and may be designed with as little as 4% saturated fat. The β-gel structure has other positive physiological effects; e.g. blood TAGs, free fatty acids and insulin levels are lower following a concentrated intake of the

γ-oryzanol and phytosterols are both capable of acting as hardstock lipid replacers at concentrations of between 2-4% in vegetable oil [3]. γ-oryzanol and phytosterol mixtures form fibrillar hollow tubes that are 7.2±0.1 nm in diameter [4]. The ability of these compounds to act as a hardstock lipid replacer is dependent on several structural features of phytosterols. These include; the position and presence of the hydroxyl group, the presences of unconjugated rings, and the number of double bonds present in the ring structure. Constraints acting on phytosterols’ gelling systems include the narrow melting ranges and the difficulties experienced in significantly manipulating their structure. The most intriguing aspect of this novel system, however, is that plant phytosterols are capable of lowering blood cholesterol levels. This characteristic imparts a healthy aspect to this potential food ingredient.

Each of the aforementioned systems has at least one significant limitation. These include health implications, a lack of crystal network flexibility and practical limitations. The final system, which may overcome these practical limitations, is the application of ceramides to replace traditional fat crystal networks.

**The role of ceramides**

Ceramides are a class of polar lipids found everywhere in nature. It has been demonstrated that sphingolipids and ceramides reduce total serum cholesterol by 30%, improve the chemical composition of serum lipoproteins and can also induce apoptosis (cell death) in cancer cell lines. The crystal network of ceramides can be modified...
by adjusting their chemical composition. Ceramides, like triacylglycerides exhibit variability in the fatty acid chain length, degree of saturation and chemical substitution. For example, ceramides with short carbon side chains form long thin fibres several hundred microns in length [5]. Conversely, mixed ceramide systems extracted from milk or eggs have long carbon chains (i.e., C16-C24) and produce small maltese-cross crystals, which are capable of immobilising the oil efficiently. The only limitation to this technology is the lack of an industrial supplier who can extract these compounds from a food grade source, in a food grade fashion, and at a reasonable price. Current research in this field is examining the feasibility of extracting these compounds from by-products of the biodiesel and bio-ethanol industries, which concentrate ceramides during the processing of these commodities.

With metabolic syndrome quickly becoming a worldwide epidemic there is an urgent need to reduce or eliminate trans and saturated lipid consumption from manufactured foods. Research must be implemented quickly to reduce the amount of unhealthy fats, sugar and sodium in our food. If action is not taken, serious health consequences will follow. Ceramides are a promising group of compounds able to solidify liquid vegetable oils. These compounds confer desirable health benefits and are also able to closely mimic the structure of colloidal fat crystal networks. This technology is the first viable alternative to structuring lipid products without the use of saturated or trans fats.

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Comments on this article? Feel free to post them at www.fei-online.com/comment/Ceramides
The application of nanotechnology to food science is gaining ground. Research is growing into how particles at the nano scale can be used for the development of new food products. In this article, Food Engineering & Ingredients Magazine talks to Dr Arpagaus, from Büchi Labortechnik AG, about the latest developments in spray drying that are set to take the food industry by storm.

Q1. Büchi has been developing spray drying technology for over 30 years. With your latest model the Nano Spray Dryer B-90, particle sizes in the nanometre range can be obtained. How does your technology make this possible?

Büchi Labortechnik AG has integrated a unique new technology into this spray dryer. It features a nozzle incorporating vibrating mesh components to produce extremely small droplets, which can be dried to very fine solid particles. An electrostatic particle separator is also present to collect the finest particles (down to the nanometre scale) providing very high recovery rates for even small amounts of powder. In addition, a patented heater technology gently dries delicate and valuable substances in a laminar gas flow.

Q2. What are the possible applications within the food industry for spray drying such small scale particles?

Typical spray drying applications include the production of milk powder, baby food, fruit juices or coffee extracts for easier dosage, lower volume and better conservation. The Nano Spray Dryer B-90 focuses on small amounts of powder for very fine functional food additives, like vitamins, proteins, aromas, flavour enhancers, herbal extracts or other precious ingredients. Such heat-sensitive food additives are typically encapsulated in matrix materials like maltodextrin or gum arabic to maintain their vitality.

Other potential applications in the packaging industry are also foreseen. Here, food quality is improved by light resistant, oxygen protective or anti microbiological packaging materials based on novel nano scale features.

Q3. Are there currently any projects underway which uses the new technology for food research?

By Dr Cordin Arpagaus

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Many researchers are very active in the development of nano food ingredients encapsulating nutraceuticals, a combination of food extracts (e.g. antioxidants) which have a medicinal effect (e.g. controlled release) on human health. Using Nano Spray Dryer B-90 technology it is possible to generate breakthrough innovations in this research field. For example, the very small spray dried particle sizes and the typically amorphous powder structure increase the bioavailability of food additives.

Q4. How important is it to fully research the way molecules act at the nano scale if materials are used to be in food?

It is crucial to be absolutely sure about product safety before releasing a new ‘nanofood’ ingredient onto the market. Nanoparticles have to be tested as if they were completely new substances, and there is a need to look at each individual case in detail. Feasibility studies have to be carried in order to measure toxicity and health impacts. So far, only a few nano ingredients are available on the market and we are still very much at the early stage of development. An example of this is research into fats or proteins and their novel properties for better handling, taste, stability or functionality. Research will continue to incorporate nanostructures into food processing systems for improved food quality and to promote human health.

Nanotechnology is an emerging area with massive potential and will attract interest from the public, some of whom will welcome it, while others will mistrust it. The particles produced in the Nano Spray Dryer B-90 are less harmful when compared to ordinary nano particles, because the particles produced by the dryer group together physically in micron-size agglomerates. These agglomerates will not cross the body’s natural defensive barriers.

The new Nano Spray Dryer B-90 technology presented here is designed to enhance the health promoting properties of beverages and foods, whilst providing substantial protection against deterioration to the encapsulated ingredient during its shelf life.

Lab-scale spray dryers will be used in R&D laboratories and in academia in order to research formulations for new food ingredients. Small batches of highly valuable products in powder form will be produced. If an ingredient receives the green light for launch to consumers this novel spray drying technology can then be scaled-up on an industrial basis.

Q5. Looking to the future, how do you envisage your technology will be used in the food industry over the coming years?

The food industry is increasingly turning to encapsulation technologies as a way of adding product value. Innovative spray drying techniques are becoming increasingly important to food manufacturers. While the focus has been on microencapsulation, more and more research is examining the potential for nanoencapsulation.

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The effects of irradiation on meat flavour: an overview

by Professor S. Brewer

Irradiating food with $\gamma$-rays, X-rays and accelerated electrons can kill microorganisms responsible for both spoilage and foodborne illness. However, the high energy input, which results in the radiolytic cleavage of water and kills microbes, can also initiate oxidation of fats and break down of sulfur-containing amino acids resulting in off-odours and flavours.

**Irradiation**

The potential for inactivation of foodborne and spoilage bacteria using irradiation ($\gamma$-rays, X-rays and accelerated electrons) has long been known. Soon after the discovery of X-rays (1896), patents were filed to use irradiation in order to improve the condition of food. Most food spoilage organisms are eliminated with a 1.0 kGy dose. A 1.5 kGy dose of irradiation can result in a 6-log reduction in *E. coli* O157:H7 [1]. Recently, Ramamoorthi, Toshkov and Brewer [2] reported that irradiating fresh (inoculated) beef at 1.0 – 1.5 kGy reduced initial total plate counts from >5 CFU/g to <2 CFU/g. These reductions were maintained over the 21 day storage period. Irradiation at 2.0 kGy resulted in no detectable microorganisms.

Raw meat, especially raw ground meat, has been the vector of a variety of pathogenic bacteria which has resulted in outbreaks of foodborne illness in recent years (e.g. *E. coli* O157:H7, *Campylobacter*). The maximum irradiation dose permitted for meat depends on the type (poultry vs. red meat), and form in which it irradiated (chilled vs. frozen). Irradiation of fresh and frozen poultry was approved in 1992 [3] and is published in the Code of Federal Regulations [4]. Irradiation of red meat was approved in 1997 [3]. Up to 4.5 kGy is permitted for uncooked, chilled red meat for pathogen reduction; up to 7.0 kGy is permitted for uncooked, frozen meat; up to 3.0 kGy is permitted for fresh or frozen poultry.

The radionuclides approved for food irradiation include $^{60}$Co and $^{137}$Cs. They decay to nonradioactive nickel and barium, respectively by emitting $\gamma$-rays and $\alpha$ or $\beta$ particles. The $\gamma$-rays kill rapidly growing cells (microbes) but do not leave the product radioactive. $\gamma$-rays are highly penetrating, so they can be used to treat packaged food. High energy particles can be produced by ‘accelerating’ electrons using electricity, then propelling them out of an electron gun in a stream (e-beam). The electrons can penetrate 5-10 cm into food. Treating packaged food is advantageous in preventing post-processing contamination.
Development of off flavours and odours in meat

Irradiating fresh meat for safety, even at low doses, can result in off-odours and flavours (rotten egg, wet dog, blood, fish, barbecued corn, burnt, sulfur, metallic, alcohol, acetic acid). The odours produced vary depending on the type of meat, composition of the fat (highly saturated vs. polyunsaturated), temperature during irradiation, exposure of the product to oxygen during and/or after the irradiation process, packaging, and the presence or addition of antioxidants.

‘Flavour’ results from the combined effects of the basic tastes (salt, sour, bitter, sweet, umami) and odours, which are derived from substances originally present in the food product or are produced via various reactions [5]. The precursor compounds depend on the chemical composition of the fresh product. A wide array of flavour- and odour-active volatiles occur in meat (acids, alcohols, aldehydes, aromatic compounds, esters, ethers, furans, hydrocarbons, ketones, lactones, pyrazines, pyridines, pyrroles, sulfides, thiocarboxylic acids, pyrazines, pyridines, pyrroles, sulfides, thiazoles). Compounds that elicit various tastes and odours have widely different thresholds for perception and a particular compound may taste/smell different at different concentrations. The ultimate flavours of meat products subjected to irradiation can vary widely. However, most of the irradiation-induced odour/flavour changes in meat are a result of lipid oxidation, breakdown of sulfur-containing amino acids or both.

Irradiation energy can cause atoms/molecules of biological materials to eject electrons. Ultimately, radiolysis of water by highly energised electrons into free radical species (•OH, •H, H₂O, e⁻) may be the initiator of both lipid oxidation and sulfur-containing volatiles responsible for irradiation odour. γ-rays can provide the activation energy required for radiolysis. Most chemical changes in irradiated meat are associated with free radical reactions. Hydroxyl radicals (•OH) tend to react with conjugated systems and are often considered to be the initiators of lipid oxidation in muscle tissue. Unsaturated fatty acids (linoleic, linolenic, arachidonic) are of primary concern. They are electron-deficient at the carbonyl groups and at the carbon-carbon double bonds making them particularly likely to form free radicals. Once free radicals form, autoxidation then proceeds via traditional pathways [Figure 1]. Reducing the temperature during the irradiation process reduces free radical generation and dispersion reducing the effects on odour/flavour. Freezing increases the viscosity, which also reduces free radical dispersion.

Irradiation generally accelerates lipid oxidation, especially the unsaturated fatty acids [6]. The most common fatty acids occurring are oleic, linoleic, arachidonic, palmitic and stearic acids. Turkey and chicken dark meat contain similar amounts of linoleic acid (18:2, 1.75 and 1.87 g/100g lipid, respectively; Table 1) and substantially more than is found in beef (0.12 g), pork (0.30 g) and Atlantic salmon (0.67 g). The total amount of fatty acids 16:1, 18:1 and 18:2 are highest in chicken dark meat (5.33 g). It is similar in turkey white and dark meat, and Atlantic salmon (3.84, 3.34, and 3.49, respectively), while it is lower in beef and pork (1.54 and 1.82, respectively). These unsaturated fatty acids are the primary source materials for lipid oxidation.

Irradiation can induce the formation of volatile compounds (1-heptene and 1-nonene) resulting in fatty, tallowy odours, and aldehydes (propanal, pentanal, hexanal) resulting in cooked, pungent, and grassy odours from the fat fraction of the meat. Increasing the irradiation dose increases the volatiles, while cooking reduces them. Once formed, aldehydes are generally influenced most by packaging type (aerobic vs. vacuum). Ramamoorthi, Toshkov, and Brewer [2] reported that the beef odour of raw beef irradiated over a range of doses (0.5 to 2.0 kGy) was higher initially and after seven days of refrigerated storage than after days 14 to 21 days. Aerobically packaged samples had lower beef odour scores than those in modified atmosphere containing carbon monoxide. Irradiation slightly decreased sour/acid odour. Storage time had a significant effect on acid/sour, grassy, sweaty and rancid odours. Acid/sour odour increased and rancid odour decreased on days 14 and 21. Grassy and sweaty odours increased on day 21. Changes in grassy, sweaty and rancid odour are indicative of oxidation, which often occurs over time. Loss of beef odour and increases in acid/sour odour can also be indicative of spoilage over time. Ultimately, they concluded that storage time was the major factor affecting odour, decreasing raw beef

| Table 1-- Fatty acid composition of selected types of meat. |
odour, and increasing acid, grassy, sweaty and rancid odour. Ramamoorthy, Toshkov, Tucker, Stetzer & Brewer [7] reported similar changes in acid/sour and rancid odours or irradiated beef.

Irradiation can also affect the protein fraction of meat. Aqueous electrons produced from radiolysis of water promote the release of sulfur from sulfur-containing compounds such as cysteine, methionine, glutathione, taurine, and thiamine in fresh meat [8].

Fishy, putrid odours are the result of formation of dimethyltrisulfide, while sulfurous odour is often the result of bismethylthiomethane. Sulfur-containing compounds generally have very low thresholds for human sensory detection; the odour detection threshold for 2-methyl-butanethiol is <0.0001 ppb. For this reason, these compounds can have significant negative impacts on aroma. The concentration of sulfur-containing amino acids in meat prior to irradiation might be expected to have significant effects on the odour after irradiation. When expressed in terms of total sulfur-containing amino acids (cysteine + methionine), chicken contains 1.58 g/100 g, about twice that of beef, lamb, perch and salmon (0.87, 0.75 g, 0.97 and 0.89 g/100g, respectively; [9]).

The volatile compounds responsible for the off-odour in irradiated meat produced by the impact of radiation on protein and lipid molecules are different from those of lipid oxidation alone. Increasing lipid peroxidation products (especially hexanal) in combination with the loss of desirable meaty odourants (4-hydroxy-2,5-dimethyl-3(2H)-furanone) results in development of ‘warmed over flavour’, the stale flavour of re-heated meat. However, irradiation produces alkanes and alkenes that appear to be the result of both unsaturated fatty acid and amino acid breakdown producing the rotten egg, wet dog, bloody, fishy, barbecued corn, burnt, sulfur, metallic, alcohol, and acetic acid odours commonly attributed to irradiated meat.

The irradiation-induced oxidation increases as storage time increases. However, if the product is stored in an aerobic environment, the low molecular weight sulfur compounds, which are highly volatile, can dissipate - allowing the meat to regain some of its original flavour.

**Prevention of adverse effects**

Oxygen exclusion (vacuum packaging), replacement of oxygen with inert gases (nitrogen), addition of protective agents (antioxidants), and post-irradiation storage to allow flavour to return to near-normal levels (re-packaging or double packaging in oxygen permeable film), and their combinations, are effective methods to decrease the detrimental effects of irradiation.

**References**


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**Table 2**—Flavours and aromas associated with volatile compounds found in meat.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Flavours and Aromas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butanoic Acid</td>
<td>Rancid</td>
</tr>
<tr>
<td>Hexanoic Acid</td>
<td>Sweaty</td>
</tr>
<tr>
<td>Octanoic Acid</td>
<td>Sweaty</td>
</tr>
<tr>
<td>Propanoic Acid</td>
<td></td>
</tr>
<tr>
<td>Pentenal</td>
<td>Pungent, almond, malt</td>
</tr>
<tr>
<td>Hexenal</td>
<td>Fatty, rancid, WOF</td>
</tr>
<tr>
<td>Heptenal</td>
<td>Fatty, fatty, oily, rancid</td>
</tr>
<tr>
<td>Nonenal</td>
<td>Fatty, waxy</td>
</tr>
<tr>
<td>Decanal</td>
<td>Fatty, rancid, meaty, burnt</td>
</tr>
<tr>
<td>Undecanal</td>
<td>Pungent, fruity</td>
</tr>
<tr>
<td>2-hexenal</td>
<td>Rancid</td>
</tr>
<tr>
<td>3-methyl butanal</td>
<td>Fatty, rancid, burnt</td>
</tr>
<tr>
<td>3,4-epoxy-(E)-2-decenal</td>
<td>Rancid</td>
</tr>
<tr>
<td>E2-hexenal</td>
<td>Rancid</td>
</tr>
<tr>
<td>E2-heptenal</td>
<td>Rancid</td>
</tr>
<tr>
<td>E2-nonenal</td>
<td>Rancid</td>
</tr>
<tr>
<td>E, E2,4-nonenal</td>
<td>Fatty, fruity, burnt</td>
</tr>
<tr>
<td>E, E2,4-heptadecal</td>
<td>Fishy, cooked meat</td>
</tr>
<tr>
<td>2-heptanone</td>
<td>Fatty</td>
</tr>
<tr>
<td>2-nonanone</td>
<td>Fatty</td>
</tr>
<tr>
<td>1-octen-3-one</td>
<td>Metallic, green, grass</td>
</tr>
<tr>
<td>3-hydroxy-2-butanoate</td>
<td>Aldehyde, butter, burnt</td>
</tr>
<tr>
<td>1-hexanol</td>
<td>Metallic, green, grass</td>
</tr>
<tr>
<td>1-nonanol</td>
<td>Fatty</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Sulfurous</td>
</tr>
<tr>
<td>Diethyl disulfide</td>
<td>Burnt rubber</td>
</tr>
<tr>
<td>Dimethyl sulfide</td>
<td>Cabbage, sulfur, gasoline</td>
</tr>
<tr>
<td>Dimethyl disulfide</td>
<td>Onion, cabbage, putrid</td>
</tr>
<tr>
<td>Dimethyl trisulfide</td>
<td>Sulfur, fish, cabbage</td>
</tr>
<tr>
<td>Methanethiol</td>
<td>Garlic, sulfur</td>
</tr>
<tr>
<td>Bismethylthiomethane</td>
<td>Sulfurous</td>
</tr>
<tr>
<td>2-methylbutanethiol</td>
<td>Meaty to sulfurous</td>
</tr>
<tr>
<td>4-hydroxy-2,5-dimethyl-3(2H)-furanone</td>
<td>Meaty</td>
</tr>
<tr>
<td>Pyrazines</td>
<td>Nutty, cracker, roasted</td>
</tr>
</tbody>
</table>

Food Engineering & Ingredients
Ideal food packaging not only contains the product, but also protects against deterioration, transmits information to consumers, and is convenient to use. Clear, air-permeable polyvinylchloride or polyethylene film (stretched tightly over the meat on a polystyrene or foam tray) has, for many years, delivered the desired packaging characteristics for retail meat display cases. A recent innovation in packaging technology is modified atmosphere packaging (MAP). MAP removes or replaces the gases surrounding the meat before sealing it in vapour-barrier materials. Although MAP packaging materials are usually more expensive, they are valued for utilising less retail labour and space, increasing shelf life, improving inventory control, maintaining uniformity and reducing waste.

The headspace environment and product may alter during storage, but there is no additional manipulation of the internal environment as with controlled atmosphere packaging (CAP). CAP continuously monitors the product environment so it can be maintained at a stable gas atmosphere, temperature, and humidity. CAP has most often been used to control ripening and spoilage of fruits and vegetables in bulk containers larger than retail-sized packages.

**Expectations of meat colour**

The colour most expected by consumers for red meats is *cherry red*, arising from the binding of oxygen (O₂) (blooming) or carbon monoxide (CO) to myoglobin pigments. Any change in the oxidation-reduction mechanism gives rise to other meat colours. A purple colour occurs when oxygen is totally excluded, as with both vacuum packaging and anoxic packaging containing nitrogen (N₂) and/or carbon dioxide (CO₂) gases. Brown (oxidized)
colours are caused by lack of reducing capability as meat ages or is exposed to light, heat, or other oxidizing conditions.

**Innovation in packaging**

Many advances in MAP for meat products have been in those areas of technology labelled as active or intelligent packaging. Active packaging incorporates specific compounds into packaging systems in order to maintain or extend product quality and shelf life. Intelligent or smart packaging can sense food properties or the package environment in order to alert the processor, retailer and/or consumer to environment or food status. Other packaging innovations are less conspicuous, but allow for increased shelf life and quality.

No single type of plastic possesses all of the properties required to create the ideal packaging solution. As a result, laminated films (films physically bound in layers) or extruded films (films chemically bound in layers) have been developed. Progress in lamination and extrusion technologies has created a wealth of choice in terms of film type, thickness, porosity, and size. Demands for source reduction and materials that can be recycled has also driven the development of new and different plastics. Alternatives to petroleum-derived plastics such as polyactic acid or edible films have not been readily adaptable to meat products. This is because meat has a high moisture content, is relatively dense, and has a relatively short shelf life. Packaging equipment manufacturers have kept pace with automated systems which allow for high speed assembly, packaging, sorting, labelling and cartoning of meat in MAP.

MAP packages with gaseous atmospheres have a headspace between the product and underside of the top film and also sometimes on the sides of the product. Any temperature differentials between the package interior and the external environment may cause condensation of water droplets on the underside of the film due to the high moisture content in meat. Chemicals to lower the surface tension of the water act as antifogging agents and are either sprayed or dipcoated onto the inner film layer or extruded into the polymer for migration to the film surface. Surface antifog compounds tend to lose effectiveness more rapidly than imbedded antifog agents.

**Oxygen concentration is key**

O₂ levels are important in many MAP packaging systems. In aerobic systems, oxygen above 40% is necessary to provide the red colour bloom of the meat. This ensures that colour is not the first characteristic to deteriorate to an unacceptable level. In anoxic or anaerobic MAP systems, it is necessary to reduce residual O₂ levels to below 1%, and preferably below 0.5%, during the packaging process because O₂ between 1 and 12% will cause the myoglobin pigment present to change irreversibly to a brown colour (metmyoglobin). Oxygen scavengers are sometimes used in sachet-type packets to reduce O₂ to acceptable levels.

Another concern for raw chilled meat in storage is exudate or purge; the fluid that is released from the meat due to pressure from contact with other packages or due to the effects of gravity over time. Absorbent pads are often placed in the bottom of trays to absorb any excess fluid. These may be paper, fiber or plastic composites. Some trays have imbedded absorbent materials and holes in the layer next to the meat to allow wicking of the fluid from the bottom of the tray and into the absorbent material.

**The presence of pathogens**

Microbial presence and growth is always a concern in meat, whether as spoilage bacteria that limit shelf life or pathogens that impact product safety. Some antibacterial agents have been tested as coatings to, or imbedded compounds in, films but effectiveness is reliant upon the film contacting the meat surface and transferring sufficient antibacterial agent to destroy or inhibit the microorganism. A difficulty with film-to-meat contact is that many of the plastic polymers initiate oxidation reactions that cause the red colour of bloomed meat to become irreversibly brown. For that reason, films with antibacterial agents will have more use in packaging of processed ready-to-heat or ready-to-eat meats that have a stable colour or are not expected by consumers to have a red colour. Antioxidant compounds imbedded into plastic materials have similar limitations as antimicrobial agents. Contact with the packaging materials is needed for effective control of oxidative deterioration.

**Extending shelf life**

Several technologies have been proposed to extend the shelf life of meat in MAP whilst providing the conditions that will cause meat to exhibit the expected red colour for retail display. Meat in air (21% O₂) has a shelf life of seven days or less. Use of greater than 40% O₂ will promote lipid oxidation and sometimes bone darkening in meat without antioxidants earlier
than the 14 to 16 day colour display life usually obtained with high oxygen levels. Gas exchange systems that initially package meat in anoxic atmospheres (usually vacuum or CO₂ and N₂) allow up to 30 days storage and distribution before exchange of the gases with the desired display gas that contains O₂.

One system uses meat conventionally overwrapped in air-permeable film with one or more packages placed in a larger master pack that is flushed with the anoxic gas mixture. Removal of the overwrapped packages from the master pack will allow air to permeate through the film and change the meat colour to red. If the air-permeable film is stretched too tightly against the meat, the rate of air contact and the development of colour will be slowed. Other systems rely upon dual lidding films, one permeable and the other acting as a barrier, with the permeable film innermost to the meat and the barrier film on the package exterior. When it is decided to expose the product to room air, the barrier layer is peeled away so air can diffuse through the permeable film and cause the product to bloom. In practice, unless the permeable film has been perforated with microscopic holes that allow air to penetrate, the pores in unperforated film are not sufficient in number or size to allow uniform blooming of the meat surface.

Another difficulty is that the static nature of the anoxic gas makes diffusion of air through the permeable film very slow. These technical deficiencies can be resolved by using equipment that either make a small hole in the barrier film or slices open the seal on barrier packages. Vacuum pumps remove the anoxic atmosphere and high CO₂ gas mixtures, usually with CO₂ added, are flushed back into the package before either the small hole is patched with a label or the end of the package is resealed. The use of equipment for actively exchanging the gases speeds the process and provides a uniform and assured red colour development. However, the use of such machinery is not familiar to retail personnel and has a higher capital cost than most retail meat equipment. As a result, this form of gas exchange technology is not in commercial practice.

Other systems use CO to cause carboxymyoglobin red meat colour at the time of packaging. This process can take place in barrier MAP or within a master pack system using air-permeable packaging. The consumer controversy over potential exposure to the low levels (less than 0.5%) of CO have partially subsided, so retail sales of meat in these packages continues on a limited scale in the US. To conclude, the food industry requires improved product consistency and cost-effectiveness, a long shelf life, and an acceptable product appearance. As a result, any current, proposed, or future MAP systems must excel in these areas in order to ensure their adoption in commercial practice.

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The cherry red colour of red meat is due to binding of oxygen (O₂) or carbon monoxide (CO) by myoglobin pigments.

Comments on this article?
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Over the past three decades, Near Infrared Reflectance (NIR) spectroscopy has been shown to be one of the most efficient and accurate tools for predicting various meat quality criteria. NIR spectroscopy is a suitable alternative to other analytical procedures since it is a rapid and non-destructive method, entailing minimal sample preparation. The technique does not require reagents nor does it produce waste and it can be easily integrated into the production process.

Meat demand and consumption is generally high in most developed countries. As a very heterogeneous product, chemical composition and sensory attributes are strongly influenced by pre-slaughter factors (individual breed, sex, age, weight and environment) and post-mortem factors (maturation time, temperature conditions). Variability in the quality of meat available has shown to be a concern in consumer preference studies. Indeed, it has been noted that in most developed countries where the purchasing power of the population does not limit the consumption of meat, some consumers are willing to pay a price premium for a more dependable product along with certain additional quality characteristics, such as tenderness.

Nowadays, meat is increasingly consumed as part ready-to-eat, convenience products such as hamburgers and sausages. In the processed meat sector, premium quality material can be adulterated by the inclusion of inferior grades, which carries with it a number of legal sanctions. Consequently, consumers need assurance that they have received the precise quality of meat they have paid for.

In order to keep quality standards high, meat products must be subject to control procedures. Different techniques including chemical procedures, instrument testing, sensory analysis and screening have been used to provide reliable information. However, these
techniques are destructive, time-consuming and consequently unsuitable for on-line applications. In contrast to conventional methods employed to determine meat quality, near infrared reflectance spectroscopy is a sensitive, fast and non-destructive analytical technique, entailing minimal sample preparation. NIR facilitates the simultaneous assessment of numerous meat characteristics.

NIR spectroscopy utilises the spectral range, 750 to 2,500 nm [Figure 1]. The process [Figure 2] involves measuring the response of the molecular bonds O-H, C-H and N-H, when subjected to vibrational energy changes during irradiation by NIR frequencies. These hydrogen bonds have unique and characteristic absorption frequencies relatively free of bias from internal and external sources; hence it is possible to build a characteristic spectrum that behaves as a fingerprint for a particular sample. In a scanned sample, the NIR composite spectrum data provides information about chemical constituents as well as tissue ultra-structure.

**The applications of NIR**

NIR spectroscopy has been successfully applied to the quantitative determination of the major constituents (moisture, fat and protein) of meat and meat products [1]. In fact, the near infrared procedure has been approved by the international committee for validating analytical procedures (AOAC) [2] as applied to the commercial analysis of moisture, fat and protein in meat and meat products. In addition, discrimination between frozen and unfrozen beef [3], beef and kangaroo meat [4], as well as adult steers and young cattle ground meat samples [5] is possible using NIR.

However, studies established in order to exploit NIR’s ability to predict technological (instrumental texture and water holding capacity) and sensory (tender- ness, juiciness and flavour) parameters in meat and meat products show less reliable results [6,7]. The association between NIR measurements and technological and sensory attributes emerges from either the chemical (e.g. water, lipid and protein content) or physical or structural (e.g. muscle fibre characteristics) properties of the meat. It should be noted that NIR spectroscopy is a secondary method, so that its true precision depends on the reference method used for calibration. E.g. instrumental texture or the subjectivity of the assessors when scoring the sensory attributes (in albeit scientifically-constructed consumer taste panels). Therefore, the reference method must be chosen carefully according to the particular needs of each study. As a secondary procedure, NIR requires calibration by reference to a primary method which uses a calibration set of typical specimens representative of all future samples. This means that all the variables one is likely to encounter in future samples must be represented in the calibration set. Otherwise, NIR spectroscopy findings will not be wholly accurate.

**Improving workability**

Although the individual analytical cost of using NIR is low, the price of a suitable NIR instrument is over £30,000. This means that the technique may not be viewed as attractive to food processors and producers. In addition, the technique needs to be tested and calibrated in research trials. Recently, meat researchers and analysts have been trying to identify wavelengths at which NIR measurements are closely associated with various characteristics of meat quality. By isolating the critical wavelengths, it should be possible to obtain more robust calibrations, and so develop simple and low-cost instruments employing only these specific wavelengths. Furthermore, the use of fibre-optic probes may significantly improve the ability of NIR to monitor and control meat processing via remote on-line detection. For example, Brøndum et al. [8] and Hoving-Bolink et al. [9] used a fibre-optic probe on intact carcasses to estimate meat quality attributes. Despite the challenging operational environment at abattoirs and slaughterhouses with, for example, fluctuations in temperature and humidity, fibre-optic probes significantly improved the ability of NIR to monitor and control these processes. This demonstrates that NIR is a suitable technique to simultaneously predict...
various meat quality criteria, on-line, at processing speeds, taking place in a commercial environment.

In conclusion, it is anticipated that NIR spectroscopy will become more widely accepted in many meat industry applications as more attention is given to reducing errors in reference methods, more robust calibrations are developed by using larger sample data sets (with wide ranges and variation in the reference values) and the transfer of calibration models is enabled for commercial applications.

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Product news - Packaging technology

Portable quality control

The CheckPoint II is a portable headspace analyser that gives operators and QC managers easy access to important information about the gas composition in modified atmosphere packaging. The device has data logging capabilities, the possibility of transferring data to a PC and an optional bar code scanner. The CheckPoint II is ideal for small to medium volume production facilities or other situations where a portable analyser is useful. This new machine ensures traceability of any modified atmosphere production package - without relying on paper logs. The simple user interface ensures that line operators can be easily taught to use the CheckPoint II thus ensuring the shelf life of MAP-packed products.

PBI-Dansensor A/S
Ringsted, Denmark
www.fei-online.com & search 10652

Four-ply aseptic bags

The new four-ply aseptic bag solves the issue of flex cracking, a very frequent problem causing de-lamination, demetallisation and eventually breaking the bag. This happens frequently and can jeopardise product preservation, caused by the continuous movement of the bag content during handling and transport, which leads to erosion of the bag structure. The use of superior resin recipes and the addition of a fourth inner ply, has created an aseptic bag with an extremely flexible structure, which maintains the usual barrier and mechanical properties, but performs exceptionally well against flex cracking. The new 22OI bag is available in the standard and extra-high barrier (with aluminium foil) versions and it is particularly suitable for low-viscosity products such as citrus fruit concentrates, juices, apple juice, purees and diced tomato.

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This article describes a strategy to improve poultry meat shelf life. Traditional packaging methods are described alongside new research, which examines how Modified Atmosphere Packaging (MAP) can be employed to reduce spoilage by microorganisms and minimise product oxidation. In particular, the impact of using a MAP argon/carbon dioxide gas mix to extend the shelf life of turkey meat is assessed.

In the last few decades, the retail presentation of meat and processed meat has changed dramatically as a result of the use of MAP and cold storage. This technology has contributed to the reduction of microbial spoilage and microbial and lipid oxidation of meat products. MAP has encouraged new product development and opened up new markets by facilitating alternative meat storage management and distribution practices. Shelf life and consumer handling have also been improved. However, the success of this technology for meat packaging depends on the specificity of gas mixtures being tailored to meet product requirements, the nature and initial quality of the meat, temperature control, the barrier properties of the packaging film, and the efficiency of the equipment used.

MAP gas mixtures approach
The usual gas mixture used for retail sliced poultry under MAP is 20% carbon dioxide (CO₂), 70% oxygen (O₂) and 10% nitrogen (N₂) yielding a shelf life of approximately eight days. The elevated oxygen levels employed in high oxygen MAP saturate meat pigments with oxygen and slow surface metmyoglobin formation. However, they also accelerate lipid oxidation, off-flavour development and premature browning during cooking [1]. The use of CO₂-enriched atmospheres extends the shelf life of raw meat by inhibiting psychrotrophic Gram-negative bacteria and Pseudomonas spp. CO₂ is the only gas with a direct antimicrobial effect, resulting in an increased lag phase and generation time during the logarithmic phase of bacterial growth. Eventually, however, meat spoilage and changes in organoleptic characteristics are observed as slower-growing microorganisms begin to proliferate.

Other anaerobic gas mixtures can also extend shelf life. The degree by which shelf life can be extended varies by one or two weeks according to the poultry meat’s quality, colour and temperature [2].
However, the aspect (colour) of the meat is not always attractive to consumers at this point. Processors continue to search for alternative technologies in order to match the acceptability of retail fresh meat, whilst extending shelf life and product safety. The only other gas, apart from the CO₂, O₂, and N₂ gas mixtures used in raw meat packaging that has been adopted and studied in red meat is carbon monoxide (CO). However, its use is forbidden by law in Europe. On the other hand, other gases such as argon (Ar), helium (He), and nitrous oxide (N₂O) are permitted in meat packaging under the European Union (Directive 95/2/CE; EU, 1995).

Recently, there has been great interest shown in the potential benefits of Ar and other gases in MAP applications for meat. According to Morgan [3], Ar is increasingly used in MAP. In fact, Ar is an inert, odourless and tasteless gas, more dense and more soluble than N₂. The physical properties of this gas offer certain advantages over the N₂, O₂, or CO₂ atmospheres, and over other MAP gas mixtures typically used to prolong shelf life quality or freshness of packaged foods. Since it is chemically inert, Ar does not react with food constituents, unlike O₂ or CO₂. Ar also inhibits the action of some oxidase enzymes that cause food spoilage and, since it is denser and exhibits greater solubility in both water and oil, it is more effective than N₂ for displacing O₂ from the oils and fats in foods. A US patent has already been issued for the use of Ar in the preservation of cut and segmented fresh fruits [4]. Argon gas, introduced as a major constituent of MAP has also been effective in MAP at 0°C [7]. Sliced breast samples were individually packaged in normal atmosphere and in four modified atmospheres containing different gas mixtures such as 100% N₂, 50% Ar/50% N₂, 50% Ar/50% CO₂ and 50% N₂/50% CO₂. “HBX-070” bags (a multilayer EVOH-based film) sealed with a packaging machine were used for the MAP samples. The aerobic and MAP samples were immediately stored (0±1ºC in the dark) for 12 and 25 days respectively. Microbiological analysis and lipid oxidation evaluation using a thiobarbituric acid test (TBA) were performed on both samples on days 0, 5 and 12 of storage and then also on days 19 and 25 for the MAP samples.

Results show that the microbial shelf life of sliced turkey meat under MAP is extended by an extra week compared with aerobic packaging (5-d shelf life) when 100% N₂ and 50% Ar/50% N₂ mixtures are used. The shelf life is extended by two weeks for 50% N₂/50% CO₂, and three weeks for 50% Ar/50% CO₂. The mixture with argon and CO₂ was also more efficient at delaying flora development than the CO₂/N₂ mixture, with a log difference on the 25th day of storage for total psychrotrophic, total anaerobic and Brochothrix thermosphacta counts. However, the presence of Ar in gas mixtures had no additional protective effect on lipid oxidation of turkey meat. There is no advantage, therefore, in selecting Ar over N₂ in MAP gas mixtures.

References

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October 1st saw the publication of the first series of EFSA opinions on the list of what are referred to as ‘general function’ health claims submitted by the European Commission for scientific evaluation. These are claims made under article 13.1 of the EU Nutrition and Health Claims Regulation (1924/2006) and relate to everything from omega-3 fatty acids to probiotic bacterial cultures. It turned out to be a bad day for a lot of manufacturers, hopeful that their carefully compiled dossiers would convince the EFSA Dietetic, Nutrition and Allergy Panel that the scientific evidence supported their claims. Around two thirds of the 523 claims relating to over 200 foods were rejected, broadly on the grounds that it did not.

At first glance, this looks to be something of a disaster for health claims in general and a confirmation of the worst fears voiced by some commentators in the run up to the publication date. It was no surprise that the mainstream press also had fun with the story and took the opportunity to direct some rather barbed comment at the food industry, especially over claims for probiotics and some other high profile functional ingredients. But the days that followed the initial shock gave food manufacturers a chance to take a more detailed look at the findings of the Panel and the precise reasons why the claims were rejected. A chance for reflection usually helps identify the positives in any situation – and this was no exception.

A study of the claims that were accepted provides the first chance to salvage something positive. Most of these related to vitamins and minerals – hardly controversial in terms of their positive effects on health – and to dietary fibres and fatty acids. These claims and the supporting evidence for them can at least be used as a future model for what is needed to achieve a positive evaluation. A look at the rejected claims shows that about half were rejected on the grounds that the substances responsible for the positive effect were not clearly identified in the submission and so could not be properly evaluated. This problem seems to have afflicted claims for probiotics and botanicals in particular. As EFSA commented, “Without clear identification of the substance in question, the Panel could not verify that the scientific evidence provided to EFSA related to the same substance for which the health benefits are claimed.” – well quite. This is a deficiency that should be fairly easy to overcome for future claims. It has also become clear since October 1st that the Panel did accept that some positive health benefits were demonstrated for claims where the overall evidence was insufficient to back the claim. This offers the hope that further consideration of the claims by the Commission and by Member States could still be favourable, since the EFSA opinions are intended to “inform future decisions.”

It is still a bit early to analyse the fallout from the publication of these opinions. It is also worth remembering that the 523 claims processed so far are just the first group of more than 4,000 that EFSA has on its books. However, it is already clear that the Authority will not accept any claims that are not supported by watertight scientific evidence and will reject any claims containing ambiguities. There is clearly no point in submitting a claim that has any gaps in the science that underlies it. At least manufacturers know where they stand and will surely learn from this experience. One can be certain that future claims will be compiled with great care and thoroughly checked before they get anywhere near an EFSA Panel. This is no bad thing. The food industry has a clear responsibility to its customers and should not be trying to sell them products that will improve their health unless the benefits are proven to be genuine. Functional foods may be the added value products of the moment, but serious doubts over their effectiveness could kill the market very quickly.
The present and future of prebiotics as food ingredients

By Dr Wang Y

Although their inclusion as a specific ingredient in finished foods is a relatively recent phenomenon, prebiotics are commonly found in a variety of well-established functional foods. The following article examines how prebiotics work and presents evidence of their efficacy as ingredients. There is strong evidence that the market for prebiotics is growing and new techniques are rapidly being developed that test the interaction between these functional ingredients and gut microorganisms.

Prebiotics are defined as ‘selectively fermented ingredients that allow specific changes, both in the composition and/or activity of the gastrointestinal microflora that confers benefits upon host well-being and health.’ Thus, the basic criteria for selection of prebiotics are as follows: beneficial health effects to the host, hydrolysis and fermentation by colonic microflora, selective stimulation of growth of one or more bacteria, and resistance to digestion. With the rapid development of modern food science and technology, now is a particularly important moment in the evolution of prebiotic research.

Prebiotics and human gut flora

Gut flora consist of microorganisms that live in the digestive tracts of humans. Compared with other regions of the gastrointestinal tract, the human large intestine is a complex, heavily populated and diverse microbial ecosystem. The impact of the microbial community of the gut on host physiology and pathology has been studied and the data obtained indicates that the gastrointestinal microflora has important and specific functions. Indeed, gut flora is essential for normal anatomical and physiological development of the intestinal mucosa and provides non-immunological protection against infection. In addition, gut flora stimulates maturation and balancing of the immune system at birth and then stimulates and primes the immune system throughout life. Furthermore, gut flora facilitates a wide variety of metabolic functions in the host. In comparison to probiotics,
which introduce exogenous microorganisms into the gut flora, prebiotics aim to stimulate the growth of one or a limited number of the potentially health-promoting indigenous microorganisms. This mode of action modulates the host’s natural ecosystem and so improves human health. With the demand for better quality food, there has been considerable interest in introducing prebiotics as food ingredients in order to increase the numbers of health-promoting indigenous microorganisms in the human gut flora, specifically, *Bifidobacterium* and *Lactobacillus* spp.

### Application of prebiotics as food ingredients

Prebiotics are frequently used as ingredients in functional foods [Table 1]. The functional food industry’s perception of the importance of gut microbiology in human health and nutrition has led to a major increase in prebiotic and probiotic-based products. At the present time, some naturally occurring and synthetic substances are classified as prebiotics, i.e. disaccharides (such as lactulose and lactitol), oligosaccharides (such as fructo-oligosaccharides, soybean oligosaccharides, xylo-oligosaccharides and trans-galacto-oligosaccharides) and polysaccharides (such as inulin and resistant starches). The majority of these prebiotics are produced on an industrial scale from synthetic lactose, the extraction/hydrolysis of soy beans and extracts from plants. Recent analysis from Frost & Sullivan [http://www.food.frost.com] on the European Human Food and Beverage Prebiotics Market, found that the prebiotic products generated revenues of €295.5 million in 2008, equivalent to 91,905 tonnes. The market is expected to reach € 766.9 million in 2015, with overall volumes of 204,895 tonnes and a compound annual growth rate of 14 per cent.

As the health benefits of prebiotics become established, prebiotic ingredients are being made available in almost every product imaginable. Today, prebiotic-containing foods are commonly found and consumed all around the world, especially in Japan, Europe and the US. New prebiotics are being continuously developed as our understanding of the interactions between prebiotics and gut flora (especially *Bifidobacterium* and *Lactobacillus* spp) increases. However, as with any food component, the question of product safety still needs to be considered and further clinical research is essential.

### Future perspectives

A variety of models have been developed to stimulate and quantify the gut fermentation of prebiotics. Prebiotic effect is determined at intervals by removing samples and assessing growth through microbiological culture techniques. However, there are still some problems, it remains unclear whether the interactions observed between prebiotics and a limited number of the potentially health-promoting microorganisms are representative of a common interaction between prebiotics and human gut flora. In fact, there are still 20-40% unculturable microorganisms that we have no data for. Molecular-based microbiological techniques have been developed which should facilitate future research on the interaction between prebiotics and gut microorganisms.

### Acknowledgements:

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### References


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### Table 1: Prebiotics applications as functional food.

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>FUNCTIONAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yoghurts and desserts</td>
<td>Sugar replacement, texture and mouthfeel, fiber, and prebiotics</td>
</tr>
<tr>
<td>Beverages and drinks</td>
<td>Sugar replacement, mouthfeel, foam stabilization, and prebiotics</td>
</tr>
<tr>
<td>Breads and fillings</td>
<td>Fat or sugar replacement, texture, fiber, and prebiotics</td>
</tr>
<tr>
<td>Meat products</td>
<td>Fat replacement, texture, stability and fiber</td>
</tr>
<tr>
<td>Dietetic products</td>
<td>Fat or sugar replacement, fiber, and prebiotics</td>
</tr>
<tr>
<td>Cake and biscuits</td>
<td>Sugar replacement, moisture retention, fiber, and prebiotics</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Sugar replacement, heat resistance and fiber</td>
</tr>
<tr>
<td>Sugar confectionary</td>
<td>Sugar replacement, fiber, and prebiotics</td>
</tr>
<tr>
<td>Soups and sauces</td>
<td>Sugar replacement, and prebiotics</td>
</tr>
<tr>
<td>Baby food</td>
<td>Texture, body and mouthfeel, fiber, stability, and prebiotics</td>
</tr>
</tbody>
</table>

Comments on this article?
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Reflecting the importance of food science and related topics, the number of peer-reviewed papers is growing rapidly, to such an extent that it is frequently difficult for those working in the field to keep up with the literature. As a special service to our readers, FEI presents a selection of literature abstracts, chosen by our editorial board as being particularly worthy of attention.

Focus on food ingredients

Ice-cream as a probiotic food carrier
Ice-creams are food products with potential for use as probiotic vehicles. Ice cream has the added advantage of being appreciated by people belonging to all age groups and social levels. However, the development of ice-creams containing probiotic bacteria requires that certain, intrinsic, technological requirements are fulfilled during the processing stage. This paper reviews the technological parameters involved in the production of probiotic ice-cream. Although the application of probiotics in cheeses, and especially in fermented milks, has been widely explored in the literature, ice-cream is a relatively innovative matrix for the application of probiotics, and thus a review of its potential as probiotic food carrier has been suggested by the author to be of particular interest.
*Cruz AG et al. Food Research International 2009; 42 (9): 1233-1239.

Nutraceuticals and functional foods: whole versus processed foods
It is well known that consumption of plant-based foods, including fruits, vegetables, whole grains, cereals and nuts, as well as the inclusion of marine foods and their long-chain, ω3 fatty acids is instrumental in health promotion and disease risk reduction. There has been a growing interest in the research, development and commercialisation of functional food ingredients, nutraceuticals and dietary supplements around the globe. In addition, it is believed that certain unprocessed or minimally processed foods might have superior health benefits compared to their processed counterparts. However, this assumption may not borne out in practice when considering certain phytochemicals like lycopene in tomatoes. This overview provides an introduction to the topic of nutraceuticals and functional foods with emphasis on the use of whole foods versus their processed and minimally processed counterparts.

Comparative analysis of fruit-based functional snack bars
The aim of this study was to develop snack bars with high dietary fibre (DF) and polyphenol content. A snack bar base was formulated without fibre (control bar) or including fibre (inulin or apple DF bar). In addition, the bars were formulated with or without apple polyphenol extract (APE). The results showed that those bars with added apple DFs gave the highest level of total DF (5.3% w/w). When APE was included those snack bars enhanced with apple DF or inulin had higher levels of extracted phenolics (2.87 and 2.22 mg catechin equivalent (CtE)/g bar) than the control bars (1.45 mg CtE/g bar). It was concluded that snack bars enhanced with apple DF and APE may be a convenient functional food, offering a good source of DF and apple polyphenols.

Brazil nuts and associated health benefits: a review
Epidemiological studies have demonstrated an inverse relationship between nut intake and chronic diseases such as cardiovascular diseases and cancers. In this article, the composition of lipids, minerals, and phytochemicals, and their associated health functions in Brazil nuts have been critically reviewed. Brazil nuts contain abundant dietary antioxidants, especially selenium (Se), possess phenolics and flavonoids in both free and bound forms, and are rich in tocopherol, phytosterols, and squalene. These compounds’ possible beneficial effects are due to their antioxidant and antiproliferative activities, which are linked to a reduced risk of developing atherosclerosis and cancer.
*Jang J. LWT - Food Science and Technology
Survey reveals that health and wellness top priority for consumers

Research recently released by Tate & Lyle shows that consumers continue to see health and wellness as an important issue and will pay more for foods that display health benefits on their labels. The findings are part of Tate & Lyle’s ongoing research into European consumer’s attitudes towards labelling, ingredients and shopping habits. The survey, conducted in July 2009, polled 1,565 people in five countries: Germany, France, UK, Spain and Italy. The results show an increasing awareness and sophistication amongst participants in their attitudes towards their diet and their perceptions of food labelling. The research revealed that across Europe, 53% of consumers often check nutritional information on-pack, and 57% check the ingredient list at the back of a packaging, confirming their interest in labelling to determine if a product is healthy. The research also reveals at least half of consumers see less fat and sugar as important benefits. Additionally, around 80% of respondents noted that they would be prepared to spend more on specific claims which have, to date, been less common in some countries, such as ‘improving cardiovascular health’ and ‘helps to control cholesterol’, suggesting an opportunity for manufacturers.

Taura relocates for future market growth

Taura Natural Ingredients continues to see significant growth for its healthy fruit-based ingredient products in the US market. Establishing a more accessible and centralised support centre in Winchester, VA was an obvious move for this innovative, global manufacturer. Healthy fruit based snacking continues to grow in response to consumer demand for on-the-go nutritional products. Taura’s URC fruit products offer high fruit content, low water activity and bake-stable ingredients to manufacturers developing healthy and delicious consumer snacks. The URC range of real fruit pieces, flakes and pastes are providing on-trend ingredient solutions and driving category growth for the company’s clients.

ADM acquires Czech oilseed plant

Archer Daniels Midland Company has announced the expansion of its European oilseed processing capabilities with the acquisition of ViaChem Group’s oilseed processing assets in Olomouc, Czech Republic. This facility, in the Eastern part of the Czech Republic, consists of an oilseed crushing, refining and biodiesel plant that produces oil and meal for the food, feed and energy markets. According to Brent Fenton, managing director, ADM Europe. “This new site will support ADM’s expansion of its rapeseed and sunseed origination network in Central Europe. In line with ADM’s strategy to expand the size and global reach of our core model, this acquisition increases the Company’s presence in the growing Eastern European market.”

DSM rise to the natural emulsification challenge

DSM Food Specialties is building on the successful introduction of its breakthrough enzyme technology Panamore, by adding a second product to the range. Panamore Spring is an enzyme preparation which offers bread manufacturers a cost-effective and sustainable alternative to the emulsifiers CSL and SSL (calcium and sodium stearoyl lactylate). Panamore Spring contains several enzyme activities.

Fortitech Asia Pacific Completes Construction

Fortitech Asia Pacific Sdn Bhd, part of the global network of manufacturing and distribution companies of Fortitech, Inc., the world leader in the development of custom nutrient premixes for the food, beverage and pharmaceutical industries, has announced that construction has been completed of their new 86,000 sq/ ft facility, located in Malaysia. Servicing customers throughout the entire Asia Pacific region, the new facility will be the company’s second largest operation worldwide (after corporate headquarters) and includes a state-of-the-art laboratory for developing and testing premixes as well as a larger manufacturing and distribution center. In addition to increased technical and customer service support, blenders capable of producing over 6,000 metric tons of premixes annually offer advancements in flexible batch sizes and blending capabilities.

These activities have a combined action on the lipids naturally present in wheat flour; producing compounds which have emulsification properties. The result is a more stable, tolerant and shock-resistant dough and an end product with fine and soft crumb structure as well as good volume and extended shelf life. Used at far lower dosage levels than SSL, Panamore Spring also delivers major cost savings for bread manufacturers, not only through lower ingredient costs but also reduced storage and handling.
Examining the role of peanuts in a healthy lifestyle

Ten research studies over the past year concerning nuts (peanuts, peanut butter, almonds, walnuts and other nuts) show important implications for promoting nuts as part of a beneficial eating pattern such as the “Mediterranean diet”. In fact, in the quest for nutritious, economic, popular and health-promoting food developments, peanuts are worth a serious look.

By Louise McKerchar

Key research findings
Based on the largest meta-analysis ever undertaken of dietary factors in relation to coronary heart disease (CHD), a research team at McMaster University in Canada found that there was a causal link between a small number of dietary factors – nut consumption amongst them – and protection from CHD [1]. The team’s findings singled out vegetables and nuts, the Mediterranean eating pattern and unsaturated fatty acids as strongly associated with reduced CHD risk.

Diabetes is a global and rapidly growing health problem. At the April 2009, Experimental Biology Conference, researchers from the University of Toronto presented the findings of the largest study to date looking at the role peanuts and other nuts may play in the dietary control of Type 2 diabetes [2]. It is thought that nuts may work by improving blood lipid profiles and possibly reduce blood glucose levels.

Fighting the flab
Evidence shows that frequent nut consumption as part of a healthy diet does not pose a risk of significant weight gain or obesity in normal weight individuals. The 2009 Harvard University twenty-year study of 51,000 participants examined the relationship between nut consumption and long term weight change among nurses aged between 20 and 45 [3]. Those women eating peanuts, peanut butter or tree nuts more than twice a week over the 1990s gained less weight than women who did not eat them. They also had a lower risk of obesity during the eight years that followed. In fact, higher total nut consumption was associated with lower body mass index (BMI). High satiety due to protein and fibre content was singled out by the researchers as explaining why the nut-eaters didn’t gain weight, along with the nuts’ largely unsaturated fat energy density.

The diverse range of ingredients available (whole, granulated, nibbed, as oil, extract, flour, paste and butter) mean that peanuts offer multiple benefits and great value as an ingredient. Peanut flour, made from roasted peanuts, is a unique, versatile ingredient. It can be used to control the fat migration of products with high fat centres and in peanut butter fillings and / or peanut butter flavoured frostings and icings for baked goods. In the US, peanut flour is widely used in nutritional snack and diet bars to provide peanut flavour, modify texture and enhance the protein content. It is now becoming increasingly popular in Europe.

The United States Department of Agriculture (USDA) has studied peanuts from around the world, using trained flavour specialists and US and European consumer taste panels. Results showed that American peanuts consistently had the highest “peanutty” flavour. We now know that they have the potential to contribute to a healthy lifestyle, helping people to remain slim and fit.

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The smoothie: multi-faceted member of the beverage world

One of the fastest growing product areas in recent years has been the smoothie. In two years, UK market sales have grown by an impressive 500 percent, nudging £280 million. Fast becoming widely accepted around the globe, new and existing smoothie brands are vying for shelf space in this highly competitive market, as health conscious consumers shun sugar-filled, carbonated drinks in favour of fruit or fruit-and-yoghurt blends. The fruit smoothie’s versatility provides a wealth of opportunities for beverage and dairy manufacturers worldwide, as Kristen Borsari, Global Marketing Manager at Ocean Spray ITG explains.

**Limitless**
The beauty of the smoothie is its versatility. In hot weather, a cooler blend of pineapple and berry refreshes, whilst a heavier combination such as banana and mango provides a burst of vitality on dark winter days. With a vast array of fruit blends to choose from, the potential flavours are limitless and as research into nutritional properties continues, consumers will continue to recognise the health benefits of fruit smoothies. Creative blends of fruits can produce delicious flavours for a wide range of eating occasions.

**Timeless**
From a marketing perspective, manufacturers can choose a number of positioning options. Breakfast is an ideal time of day for fruit consumption. Delivering at least one of our five fruit portions a day, smoothies are easy to digest and, consumed either alone or as part of a more substantial breakfast, make for a healthy, wholesome start. The smoothie’s portable format makes it a convenient option. The sport and fitness sector represents a key growth market for smoothies. Manufacturers are supplementing the smoothies’ fruit base with new functional ingredients such as calcium, Omega-3s, whey protein and green tea extract as a convenient way to add functional value.

**Unbeatable**
Cranberries are well known for their health-promoting properties and are a popular choice. With higher antioxidant levels than any other fruit, cranberries deliver benefits to many areas of the body. From oral, gut and digestive health to urinary tract and cardiovascular health, cranberry’s positive effects are scientifically proven. Cranberries contain unique proanthocyanidins (PACs) which help the body ward off bacteria and infection.

**Irreplaceable**
Smoothies can be used as successful meal replacements. With the combined advantages of antioxidant activity, fibre and vitamin content, the fruit purée can facilitate the elimination of excess toxins from the body. Unlike many ‘light’ or ‘diet’ snack options and slimming shakes, which can contain highly modified ingredients and leave the body undernourished, the natural sugars in fruit leave dieters feeling energised and ensures that vitamins are not sacrificed during the weight loss process. Smoothies are a flavoursome meal replacement option, making a regime interesting and thus sustainable and so challenging the perception that a healthy, nutritious diet equates to a dull diet. Ocean Spray’s cranberry purée consists of 100% fruit, offering manufacturers a clean-label ingredient.

**Insatiable**
It would appear that consumers cannot get enough of these exciting fruit concoctions. In the UK, smoothie consumption was up 44 percent 2008 on 2007, making the segment the fastest growing within the beverage sector. Offering high levels of convenience, endless variety and significant health attributes, the smoothie is one of the few beverage innovations capable of meeting the demands of the 21st century.

**The author**
Kristen Borsari
Global Marketing Manager
Ocean Spray ITG

*www.fei-online.com & search 10628*
All the fun of the Frankfurt fair

Food ingredients Europe, the industry show which introduces FMCG food & beverage manufacturers to raw & processed ingredients suppliers, is on track to eclipse both food and trade show industry growth forecasts. The 2009 exhibition is set to be the largest in its 20-year history. Over 1,100 companies from 94 countries will be exhibiting ingredients for food and beverage products, 10% more than the previous show in 2007. Over 25,000m² of floor space at the Frankfurt Messe exhibition centre will be devoted to the event. This year the exhibition will focus on industry trends, including sodium, sugar and fat reduction, cost control via global sourcing, product reformulation, satiety and texture enhancers, together with “Food +”, the emerging industry category referring to supplements, vitamin additives and the like.

There are numerous new initiatives at the exhibition this year. In the first place, there are 120 new exhibitors with products embracing nearly every ingredient category, from beverage to bakery, confectionery to supplements, and all points in between. Secondly, an exclusive Business Club has been launched, providing top industry executives with special access to the exhibition, information and exhibitors. Thirdly, the exhibition will feature more expert-led content than ever before, split between the co-located exhibitor seminar sessions, and on-the-floor presentations focused on key industry themes.

For the second time, FiE will be joined by Natural ingredients, an initiative which presents food ingredients inspired by nature.

Fi Europe
Frankfurt Messe, Frankfurt, Germany
17-19 November 2009
http://fi-europe.ingredientsnetwork.com/home

Lecithin and phospholipids

A new concentrated milk phospholipid with an exceptionally high level of sphingomyelin and phosphatidylserine is available. Lipamin M20 is perfect for drinks and milk products. Besides their widespread nutritional benefits, milk phospholipids are stable against oxidation, have a bland milk taste, and are easily dispersed (as 20% concentrate). Also showcased on the LECICO stand is P 900 - an exceptional quality deoiled lecithin powder. It can be used for functional foods or other food applications, such as instant products, as a release agent and emulsifier in baked goods, to improve the shelf life of chewing and bubble gum, or to control crystallisation in ice cream. Due to the structure of the product it can be easily dispersed in water or diluted in oils and fats.

LECICO GmbH
Hamburg, Germany
Fi Europe stand 8Q29
i www.fei-online.com & search 10641

Functional ingredients from pure sugar beet

A ‘Candy Innovation Matrix’ with Isomalt has been designed to support the development of new sugar-free confectionery. The Matrix will help customers with new product development by enabling them to explore and combine new flavours, different forms of packaging and different product benefits such as dental care, and low calorie characteristics.

BENEO-Palatinit
Mannheim, Germany
Fi Europe stand 9D16
i www.fei-online.com & search 10640

Versatile health ingredient

Carnipure is a special grade of L-Carnitine. On account of its outstanding efficacy, its excellent safety profile and its suitability for processing, it can be successfully integrated into various applications in the nutrition and food industries. Extensive clinical research has discovered that Carnipure can play a beneficial role in many areas of health, including recovery from exercise, weight management and healthy ageing.

Lonza
Basel, Switzerland
Fi Europe stand 8H29
i www.fei-online.com & search 10639
Colour with confidence

The D.D. Williamson portfolio of natural colours helps sell 1.5 billion servings of foods and beverages every day. Leading producers use the ingredients for a variety of products - from sauces and soft drinks, to flavours and fruit preparations, to beer and baked goods. At Fi Europe a range of product possibilities are on display including, mango iced tea coloured with caramel colour, juice beverages coloured with natural beta-carotene, and gummi candies enhanced by natural colour.

D.D Williamson
Manchester, UK
Fi Europe stand 8B49
www.fei-online.com & search 10629

Whey protein concentrate

Textrion Progel 800 is designed to build texture in food and dairy applications. It has exceptional water binding, texturising and gelling characteristics. The whey protein isolate is soluble, sets over a wide pH range and is characterised by a clean neutral flavour and aroma. The product adds viscosity and minimises serum formation in set or stirred yogurts and dessert products. It also provides texture improvement and emulsification to a variety of meat, bakery and convenience foods. The isolate is suitable for vegetarians, is Halal approved and (upon request) also Kosher.

DMV International
Veghel, The Netherlands
Fi Europe stand 8L8
www.fei-online.com & search 10643

Beverage, bakery and snacks innovation

An innovative flavour modulation technology, called fmt, which is designed to provide natural sweetness enhancement for all types and flavours of soft drinks will be presented at Fi Europe. Already successfully commercialised in North America, the technology permits up to 30% sugar reduction with a clean taste and clean label declaration.Fmt allows beverage manufacturers to claim an all-natural flavouring declaration at a much reduced cost compared with the use of fruit extracts. For the bakery market Biobake is a new, clean label gluten reduction technology suitable for all types of breads including white, wholegrain and speciality breads. Biobake works at low dosage levels with all grades of flour and all types of processing methodologies to deliver cost savings of around 50-60% through a reduction in the gluten content of bread. Snack food manufacturers seeking to target the ‘better-for-you’, natural savoury snacks market will be interested in the cheese and salami ‘Route to Natural’ baked snack flavouring. MSG-free and containing all-natural ingredients, this new snack concept falls within the daily salt guidelines set by the UK Food Standards Agency for 2012, whilst combining a reduced fat content with a satisfyingly tangy flavour.

Kerry Ingredients & Flavours
Tralee, Ireland
Fi Europe stand 8M5
www.fei-online.com & search 10644

Getting the best out of cereals

New granulated maltodextrins offering reduced dusting and high dissolution speeds are now available. The development of modern spray-drying facilities, together with the manufacturer’s technical expertise, allows for the accurate control of all critical parameters. Also to be presented at Fi Europe are a wide range of polyols, including MERISORBTM (sorbitol powder), MERITOLTM (sorbitol liquid), and MALTILITE (Maltitol syrups and crystalline) for sugar replacement in confectionery, sweet bakery and dairy products.

SYRAL
Marckolsheim, France
Fi Europe stand 8K6
www.fei-online.com & search 10634

Dried cranberry product

Whole sweetened dried cranberries have been developed in response to demand from snack and confectionery manufacturers for a larger fruit piece size. With the cranberry’s characteristic red colour, sweet tart taste and process tolerance, the product is ideal for use in the growing category of trail mixes, confectionery and healthy treats.

Ocean Spray ITG
Middleboro, MA, United States
Fi Europe stand 8C20
www.fei-online.com & search 10642
Natural honey flavour

The FTNF (From the Named Food) honey Treattarome natural flavour distillates represent an authentic alternative to honey in flavour formulations. Numerous options are available, allowing flavourists to create the exact flavour profile desired – from floral and delicate to intense and smoky. These water-based natural distillates are highly soluble and easy to use, offering distinct advantages for manufacturers looking to add a taste of honey to their products. Suitable applications include dairy, confectionery, bakery and a range of beverages.

Treatt plc
Bury St Edmunds, Suffolk, UK
Fi Europe stand 8G55
i www.fei-online.com & search 10645

‘no added sugar’ fruit concentrate

The new Ultra Rapid Concentration (URC) formulation is made from all natural fruit origins with a high level of fruit puree and no added sugars or preservatives. The product delivers up to 700gms of real fruit per 100gms of finished product. The URC formulation has been developed in response to a rapid increase in demand for 100% whole fruit ingredients by manufacturers looking to add nutrition and natural goodness to their snack and confectionery products.

Taura Natural Ingredients
Olen, Belgium
Fi Europe stand 8C55
i www.fei-online.com & search 10630

Joint health ingredient

Magnetic resonance imaging and cell experiments prove that Fortigel promotes the regeneration of cartilage tissue. Thanks to its excellent properties such as neutral taste and odour the product is easy to integrate into a wide range of food applications and the positive health aspects can be achieved even with low doses. Unlike other substances which focus on short-term pain relief, Fortigel measurably improves joint health by tackling the root causes of osteoarthritis and cartilage degeneration.

GELITA AG
Eberbach, Germany
Fi Europe stand 8L23
i www.fei-online.com & search 10631

Vitamin and mineral premix solutions

A flax-based hydrocolloid system that optimises structure, moisture, texture and shelf life in a variety of applications is available. OptiSol 5000 is part of the OptiSol range of dairy and flax based solutions designed to enhance the nutritional and organoleptic characteristics of beverages and a range of foods including soups, sauces, dressings and dairy-based dips. The portfolio also includes cost-effective gluten replacement solutions for bakery applications.

Glanbia Nutritional
Kilkenny, Ireland
Fi Europe stand 8M11
i www.fei-online.com & search 10632

Integrated cocoa manufacturing

This range of high-quality chocolates, cocoa powders, liquors and butters is extracted from a fully-integrated cocoa manufacturing process, spanning the grinding of self-procured beans from the world’s major cocoa growing regions, to producing a comprehensive range of cocoa ingredients and semi-finished chocolates. Continuing research and development into food processing applications, from baked goods to confectionery and dairy, means customers can benefit directly from ADM Cocoa’s technical expertise and innovative, customer-focused cocoa solutions.

ADM International Sàrl
Rolle, Switzerland
Fi Europe stand 8E29 and 8E30
i www.fei-online.com & search 10646
Emulsifier portfolio

The new Emulpals 400 series is based on an innovative new carrier system and offers excellent functionality at a competitive price. It is Kosher and Halal certified, 100% vegetable, non-GMO, and contains neither allergens, nor soy or milk. For yoghurt applications the company has developed new clean label blends which deliver excellent creaminess and body as well as water retention. The products are suitable for use in whole milk as well as in low fat products, fulfilling consumer demand for healthy products with excellent mouth feel. For ice cream, a new trans-free addition to the patent-pending IceTriple emulsifier stabiliser system allows ice cream manufacturers to produce a creamier, more stable and melt resistant product.

Biorigin
Lençóis Paulista, Brasil
Fi Europe stand 8B1
www.fei-online.com & search 10637

Soy isolate for beverages

A ready-to-use, stabilised and calcium-fortified soy protein isolate for pH neutral beverages has been developed. Solpro 958QS combines the synergistic properties of non-GMO soy protein isolates, a calcium source and natural stabilisers in a single-pack. The product contains levels of calcium similar to that of milk, and is a major breakthrough for lactose sensitive consumers of all ages.

Carbery
Ballineen, Co. Cork, Ireland
Fi Europe stand 8H49
www.fei-online.com & search 10635

Green tea goodness

With distinct physiological benefits, such as improved antimicrobial and antioxidant activity, the ingredients in Sunphenon stimulate thermogenic, or fat-burning activity, at a higher rate than caffeine. Suitable for beverages, dairy and dietary supplements, the ingredient’s mild taste does not impact on the final product’s flavour profile. Sunfiber delivers the dietary fibre essential in maintaining a healthy gut in the form of a highly soluble powder. Mineral absorption is also improved, further aiding digestive health. This product is ideal for use in a wide range of beverage applications, as well as dairy and bakery products.

Taiyo Europe
Filderstadt, Germany
Fi Europe stand 91G15
www.fei-online.com & search 10650

Whey protein concentrate

For the clinical nutrition and weight management markets, Carbelac Low lactose 80, a clean tasting whey protein concentrate, and Isolac and Isolac Clear are now available. The hydrolysed whey protein, Optipep DH5A will also be on show at Fi Europe. Ideal for fortifying general food applications, particularly baked goods and bars, the product is more easily absorbed by the body than non-hydrolysed whey proteins and confers the additional benefit of a clean taste profile.

Carbery
Ballineen, Co. Cork, Ireland
Fi Europe stand 8H16
www.fei-online.com & search 10638

Natural flavour enhancement

Bionis and Biotaste yeast extract product lines introduce salted baked notes, enabling a reduction of up to 50% salt content in the final product. Also to be launched in the European market is a new line of natural ingredients for the enhancement of umami taste called Bioenhance. Other natural solutions include the Goldcell line and the ingredient Mannovin. The Goldcell line includes dry inactive, autolysed, and mineralised yeasts. The product Mannovin is exclusively aimed at the wine market. It is a natural mannan protein that contributes to wine flavour. All products are GMO-free and allergen-free.

Palsgaard
Juelsminde, Denmark
Fi Europe stand 8H16
www.fei-online.com & search 10638

Solbar Plant Extracts Ltd
Ashdod, Israel
Fi Europe stand 8G29
www.fei-online.com & search 10635
Exciting colour solutions

The Fusion range of food colours has been extended with new shades of high performance foodstuff colouring and natural compounds giving bright and stable tones for confectionery and beverage products. The new Fusion “Red Currant Red” has been formulated from a combination of carefully selected carrot and beetroot varieties. By combining the hydrophilic and lipophilic pigment structures into a new product concept, Sensient brings the advantage of novel stabilising technology effective against oxidative degradation. This new Fusion product is an excellent choice to achieve a brilliant red currant colour shade in confectionery applications such as panned sweets and hard boiled candies, as well as in dairy systems. Due to its vivid colour shade and special formulation it is a perfect clean label, vegetarian and Kosher replacement for carmine.

Sensient Food Colors Germany GmbH
Geesthacht, Germany
Fi Europe stand 8B40
i www.fei-online.com & search 10636

Innovative nutritional texturiser

Thanks to its high soluble fiber content (minimum 90%), Fibregum combines exceptional nutritional properties with documented health benefits, including a prebiotic effect, high digestive tolerance and a beneficial impact on glycemic index. Thanks to its low caloric value and its acarogenic properties, it can be used in numerous functional foods (beverages, cereal bars, extruded products). Fibregum is also widely employed for its technical and functional properties (emulsifying, stabilising, encapsulating and texturising) and is valued in the food industry for its high quality and applications in health products.

Colloides Naturels International
Rouen, France
Fi Europe stand 8H24
i www.fei-online.com & search 10647

Processing

In-container sterilisation

The multi-process capability provided by this sterilising machine gives you the possibility to process all commercially available products and containers in optimum conditions and at the lowest possible cost. Easy to maintain, SuperAgii improves upon the proven, long-life, robust design developed for the previous generation of agitating retorts. In the new SuperAgii trunnion wheels, drum drive and drum bearing can be adjusted and maintained without removing the drum. Excellent temperature distribution is also possible. By mounting the spray pipes inside the reel, obstructions between process water and food packages are eliminated. Deeper water penetration results in an excellent temperature distribution and reduced process cycle time.

John Bean Technologies N.V.
Sint-Niklaas, Belgium
i www.fei-online.com & search 10648

Corrigenda

In the October issue of Food Engineering and Ingredients there was an error in the article entitled “The detection of melamine in milk products”. Table 1 on page 24 should have read:

<table>
<thead>
<tr>
<th>Photometer</th>
<th>Limit of Detection (µg/l)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Thermo Scientific Multiskan FC</td>
<td>7.6</td>
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<tr>
<td>Thermo Scientific Multiskan EX</td>
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<td>Thermo Scientific Multiskan Spectrum</td>
<td>7.7</td>
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<tr>
<td>Thermo Scientific Appliskan</td>
<td>7.8</td>
</tr>
<tr>
<td>Thermo Scientific VarioskanFlash</td>
<td>7.8</td>
</tr>
</tbody>
</table>
Events calendar

January 25-27, 2010
Rapid Methods Europe 2010
Noordwijkerhout, The Netherlands
Tel. +31 30 2294247
Fax +31 30 2252910
e-mail: RME@bastiaanse-communication.com

January 31 – February 3, 2010
ProSweets 2010
Cologne, Germany
Tel. +49 180 538 3763
Fax +49 221 821 99 1360
e-mail: visitor@prosweets-cologne.com
www.prosweets.com

February 4-7, 2010
Packaging and Converting Executive Forum 2010
London, UK
Tel. +44 207 915 9717
e-mail: events@arena-international.com
www.paceforum.com/spgmedia.html

February 17-20, 2010
BioFach 2010
World Organic Trade Fair
Nuremberg, Germany
Tel. +49 9 11 8606 0
Fax +49 9 11 8606 8228
www.biofach.de

March 15-17, 2010
2nd TNO Beneficial Microbes Conference
Noordwijk, the Netherlands
Tel. +31 30 2294247
Fax +31 30 2252910
e-mail: BM@bastiaanse-communication.com
www.bastiaanse-communication.com

March 24-28, 2010
INTERVISI INTERFRUCTA
International technology trade fair for wine, fruit, fruit juice and spirits
Stuttgart, Germany
Tel. +49 228 949325 0
Fax +49 228 949325 23
e-mail: info@dwv-online.de
www.intervitis-interfructa.de

April 27-29, 2010
European Seafood Exposition
Brussels, Belgium
Tel. +32 2 207 842 0
Fax +32 2 207 850 3
www.europeafood.com

May 8-13, 2010
IFFA 2010
Frankfurt, Germany
Tel. +49 69 75 75 0
Fax +49 69 75 75 64 33
www.iffa.messefrankfurt.com

May 18-20, 2010
Vitafoods International 2010
Geneva, Switzerland
Tel. +44 20 701 77019
Fax +44 20 701 77818
e-mail: vitafoods@iri.co.uk
www.vitafoods.eu.com

May 25-27, 2010
Food ingredients Central & Eastern Europe (FiCEE) 2010
Warsaw, Poland
Tel. +48 22 346 559 444
Fax +48 22 346 573 811
e-mail: ficee@ubm.com
http://ficee.ingredientnetwork.com/home

June 15-17, 2010
International Probiotic Conference 2010 (IPC 2010)
Kosice, Slovakia
Tel. +421 918 707371
Fax +421 41 4000123
e-mail: info@probiotic-conference.com
www.probiotic-conference.net

June 17-20, 2010
BOFAS 2010, the 17th Busan International Food Exhibition
Busan, South Korea
Tel. +82 40 3959905 0
Fax +82 40 3999905 25
e-mail: contact@bofas.merebo.com
www.bofas.merebo.com

June 2-4, 2010
Health ingredients & Natural ingredients China
Shanghai, China
http://fiasiachina.ingredientnetwork.com/home

July 17-21, 2010
IFT Food Expo 2010
Chicago, IL, USA
www.ani-le.ift.org

September 8-11, 2010
Riga Food 2010
Riga, Latvia
www.rigafood.com

September 12-15, 2010
InterMopro / InterCool / InterMeat 2010
The international trade shows for dairy products, frozen food, ice cream, meat and sausages.
Düsseldorf, Germany
www.intermopro.de
www.intercool.de
www.intermeat.de

For more events see
www.fei-online.com/events/

Dates and descriptions of future events have been obtained from usually reliable official industrial sources. FEI can not be held responsible for errors, changes or cancellations.
Food Safety

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Using 100% Lubriplate H-1 Lubricants throughout your plant not only provides peace of mind, they can significantly simplify your HACCP program by eliminating lubrication as a potential chemical hazard.

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- Manufactured in compliance with ISO 21469 guidelines.
- Formulated with ingredients that comply with FDA Regulations 21 CFR 178.3570 and 21 CFR 172.882 for lubricants with incidental food contact.
- They Meet USDA H-1 safety standards and are authorized for use in federally inspected meat and poultry plants.
- Certified OU Kosher Pareve, HALAL Registered.

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Tel: +1-973-465-5700 Website: www.lubriplate.com / E-mail: info@lubriplate.com

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- England - London Lubricants / LL Ltd. / London England /Tel: +44 (0)20 8961 7292 / E-mail: sales@londonlubricants.com
- Germany - OIL TECH GmbH / Dusseldorf, Germany / Tel: 49-0-211-8878-4122 / E-mail: klaus.huber@olitech-gmbh.de
- Italy - AR. I. Chimica / Milan, Italy /Tel: 392-26115598 / E-mail: rear@interfree.it
- Sweden - Cargo Oil Co., AB / Partille, Sweden /Tel: 46-31-443311