Active and Other Novel Packaging

Consumer demand for safe food and retailer insistence on increased product shelf life have led to the development of packaging options designed to deliver food that meets client demand and end-user expectations.

Packaging innovations can be grouped under three principal headings:

- **Active packaging** is packaging that incorporates certain additives in the packaging film or within the container to maintain and/or extend product shelf life. Active packaging performs some desired roles other than the provision of an inert barrier to external conditions. Active packaging can control, and react to, events taking place within the package.
- **Intelligent packaging** devices are capable of sensing and providing information about the function and properties of packaged meat. They can provide assurances of pack integrity, tamper evidence and product quality and safety. The devices can also be applied to provide product authenticity and product traceability.
- **Temperature-controlled packaging** includes the use of innovative insulating materials and self-heating and self-cooling containers.

Active packaging

The shelf life of packaged perishable meat is dependent on many factors both extrinsic (contamination, storage temperature, relative humidity and the surrounding gaseous composition) and intrinsic (pH, a_w, and occurrence of antimicrobial compounds). These factors will directly influence the chemical, physical and microbiological spoilage mechanisms of individual meat products and their achievable shelf lives.

By carefully considering all of these factors, it is possible to develop active packaging technologies that can be applied for the purpose of maintaining the quality and extending the shelf life of different meat products. Active packaging systems available to industry include:

- Oxygen scavengers
- Carbon dioxide scavengers and emitters
- Preservative releasers
- Moisture absorbers

Research into the use of edible films to enhance the shelf life and convenience of perishable foods is currently being undertaken. Edible coatings, developed by Food Science Australia, are currently being tested to determine their ability to reduce weep exuded by packaged meat.

Oxygen scavengers

Oxygen can have a number of detrimental effects on meat products. Oxygen scavengers can help maintain product quality by reducing oxidative rancidity, controlling enzymic discolouration and inhibiting the growth of aerobic microorganisms.

Oxygen scavengers are by far the most commercially important active packaging system.

They commonly take the form of small sachets containing iron-based compounds and a catalyst. These chemicals react with moisture from the product to form a reactive hydrated metallic reducing agent, which scavenges oxygen within the package and is irreversibly converted to a stable oxide.

These systems are capable of reducing oxygen levels to less than 0.01%. The typical residual oxygen levels achievable by modified-atmosphere packaging (MAP) are around 0.1%.

Commercially, an attractive option is to remove most of the atmospheric oxygen using vacuum or MAP and to then use a relatively small and inexpensive scavenger to remove the residual oxygen.

Non-metallic scavengers have been developed to alleviate the potential for metallic taints to be imparted to susceptible products, and also to prevent the tripping of sensitive on-line metal detectors. Non-metallic scavengers usually employ organic reduction agents such as ascorbic

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acid, ascorbate salts or catechol. Enzymic systems employing glucose oxidase or ethanol oxidase have also been developed.

Use of oxygen scavenging sachets has met consumer resistance owing to a fear of accidental ingestion of the sachet. The development of oxygen scavenging adhesive labels and the incorporation of scavenging materials into laminated trays and plastic film have enhanced acceptance of the technology.

Meat packers will find oxygen scavenging systems most effective in the packaging of sliced smallgoods/luncheon meats where susceptibility to oxygen-induced colour change is a major problem.

Carbon dioxide scavengers and emitters

Carbon dioxide emitters can be used either alone or with oxygen scavengers to extend the shelf life of fresh meat.

The Verifrais™ system consists of a standard MAP tray with a perforated false bottom. A porous sachet containing sodium bicarbonate/ascorbate is placed under the false bottom and emits carbon dioxide when meat juices drip onto the sachet.

The carbon dioxide acts as an antimicrobial agent. It also prevents the collapse of the pack, which is caused by the development of a partial vacuum as the residual oxygen is utilised.

Use of a carbon dioxide emitter in conjunction with an oxygen scavenger, to replace the oxygen removed with an equivalent volume of carbon dioxide, has proved to be successful in the prevention of pack collapse.

Carbon dioxide scavengers do not have applications in the packaging of meat.

Preservative releasers (antimicrobial and/or antioxidant film)

Many antimicrobial and/or antioxidant packaging films have been developed but have not achieved commercial acceptance owing to doubts about their effectiveness, cost and/or regulatory constraints. Japan is one country where the technology is gaining acceptance.

Some of the synthetic and naturally occurring preservatives that have been proposed and/or tested for antimicrobial activity in plastic and edible films, include:

- Organic acids – propionate, benzoate, sorbate
- Bacteriocins – nisin
- Spice/herb extracts – rosemary, cloves, horseradish, mustard, cinnamon, thyme
- Enzymes – peroxidase, lysozyme, glucose oxidase
- Chelating agents – EDTA
- Inorganic acids – sulphur dioxide, chlorine dioxide
- Anti-fungal agents – imazalil, benomyl

Interest in the use of antioxidant packaging film has been stimulated by consumer resistance to the use of antioxidants and other additives in food.

Moisture absorbers

Excess moisture is a major cause of food spoilage. Soaking up moisture by using various absorbers or desiccants is very effective in maintaining food quality and extending shelf life by reducing opportunities for microbial growth and moisture-related degradation of texture, flavour and colour.

Desiccant sachets containing silica gel, calcium oxide and/or activated clays are extensively used in the packaging of dry products susceptible to atmospheric humidity. Sachets may also contain activated carbon for odour absorption. These have a potential use for dried meat.

Packers of high a_w foods, such as meat, have found the use of absorbent pads to be effective in controlling tissue drip exudate. Pads usually consist of a superabsorbent polymer layer sandwiched between two layers of microporous, non-woven plastic film such as polypropylene or polyethylene. Some commercially available absorbent pads are capable of absorbing up to 500 times their own weight in water.

Another approach is to intercept the moisture in the vapour phase. This allows meat packers and consumers to decrease water activity on the surface of the product by reducing in-pack relative humidity. Placement of one or more humectants between two layers of a water permeable plastic film (typically PVA) produces a meat wrapping film which dehydrates the meat by osmotic pressure and is claimed to extend shelf life under normal chilled storage conditions.

Intelligent packaging

Intelligent packaging devices are capable of sensing and providing information about the functions and properties of packaged food. These devices include temperature indicators (TIs) and time-temperature indicators (TTIs), gas-sensing dyes, microwave 'doneness' indicators and microbial growth indicators.

Temperature and time-temperature indicators

TIs and TTIs typically contain compounds that change colour when the pack is exposed to temperature abuse. They can be used both at retail level and to monitor cold chain distribution. Indicators can be adapted to client specifications regarding activation and reaction temperatures.

Gas-sensing dyes

Using gas-sensing dyes in vacuum or MAP film to monitor carbon dioxide levels will detect 'slow leakers' more efficiently than any currently available mechanical or electronic seal integrity test process. A loss of gas can seriously compromise shelf life and has food safety implications.

Microwave 'doneness' indicators

In order to achieve a microbiologically safe microwaveable food product, all points within the product must receive a heat treatment equivalent to two minutes at 70°C. Considerable research is being undertaken to ensure that product formulation and package design are conducive to achieving the desired outcome. Modified TTIs are commercially available, but technical difficulties are likely to delay general acceptance of the technology.

Microbial growth indicators

Microbial growth indicators (MGIs) currently being developed are seen as a viable alternative to available microbiological testing procedures that necessitate destruction of the pack.

MGIs are being developed to be sensitive to volatile microbial metabolites such as carbon dioxide, ammonia and fatty acids.

Temperature-controlled packaging

Self-heating and self-cooling cans are widely used for beverage packaging. Of interest to meat packers are several recently developed insulating materials suited to the protection of chilled product during storage and distribution.

Thinsulate™ is a special non-woven plastic film with many air spaces. Another approach is to increase the thermal mass of the package to withstand temperature rise. One such device is the Cool Bowl™ system, which uses a double-walled PET container with an insulating gel sandwiched between the walls.

Food-safety and regulatory issues

At least four types of food-safety and regulatory issues need to be addressed:

- The need for regulatory approval of food contact materials
- Environmental regulations covering the disposal of active packaging materials
- Labelling issues to avoid consumer confusion
- The effects of active packaging on the microbial ecology of food

Active packaging substances may migrate into the product or may be removed from it. Migration may be intended or unintended. Antioxidants and antimicrobial preservatives require regulatory approval in terms of their identity, concentration and possible toxic effects. Unintended migrants such as various metal compounds need to be excluded from the product.

Environmental regulations covering reuse, recycling and identification to assist in recycling or the recovery of energy from active packaging materials need to be addressed on a case-by-case basis.

Clear labelling of oxygen scavenger sachets and similar devices is essential to reducing the risk of accidental ingestion by consumers.

It is important to consider the effects of active packaging on the microbial ecology and safety of the product. The total microbial flora in a pack should be considered and not a single species in isolation. For example, the usage of antimicrobial films or the creation of conditions that suppress lactobacillus and other spoilage organisms within packs of high a_w chilled product may readily allow the growth of pathogens, particularly if temperature abuse occurs.

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