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Commercial Applications of Active Packaging and Biosensor Technology in Meat Packaging – A Packaging Manufacturer's Perspective

James Belcher
Sealed air Co. Cryovac Div., 100 Rogers Bridge Rd., Duncan SC-29334, USA

Abstract:
Two market drivers in meat packaging are the extension of quality life and the assurance of food safety. An overview of commercial advances in the use of active packaging systems and biosensor technology will be given. While active packaging systems have been used for years in Japan (Rooney 1995) it has been slow to catch on in the West. In the U.S., several new systems have been commercialized for Case Ready Fresh Red Meat packaging and for Smoked and Processed Meat packaging, that show new promise for extending the active packaging market. Research in biosensor technology for detecting pathogens in meat continues at a rapid rate although to date there has been little if any commercial success. One of the problems facing the production of biosensors for direct detection of bacteria is the sensitivity of assay in real samples (Ivnitski *et al. 1999*). They report that with the infectious dosage of pathogens such as *Salmonella* or *Escherichia coli* O157:H7 as low as 10 cells, until a biosensor has a detection limit as low as a single organism per ml with rapid detection and at a low cost, this technology will not be viable. This paper will review some commercial or "near commercial technology" involving active packaging and biosensor technology that is helping the meat industry meet consumer's demands.

Introduction

Today's meat processor is under pressure to deliver a fresh, safe product to the consumer in an ever-widening distribution area. Where yesterday's producer was local or at most regional, today's producer is increasingly national and in some cases international. Meat packaging systems for primal and sub-primal cuts and for Smoked and Processed meats are well established. The current vacuum or MAP systems suffice for the duration of the package. However, with the push for more case ready and value added products, meat packaging is being asked to do more than just offer preservation, containment, convenience, and information. Meat packaging is being asked to protect the freshness and safety of the product for a longer duration. This is where active packaging is playing a role now, and biosensors will play a role in the future. This paper will review some commercial or "near commercial technology" involving active packaging and biosensor technology that is helping the meat industry meet consumer's demands.

Active Packaging

Active packaging can be defined as a packaging technique, which actively and constantly changes either package permeation properties or the concentration of different volatiles and gasses in the package headspace during storage (Hurme & Ahvenainen *et.al.* 1997). Two commercial areas that are utilizing active packaging are in Case Ready Fresh Red Meat packaging and in Smoked & Processed Meat packaging. In both of these areas the use of active packaging has been employed to give national distribution to products that normally would not have sufficient shelf life to achieve this distribution length.

Case Ready Fresh Red Meat (FRM) Packaging

Case Ready packaging for FRM has seen an explosive growth over the last 5 years. Several retail chains have become completely or are in the process of converting completely to Case Ready (Tesco in the U.K. and Wal-Mart in the U.S.). Case Ready FRM packaging has been defined as a process to produce a centrally prepared, high quality, wholesome product with an extended shelf life. This process allows the product to be distributed to retail markets in a timely fashion and placed in the store's meat case for sale with no additional preparation required in the back room. To be successful, the product must be able to be produced at commercial speeds, have an in-store made appearance, be leak-proof, and must be able to be marketed in the oxymyoglobin or "bloomed" state. The major problems that have had to be overcome is to develop systems that can be run at commercial speeds, distributed nationally, and still be marketed in a "bloomed" state.

To date, Case Ready FRM packaging can be classified in two ways, short hold and long hold packaging. While both of these technologies use high barrier packaging materials and Modified Atmoshpere Packaging (MAP) only the long hold options use active packaging.

Short hold packaging: This style of packaging is used for regional distribution with shelf-life requirements of 12 days or less. The product is placed in a barrier package and is lidded or over-wrapped in a barrier film. The product is shipped in a fully "bloomed" state with a typical gas composition of O_2 and N_2 (80:20). Product in this format must have significant headspace to allow the oxygen to continue to react with the meat to keep it in the oxymyoglobin state. To get maximum shelf life from a color standpoint a typical headspace of 1cc of oxygen per gram of meat is used.

Long hold packaging: This style of packaging is used for national or international distribution and has achieved shelf life of up to 60 days for certain cuts of meats. The product is shipped in a de-oxymyoglobin state and then at the retail outlet the product is re-bloomed to an oxymyoglobin state. Several technologies involving active packaging have been commercialized and will be discussed. While these technologies differ, they each employ the same format. The product is packaged in an ultra low oxygen atmosphere (<500ppm) with the remaining atmosphere made up of nitrogen and carbon dioxide. This product can be held in distribution for up to 60 days depending on the cut. At retail, the product is re-bloomed to an oxymyoglobin state for an in-store case life of 1-4 days.

Commercial Technologies for Long Hold Case Ready FRM Packaging

Cryovac LID 550P / Barrier Foam Tray –This process uses a high barrier polystyrene foam tray and a multi-ply lidstock that has a peelable interface. The lidding film is the active part of the process. It consists of a two part laminated barrier film. The process works as follows. The product is loaded in the tray and goes through an MAP process that is capable of lowering the oxygen level to <500ppm oxygen. The package is then flushed with a gas mix of N_2 and CO_2 (75:25). The LID 550P film is then sealed to the barrier foam trays at speeds of up to 100 ppm. Because the package is devoid of oxygen (<500ppm residual oxygen), the meat is held in the reduced / de-oxymyoglobin state throughout distribution. Once the product is at the retail store, the barrier film is broken at an interface and is peeled off of the product. What is left is a highly oxygen permeable film layer that actively lets the oxygen into the package and allows the meat to go from a de-oxymyoglobin state to an oxymyoglobin state in 15-30 minutes. The typical shelf life for ground beef is 18 days total, ie. 16 days unpeeled plus two days in the retail display case. Whole muscle cuts have a shelf life of 35 days with 1-3 days in the retail display.

Pactiv ActiveTech Case Ready Packaging System: This is another long hold, low oxygen Case Ready FRM system. DelDuca (1999) reports this system consists of using a standard polystyrene foam tray, a PVC overwrap stretch film, a barrier film outer bag and an activated oxygen absorbing sachet. This system works as follows. The cut of meat is placed in the polystyrene foam tray and is wrapped on a standard tray overwrap system with stretch PVC film (O_2 transmission rate 13,000 $CC/M^2/24$ hrs). The primary package is then gas flushed in a Horizontal Form Fill and Seal (HFFS) system using a non-shrink barrier film (O_2 transmission rate 10-15 $CC/M^2/24$ hrs). The active part of the system is the use of a fast acting oxygen absorbing sachet that is put in the secondary package. The oxygen absorbing sachet reduces the oxygen level to <500ppm within 48 hours. The product is then shipped to the retail store in the reduced, deoxymyoglobin state and can be stored for up to 35 days for whole cuts of meat and 21 days for ground beef. Once the product is ready to be displayed, the secondary package is removed along with the oxygen absorbing sachet and the meat is able to bloom into the oxymyoglobin state in 30 minutes. The case life of this product is 1-2 days for ground beef and up to 5 days for whole muscle cuts.

Cryovac Trifresh Packaging System: This system consists of a "peelable" retail pack containing a mixture of CO_2 and N_2. In this system, the pack also contains a Trifresh sachet, which chemically scavenges O_2 and generates CO_2. The system is capable of reaching O_2 levels of 0.01%. At the retail level, the top web, which has a high O_2 barrier, is peeled off the base tray, exposing a permeable film over the meat. Oxygen then permeates into the pack resulting in the meat converting to the red oxymyoglobin state (Bill,1999). This system differs from the other two systems in that it utilizes a gas mixture of CO_2: N_2 (80:20). Normally, with this amount of CO_2, the packs will distort or collapse as the CO_2 is absorbed. The Trifresh sachets added to the trays were designed to generate a volume of CO_2 to counteract the CO_2 absorbed by the meat. Testing with this system is still ongoing and there are no commercial applications to date. Test results have shown that whole muscle cuts of beef and pork can be stored for up to 10 weeks with excellent re-bloom and retail case life of 2-4 days.

Smoked and Processed Meats

Cryovac OS1000 Film Oxygen absorbing technology has been available since the commercial launch of the iron based pouch type absorbers in 1977 in Japan (Hurme and Ahvenainen 1997). They state that the current annual production of sachets in Japan is 7 billion units compared to one hundred million units produced in the U.S. and 10 million units produced in Europe. The main use for oxygen scavenging in meats is for light sensitive products where color changes are a problem (Hurme and Ahvenainen 1997). With the increase in sliced luncheon meats in a MAP format, the need for oxygen scavenging has increased in the U.S. and Europe. While the Japanese have been quick to accept the use of oxygen scavenging sachets, the western world has been slow to embrace this technique. According to Idol (1991) the enhanced fear of accidental ingestion and the cost of the sachet are the main reason for the slow growth of this market.

While most oxygen absorbing packaging materials are typically activated by the moisture in the product or the moisture in the atmosphere, the OS1000 film has a coextruded scavenging layer that consists of a photoinitiator and a catalyst system. The OS1000 film is triggered by UV light at the time of packaging which eliminates the need for special storage and packaging requirements that have hindered the use of oxygen absorbing sachets. Because water and carbon dioxide are not involved in the scavenging process the OS1000 film can be used with high water and low water activity products, as well as in conjunction with mixed gas atmospheres. Since the initiation of the scavenging polymer takes place on-line and the scavenging layer is buried in the structure, machining characteristics of the film are virtually unchanged The OS1000 film reduces the residual oxygen content in a MAP package from >0.5% to <0.1% in 7-10 days.

Biosensors

Biosensors are defined as indicators of biological compounds that can be as simple as temperature sensitive paints or as complex as DNA-RNA probes. Research on biosensor technology for detecting pathogens in meat continues at a rapid rate, although to date there has been little if any commercial success. One of the problems facing the production of biosensors for direct detection of bacteria is the sensitivity of assay in food samples (Ivnitski *et al.* 1999). They report that with the infectious dosages of pathogens such as *Salmonella* or *Escherichia coli* O157:H7 as low as 10 cells, that until a biosensor has a detection limit as low as a single organism per ml with rapid detection and at a low cost, this technology will not be viable. Two systems that have been developed to the semi-commercial state in North America are the SIRA "Food Sentinel" system and the Toxin Alert "Toxin Guard" system.

SIRA "Food Sentinel" system This system uses a bar code monitoring system for the detection of specific food contaminants associated with packaged food products. Park *et al* (1998) state that the system is based on immunochemical principles taking place under a uniquely designed commercial uniform product code (UPC). The principle of the system is that there would be a continuous flow of product juices potentially containing contaminating bacteria. These bacteria are bound to an available antigen –specific colored immunobead complex. The complex then migrates to be captured by a specific capture antibody attached to a membrane. The presence of the contaminating bacteria in excess of any mandated action level is evident by the formation under the bar code, of a localized dark bar on the membrane as a result of the immunobead-antigen complex binding to the capture antibody. This renders the bar code unreadable by the scanner.

Toxin Alert Inc "Toxin Guard' system Bodenhamer (2000) states that Toxin Guard™ is a system for manufacturing flexible packaging materials which can detect and identify microbial materials (toxins) in a package. It can detect and identify multiple toxic materials in an individual package. This system utilizes biologically active ligands such as antibodies to detect the presence of toxins in foods that are packaged in flexible polymer films. The author states that there will be 144 test sites per square foot of package surface for sensitive applications. As the toxin inside a package comes in contact with the test site, it will bind to a specific ligand. Over a time period of 30 minutes to 72 hours, produce a distinct visual cue on the packaging material signifying what toxin has been detected.

Conclusions

Active packaging in both the Case Ready FRM area and the Smoked and Processed meats area is beginning to emerge in the U.S. and Europe as distribution range is increased. While there is still several drawbacks to this technology, commercial successes are being seen. Research to overcome these shortcomings is continuing and the applications for use are becoming numerous. Research in biosensor technology continues and some perceived drawbacks must be overcome before a commercial success is realized. The main drawback to this technology will be in the biosensor's ability to detect the pathogen at extremely low levels and to detect them accurately. Until a very low detection level is achieved under commercial conditions, this technology will be limited.

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