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Review

Industrial packaging developments for the global meat market

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Abstract

Packaging companies must carefully monitor retail and consumer trends to best utilize, direct, or prioritize their research dollars in developing packaging and packaging systems to meet these demands. This paper reviews packaging developments that are resulting from numerous trends taking place in the meat industry and in the retail sector. Current case ready packaging solutions that meet the needs of retailers to reduce labor in the back of the retail stores, and the consumer needs for a fresh product with excellent quality and palatability are also discussed. It will also review the current packaging options that are being developed to help consumers battle their ''time crunch'' with ready meal solutions. Finally, the necessity to increase food safety or eliminate pathogens while producing a high quality product continues to drive packaging development. Current systems and packaging available for post packaging pasteurization will be discussed.

Keywords: Meat packaging; Case ready fresh red meat; Ready meals; Post packaging pasteurization; Consumers; Technology

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1. Introduction

There are several fundamental trends that are driving packaging companies' allocation of research dollars to develop packaging and packaging systems that can help meat companies satisfy both retailer and consumer. Three trends continue to stand out year after year in meat packaging. The first trend is the need to reduce labor in the back of the retail store. In the US as well as other countries, retail stores are open for longer period of times. Several hyper market formats in the US are now open 24 hours a day, 7 days a week. This increasingly leads to out of stock situations unless the stores have meat cutters available for all shifts. The second trend that we see is that today's consumer's severe time crunch and the need for fresh, high quality, convenient meat items, and ready meal entrees continue to drive packaging solutions. The final trend continues to remain the highest priority and that is how the meat industry can deliver a safe food item to its customers every time. While a tremendous amount of work has been done inside the meat plants to eliminate pathogens and improve the quality of the product, packaging has played a pivotal part in several advances.

2. Trend toward case ready meat packaging to reduce backstore labor in the retail market

2.1. Current case ready penetration in US

A 2004 study conducted by the Cryovac Division, Sealed Air Corporation, the National Cattlemen's Beef Association, and the National Pork Board assessed case-ready product in meat cases across the country (Mize & Kelly, 2004). The study found that case-ready products have grown to 60 percent of the meat case. This is up from 49 percent in 2002. Fig. 1 shows the break down by specie.

It is important to note from this chart that chicken and turkey are leading in case-ready products. In the US, these species have been case ready for the past 20 years. This is mainly due to the marketing efforts of poultry companies, their distribution system, and the uniformity of color of the meat throughout the distribution period. On the other end of the spectrum, beef has only penetrated the case ready market at 23% (up 9% from 2002). This is in part due to the demands by the retailer to market the product in the oxymyoglobin (red) state and the relatively short quality life of the product in this state. Ground beef continues to lead the way on fresh red meat with a 66% conversion. Eilert (2005) states that ground beef has typically led the movement among red meat categories, because it has a higher food safety concern than intact muscle cuts, and it is often easier to justify movement to case ready than some other products.

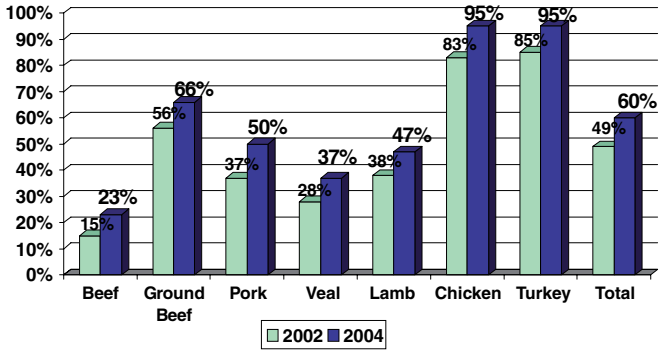

Fig. 1. Case ready penetration increased for each major specie based on package counts.

2.2. Current case ready penetration in Europe

In the U.K. and other parts of Europe (Carter, 2004), case ready packaging is growing at 15% per year, and is becoming one of the fastest growing segments of the self service sector. The European fresh meat market is expected to grow from 4.16 million metric tons in 2001 to 4.9 million metric tons by 2005. While this is not a huge increase in volume, the sector shows a clear change with case ready meats increasing by 13% to a total of 43%. Salvage (2005) states that there is a large variation in case ready penetration throughout European countries. Case ready packaging is approaching 90% in the U.K., while in Italy it is only about 10%.

2.3. Criteria for successful case ready meat packaging

The following criteria are dictating the types of case ready packaging and case ready packaging systems that are being developed.

1. Obtain the longest possible quality life of the product to allow adequate distribution time from the central packing facility. This can only be done in conjunction with excellent temperature control and hygiene.
2. Allow the product to be displayed in the retail store in the oxymyoglobin or red state. There is some product being marketed in the myoglobin state or purple state although this is in the minority.
3. The product needs to arrive at the retail establishment hermetically sealed, pre-priced, and labeled with a sell by date.
4. The product needs to be clearly seen and the package must not appear shop-worn.

2.4. Examples of current case ready meat packaging

2.4.1. High oxygen/barrier tray/barrier lid

Globally, this is the most popular format at the present time. This package consists of a clear or colored barrier lined tray (polystyrene, polypropylene, polyethylene) that is paired with a clear or printed barrier film. This style of package normally has a 1:1 headspace ratio and contains an atmosphere of 80% O_2 and 20% CO_2. The 1:1 ratio is needed to give the product a minimum of 55% oxygen through out the shelf life, which was found to provide optimal color life (Jakobsen & Bertelsen, 2000). The O_2 reacts with the meat to extend the oxymyoglobin state while the CO_2 acts as bacteriostatic agent (Bartkowski, Dryden, & Marchello, 1982; Kropf, 2004). The advantages of this type of product is that everything can be done at the packing plant and all that needs to be done by the processor is to place the pre-priced/pre-labeled package into the case. The disadvantage is that by marketing the product in the oxymyoglobin state the quality life of the product is limited to about 10–12 days for ground beef and 12–16 days for whole muscle. Lipid oxidation tends to be a problem with this style of package (Jackson, Acuff, Vanderzant, Sharp, & Savell, 1992). Also once the product is placed under retail lights the quality life of the product is only 2–4 days (depending on product), which is still about double what the retailer gets now with the traditional PVC wrap.

2.4.2. High oxygen/tray/barrier over wrap

This format is popular especially in Europe. This package is similar to the Tray/Lid in that it has the same requirement for head space and uses the same gas mixtures. The difference with this package is that it uses a non-barrier polystyrene tray similar to what is used by retailers today and it is completely over wrapped giving it a more in-store look. The same advantages and disadvantages exist with this option as with the first.

2.4.3. Low oxygen barrier tray/barrier peelable lid with CO

The use of carbon monoxide in the primary package of a case ready meat product had only been practiced in Norway since 1985 (Sorheim, Nissen, & Nesbakken, 1999). Concerns had always been expressed in the past that such a system could mask spoilage. Eilert (2005) states that this was challenged and a finding was issued by the FDA in 2004 that low levels of CO did not mask spoilage, and that could appear in a package of fresh meat. Eilert goes on to state that the FDA decision noted that while color did not degrade in a package containing CO, offensive odors could still form in the presence of CO. Thus a new format of case ready packaging has begun to appear in the US. This format seeks to extend the quality life of the product by distributing and marketing the product at retail in the carboxymyoglobin (bright red) state. This package consists of a barrier lined tray that is paired with a clear barrier film. The package, which must contain some amount of headspace, normally contains an atmosphere of 79.6% N_2, 20% CO_2, and 0.4% CO. The O_2 requirement is very strict and must be below 0.5%. Several commercial packaging systems such as those manufactured by Reiser, Ulma and Mondini etc, can routinely produce packages that meet this oxygen requirement. The advantages of this package are that the distribution life is extended by 5–10 days depending on the cut and the headspace of the product is reduced by 50%. Since the product is distributed and marketed in the carboxymyoglobin state, there is no reduction of the color during display. Oxidation of the meat, which is associated with high O_2 packaging, is not an issue with this package. The product can be pre-priced and pre-labeled at the packer. As with vacuum and other low oxygen formats, hygiene and temperature control as well as a strict adherence to the sell by date are critical for this type of packaging. The main technical disadvantage with this style of packaging is that if products are stored under inappropriate conditions, the presence of CO may mask the visual evidence of spoilage (EU Scientific Committee on Food, 2001).

2.4.4. Low oxygen/barrier tray/barrier peelable lid

This format seeks to extend the quality life of the product by distributing it in the myoglobin (purple) state and marketing the product at retail in the oxymyoglobin state. This package consists of a barrier lined tray that is paired with a clear barrier film. The barrier film consists of a barrier layer (on the outside) and a non-barrier layer (sealed to the tray). The package which has no headspace requirement normally contains an atmosphere of 80% N_2 and 20% CO_2. Fresh meat is particularly susceptible to discoloration by low levels of oxygen (Sebranek & Houser, 2006). They state that a partial oxygen pressure in the range of 5–10 mm of mercury will rapidly convert the myoglobin pigment in meat to metmyoglobin. Because of this, the residual O_2 requirement is very strict and must be below 0.05% after packaging, and essentially zero within 24 hours following packaging (Solomon, 2004). When the product reaches the retailer, the lid is peeled exposing the breathable layer. The product will bloom in 20 minutes. The advantages of this package are that the distribution life is extended by 5–10 days in the low-oxygen state depending

on the cut and the headspace of the product is reduced by 50%. There are no oxidation issues with this style of packaging. The disadvantages are that the retailer must peel the package, price, and label at the store. It also makes it difficult for the packer to code date the product.

2.4.5. Breathable package in a low oxygen pouch

This format also seeks to extend the quality life of the product by distributing it in the myoglobin state and marketing the product at retail in the oxymyoglobin state. This package consists of a non-barrier tray and non-barrier over wrap around the product. This product in the non-barrier package is then overwrapped in another barrier package that allows the product to be distributed in the myoglobin state. The package which has no headspace requirement normally contains an atmosphere of 80% N_2 and 20% CO_2. Again, with this style of packaging, the residual oxygen level must be kept below 0.05%. In this style of package the O_2 requirements have to be met by using an activated oxygen scavenger. In 2003, this package was further enhanced with the use of 0.4% CO in the outer package (Merriman, DelDuca, Luthra, & Goulette, 2003). With this addition, the product is distributed with the myogloblin in the carboxymyoglobin state and then when it reaches the retailer the outer package is discarded. The advantages of this package are that the distribution life is extended by 5–10 days depending on the cut, the headspace of the final product is reduced by 50% and the product can be pre-priced and pre-labeled. Any issues with oxidation are minimized with the low oxygen atmosphere. The disadvantages are that the retailer must open the outer package and it requires multiple pieces of equipment at the packing plant. It also makes it difficult for the packer to code date the product.

2.4.6. Low oxygen vacuum skin packaging (VSP)

This style of package uses a barrier styrene or polypropylene tray and uses a barrier film that can form around the product to reduce any amount of purge from coming out of the product. An additional web of film or a header can also be added for pre-pricing and pre-labeling. An advantage and disadvantage of this package is that it gives the product a unique look. The product shelf life can be 15–22 days depending on the cut. Since the product is displayed in the myoglobin state, there is no loss of color in the display case and oxidation issues are minimized with this type of package.

3. Trend toward developing value added meat products and ready meal entrees to save time and add convenience

3.1. Consumer need for fresh and convenience

Another area that packaging companies are spending research dollars is in the areas of convenience packaging for products that can save consumers time when cooking. While 75% of all adults still ate last night's meal at home, the number of meals prepared at home continues to decline, falling from 64% in 2003 to 58% in 2005 (MSI, 2005). This report goes on to state that the number of scratch dinners that were prepared at home continues to decline and now account for only 32% of all evening meals. One quarter (26%) of last night's dinners used convenience foods and 17% used restaurant/supermarket take-out, while 23% were eaten at a restaurant. When consumers are buying their entrees in a retail store, they increasingly are turning to refrigerated options, which are perceived to be fresher and healthier. Dollar sales in the US increased by 8.2% over the previous year compared to 4.7% for frozen and 2.5% for shelf stable (IRI, 2005). Fresh is the most desirable food label claim and is extremely/very important to 62% of food shoppers (Health Focus, 2005). Consumers also believe that refrigerated meals use fresh ingredients and contain fewer additives (R&M, 2005).

3.2. Criteria for successful pre-cooked entrees

In a series focus groups funded by Cryovac in 2003, we found similar criteria for successful pre-cooked entrees as were identified by Parlin (2004). These attributes have been listed below:

- Microwaveable – heat and serve in one package;
  - Ultimate would be to cook, store, distribute, display, reheat and serve;
- Excellent graphics and communications;
- Easy open/self venting;
- Enhanced product presentation;
- Display and store chilled (versus frozen);
- Costs associated with value of product.

3.3. Current packaging formats for ready meals

3.3.1. Pre-cooked entrees in MAP Format

Numerous formats are on the market today with microwaveable trays that contain a pre-cooked entrée and lidded with a barrier film. These products can be manufactured on most standard roll stock systems and use a low oxygen gas mixture such as 70% N_2 and 30% CO_2. These entrees must use controlled temperatures, excellent hygiene and high barrier packaging to allow them to extend the quality life of the product from 21 to 35 days depending on the product. These types of products do not typically lend themselves to any post packaging pasteurization steps. The advantage of these types of packaging is that they have excellent product presentation. Along with convenience?

3.3.2. Cooked in the package entrees in thermoform format

Several large companies in the US have achieved national distribution with this type of process. The entrees, which usually include an amount of gravy or sauce, is packaged in a film that can withstand a hot water cook of up to 12 h

at 90 °C. The product is packaged under a full vacuum and then the product is cooked in either steam or hot water. The packaged product is then placed in a microwaveable tray, lidded with a non-barrier film and then put into a sleeve or box to distribute. The advantage of this package is the significant increase in quality life by not having to handle the product after it is cooked. This type package can also be assembled with a pre-cooked entrée and then go through a post packaging pasteurization step to eliminate any vegetative pathogens. The consumer can then heat the entrée in the microwave or in hot water. The disadvantage is that the presentation of the entrée is not very appealing and is usually marketed in a box or a sleeve. The consumer also has to puncture the product prior to microwave heating and remove the hot product from the package prior to serving.

3.3.3. Cooked in the package entrees in tray/VSP Format

Probably the newest entry into the ready meal market is a package that is being marketed under the Simple Steps trademark. Parlin (2004) states that this package has changed some of the disadvantages previously seen in packaging for pre-cooked entrees. This package utilizes a barrier microwaveable, self venting tray, and a barrier top film that forms tightly around the product. The package can withstand a cook temperature at the processors of just below 90 °C. The consumer can then transfer the package directly to the microwave without the use of any utensils to puncture the product. The lidding material is designed to be both self-venting and easy opening after heating and the product can be served directly from the tray.

The packaging designs for this market will continue to evolve. Packaging companies are currently working on materials that can be retorted at the processors and that can be re-heated in either the microwave or conventional ovens. There have been several recent advances in ovenable films and trays that can be hermetically sealed and capable of withstanding the abuse requirements and packaging requirements of meat packers.

4. Food Safety by post packaging processing steps

4.1. Pasteurization treatments

The Food Safety and Inspection Service (FSIS) of the USDA has proposed several strategies for reducing the risk of *Escherichia coli* O157:H7 in raw meat and *Listeria monocytogenes* in ready-to-eat (RTE) foods. On June 6, 2003, FSIS issued an interim final rule on control of *L. monocytogenes* in (RTE) meat and poultry products (USDA/FSIS, 2003). The industry has explored numerous technologies for pathogen reduction in the package but the three that have received the most interest seem to be thermal, high pressure, and irradiation.

4.1.1. Thermal pasteurization

This process applies an in-package surface pasteurization of whole muscle cooked products which reduces the risk of pathogens and also increases the quality life of the product. Temperature ranges for most post packaging pasteurization units range from 70 to 96 °C and dwell time will range from 30 s to 10 min. There is always a balance between the criteria needed to ensure adequate pasteurization and the amount of purge that can be generated. Several companies have developed pasteurization units, with Alkar, Unitherm, Gal-esh and Stork being the most common. Packaging companies have developed materials that can withstand the thermal treatment and the abuse of these units and still have the attributes of good ink adhesion, high gloss, and high shrink required for retail marketing. Another development underway for deli type products that normally require additional browning is the development of color/flavor transfer products. These products can transfer color and in some cases flavoring from the plastic casing allowing the meat processor to cook and ship in the same package. This eliminates the handling required by a browning/flavoring step and the need for post package pasteurization.

4.1.2. High pressure processing (HPP)

HPP is another in-package pathogen reduction technology and refers to the exposure of foods within vessels to high hydrostatic pressures (300–700 MPa) for a short time (few seconds to several minutes). Several companies have developed semi-automatic systems that can hold several hundred pounds of packaged product at a time. This is being used by meat packers in high value non-whole muscle products or where thermal treatment is not an option (proscuitto ham). There is not a separate regulatory approval process for packaging materials subjected to high hydrostatic pressures. They are treated as part of the Good Manufacturing Practices of the process. Flexible and semi-rigid packaging materials are best suited for HPP in order to prevent package deformation. Most film/bag compositions can resist delamination under the severe pressures, but there are a few known exceptions. These include packages with headspace and some easy open films. Packaging development has centered on addressing these issues when using HPP.

4.1.3. Irradiation

Irradiation is the third technology used for in-package pathogen reduction. It has been considered a means to reduce or eliminate several different pathogens in raw meat products, but the main driver for its use was the elimination of *E. coli.* O157:H7 in raw ground beef. Food irradiation involves exposing pre-packaged fresh meats to gamma, X-ray or electron beam irradiation. Irradiation has been approved in the US for fresh poultry for over twenty years and for fresh red meat for almost a decade. Its approval for processed meats is still pending. While there is little doubt of the effectiveness of irradiation, there continues to be hurdles to its acceptance. These hurdles include a limited number of approved food applications, some significant transportation/processing costs/logistics,

and there are a limited number of approved packaging materials. All packaging materials that can be used for irradiated foods in the US are regulated by the FDA under 21 CFR 179.45 and these have not significantly changed since 1968. Packaging companies have found it difficult to obtain regulatory approvals for additional resins/structures. The demand for irradiated meat products in the US has faded over the past five years. At this time there are several generic packaging structures approved, and there are no approval petitions presently underway.

5. Conclusions

It is critical that packaging companies work with meat companies to understand and solve the problems that consumers and retailers encounter with meat products. They must focus their research dollars on developing new products and new packaging formats to address these issues and delight the customer. The world is becoming flat and trends occurring in Europe today will be happening in Asia tomorrow. Case Ready packaging will continue to evolve in all areas of the world as labor issues become a problem. Consumers will always be demanding and willing to pay for convenience if it solves their problems. The meat and packaging industry must continue to work on systems that will ensure a safe and palatable product. This paper has dealt with commercial materials and systems developed to meet specific concerns in the meat industry. To meet tomorrow's concerns, there continues to be a large amount of research to evaluate areas such as active packaging, traceability, sustainable resources and anti-microbial packaging. Advances in these areas will continue to give us a safe and sustainable food supply.

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