



Review

# New packaging technologies for the 21st century

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## Abstract

This paper reviews the major influencers that will drive change in meat packaging. A review of the current state of fresh-meat packaging in the US has shown a continued evolution to case ready packaging, with 60% of the packages audited being in the case ready format, versus 49% just two years earlier. Additionally, the market is moving to a higher degree of convenience in the meat case, and reducing the linear feet devoted to fresh meat (69% fresh meat linear feet two years ago, versus 63% in 2004). Additional evidence for the growth of convenience items was shown by a 48% growth in shelf stable meal kits between 1998 and 2003. Packaging innovations have been developed to meet these needs for convenience, but have largely been implemented outside of the meat industry. These include, but are not limited to, lines of hand-held soups, self-heating cans and cartons that are replacing the traditional steel can for retort purposes. The recent developments of films that are ovenable in traditional as well as microwave ovens are critical to the further advancement of convenience meat items. Material costs are also driving the need for packaging innovations. Polyethylene costs rose 20% during the second half of 2003, which is largely due to increased petroleum costs. As petroleum costs are sustained at the current high levels, renewable packaging for food, such as materials based on polylactide, will become more feasible. Labor costs and availability at retail will continue to drive the demand for case ready packaging innovations. The recent regulatory approval of carbon monoxide in fresh meat packaging in the US will enable greater usage of low oxygen packaging formats and should provide greater retail acceptance of case ready in the US.

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## 1. Introduction

When tasked with a review of “Packaging Innovations for the 21st Century”, the approach chosen was to first review the influencers of change in packaging, and then the technologies that are enabling those changes. By doing so, greater relevance will be added to this discussion, as opposed to a pure discussion of technology without any regard for the need or demand for that technology. The discussions will be focused on the US industry. With respect to our global colleagues, it was felt that it would be more pertinent to focus more in depth on this geography rather than having a more cursory view of the global community.

As packaging innovations were researched across the food industry, it was noted that the majority of the significant innovations were taking place in product lines outside of the meat industry. There are numerous examples of breakthrough innovations in the snack and beverage categories. These innovations will be discussed, as they may have application to the fresh or prepared meats industries. Also, it is important to study these innovations as lessons on how to change our paradigms around meat packaging. One of these recent innovations is the high-density polyethylene coffee container.

Hartman (2004) outlines the development and increased market penetration of this innovation. For 150 years, coffee has been packaged in a three-piece metal can. Procter & Gamble (a leading manufacturer of coffee) has worked for the last few years to challenge that paradigm (that coffee has to be packaged in a metal can). In 2003, they introduced the HDPE container to the market. Since that time, they have continued to convert many of their operations from the steel can to the HDPE container. Among the advantages is a smooth rim that is devoid of the sharp edges of a typical metal can. The lid has a peelable factory seal that contains a patented one-way valve. Previously, in a metal can, coffee would have to be cooled prior to filling so that off-gassing could occur. With the design of this seal, coffee could be filled while still warm, which would simplify operations and preserve freshness. Additionally, a snap fitting lid helps preserve freshness upon opening. This package is the culmination of a series of innovations that have been successfully bundled into a consumer product. It has been influenced by the need for cost control of process and for convenience to the end user. It is an example of the type of innovations that are needed in the meat industry to maintain and stimulate demand.

## 2. The current state of meat packaging in the US

### 2.1. Fresh-meat packaging

A study was conducted in 2004 to audit and report the trends in fresh meat packaging at the retail level (Mize & Kelly, 2004). This study gives a detailed account of the type of packaging formats being used and the relative degree of their use, and to compare these results to a similar study conducted in 2002. In 2002, 69% of the linear footage of the self-service meat case was occupied by fresh meat and poultry. This figure declined to 63% in 2004, reflecting a growing conversion of meat items to products with greater consumer convenience, such as fully cooked entrees and marinated meats, as well as hams and sausages. Another key finding in this study is the proportion of packages that are case ready, or defined as products that were not repackaged in the backroom of the store. In 2004, 60% of the packages audited were case ready, which had increased from 49% in 2002. These data reflect an audit of packages, and does not directly measure actual volume of meat converted to case ready. However, these data are accurately reflective of the growth of case ready in the US.

It is important to note the relative level of case-ready penetration by product species (Mize & Kelly, 2004). Chicken and turkey have continued to increase in case ready penetration, to the point that virtually all (95%) of the packages audited in 2004 were case ready. On the other extreme, while beef case-ready penetration continues to grow, it is offered in a case-ready format in only 23% of the packages audited. Ground beef was offered in a case-ready format in 66% of the packages audited, which is up from 56% in 2002. Ground beef has typically led the movement amongst red meat categories in the US. As ground beef inherently has a higher food safety concern than intact muscle cuts, it is often easier to justify movement to case ready than some of the other products.

The types of packages were also reviewed in this study (Mize & Kelly, 2004). As the amount of case-ready packages grew, the traditional Styrofoam tray with polyvinyl chloride wrap declined in package occurrence from 51% in 2002 to 47% in 2004. This format is offered in both case ready as well as in-store preparation. However, most of the other package formats are offered almost exclusively in centralized packaging operations. Modified atmosphere packages increased by 4% over the last two years (9% in 2002 to 13% in 2004),

and vacuum packages were up 3% (10% in 2002 to 13% in 2004).

In summary, the fresh retail meat case is evolving. This evolution is largely being driven by the need for conversion to centrally packaged meats (an economic influencer) and the need for increased convenience on the part of the consumer. These influencers will be discussed in greater detail later in this paper.

## 2.2. Value added meat packaging

The majority of packages in this category are still in a flexible film, vacuum sealed state. Many sliced products are moving away from this to a modified atmosphere package in order to accommodate easier separation of slices for the consumer. Fully cooked entrees are a category of products that has seen a great deal of growth over the last five years. The majority of these products are packaged in a flexible film that the product was cooked in, with a variety of secondary packages around the product. The economic and consumer convenience influencers reviewed in this paper will further detail the need for innovation in these product lines.

## 3. The consumer as an influencer of meat packaging

### 3.1. Need for convenience and ease of preparation

There is no denying the demands for foods with greater convenience. A report by the Food Institute (*Meal kits with meat included capture most of the segment's sales, 2004*), which outlines the growth of the meal kit category as an indicator of this demand. Between 1998 and 2003, the sales of shelf stable meal kits grew 48%. This category has slowed in sales over the last couple of years, largely due to the introduction of meal kits with even greater convenience. These would include kits that have a meat or poultry portion already included. It is expected that this category will grow to sales of \$50 million by 2008. In 1998, this category reported only \$11 million in sales.

The major influencers of this increased demand are three-fold. First, the increasing number of young people with minimal cooking skills will continue to influence this market. It is hard to imagine a complete reversal of this trend. Secondly, employment and lifestyle trends continue to erode the time available for complete preparation of meals at home. Third, as the baby boom generation reaches retirement age, their willingness to devote time spend in complete preparation of meals is waning (*Meal kits with meat included capture most of the segment's sales, 2004*). Technology advancements that are further enabling food manufacturers to meet these demographic influences will now be studied.

### 3.2. Examples of technology enabling industry to meet these needs

There are very notable examples in the food and beverage industry that have addressed the consumer needs for convenience. The Campbell's Company designed a product line (*Soup at Hand*) to address the needs for convenience. This line of soups does not require a can opener nor does it require a spoon, which previously have been two implements necessary for consumption of soup. Additionally, it is shaped to fit in the cup holder of a vehicle. However, even this innovation does not achieve the level of convenience that has been designed into the self-heating can (*Innovation abounds in '04, 2004*). This recent introduction into the market place is designed as a can within a can. Between layers of this package is crushed limestone. When the consumer wishes to heat the beverage, a button is pushed which releases water into the crushed limestone, and causes a thermal reaction to occur, heating the beverage in the inner can. This item is now on store shelves in the US. While it is difficult to say how common such a convenience will be in the future, it is a sign of the type of efforts that will be made to address the need for convenience in the food industry.

One area in the meat industry that is evolving is the packaging of prepared meat items. As in the case of coffee, the traditional can for chili has now found a replacement in the Tetra Recart Carton (*Burn, 2004*). This carton is capable of being retorted and its brick shape is more user friendly for distributors and consumers. Additionally, it does not require a can opener. It is speculated that this retorted brick package design will continue to replace the can as a form of shelf stable packaging. While this is a major advancement in package design, it is not a package that can be microwaved. The evolution of materials that are suitable for retort and reheating in the microwave is continuing with the Tetra Wedge Package (*Burn, 2004*). This package contains a silicon dioxide barrier, rather than aluminum, which will allow it to be retorted as well as to be reheated in the microwave.

There is a need to improve the convenience level many of the product offerings in the fully cooked entrée category. Most of the products are vacuum packaged in a horizontal thermoformed cook-in material, and placed in a secondary container for distribution to the consumer. This package design has many opportunities, as it requires a sharp instrument to open the primary package. Additionally, the final package usually contains two additional components of secondary packaging. The development of *Simple Steps* (*Parlin, 2004*) has changed some of these paradigms. This package can be processed at just below 100 °C, and can be transferred directly to the microwave without the use of any utensils to puncture the product. The lidding material on this package

is self-venting, and is designed for optimal reheating in the microwave.

The design of materials will continue to evolve that are capable of being retorted and reheated in either the microwave or conventional ovens. Convenience in prepared meat packaging will be enhanced with the ability to provide a shelf stable package that can be reheated in virtually any reasonable. This level of convenience is starting to be achieved and will likely experience a higher degree of development going forward. Recently, a major advancement in this area was introduced through a film structure that provided conventional and microwave reheating capabilities ([Microwave packages cook up consumer convenience, 2004](#)). This technology was enabled through the merging of crystallized polyethylene terephthalate (CPET) with amorphous polyethylene terephthalate (APET). This combination of structures allows for dual oven characteristics and refrigerated storage of products. These types of film and packaging structure advances will need to continue in order to further meet the needs for high quality, convenience foods.

#### 4. Economic factors as an influencer of meat packaging

##### 4.1. Material costs

At the time of preparing this review, crude oil prices continued to hover in the \$50/barrel range. Surging petroleum prices is not a new phenomenon to the manufacturing industry. However, one has to question if a fundamental shift in the demand for petroleum has occurred. This economic shift will influence the market in a number of ways, inclusive of the price of packaging materials. [DeMarras \(2004\)](#) reported that Sealed Air Corporation raised prices by 6–8% in the last year on materials made from plastic resins. This article also reported that polyethylene costs increased 20% during the second half of 2003.

Traditionally, it has been very difficult for alternative materials, such as biomaterials, to make inroads to the petroleum-based packaging materials market. This difficulty is due to limited functionality in many cases, but also due to the fact that the economics of biomaterials could never compete with petroleum-based materials. However, as previously stated, if \$50/barrel crude oil prices are now the rule rather than the exception, alternatives to petroleum-based materials will likely evolve and become more economically viable.

##### 4.2. Availability of trained labor for meat merchandising

Much has been written and reported as to the growth of centralized fresh meat packaging in the United States. One of the key influencers of this growth is the reduction in skilled labor required at retail level for meat fabrica-

tion. The programs of apprentice butchers of the past have been disbanded. Very few technical schools are available that teach basic meat processing and fabrication skills. As retailers face this reality, the need for centralized packaging of fresh meat will continue to evolve. Additionally, as the hours of retail operation evolve to more formats with 24 h of operation, the needs for pre-packaged fresh meat will continue to evolve.

This review is not going to extensively discuss traditional formats of case ready packaging, as this topic has been extensively reviewed in the past. The discussion in this area is going to focus on the evolution and technologies that might enable pre-packaged fresh meat in the United States to grow at a faster pace than has been recorded in the last 4–5 years.

#### 4.3. Examples of technology enabling industry to respond to these economic factors

##### 4.3.1. Material innovations

A breakthrough in food packaging occurred in 2004 with the introduction of *Biota* (Biota Brands of America, Telluride, CO) bottled water in commercially compostable material ([Lingle, 2005](#)). This material is polylactide, is a renewable material made from corn and marketed under the trade name *NatureWorks PLA* (Cargill Dow, Minnetonka, MN). The first uses of this material have been for short life, cold fill applications ([Innovation abounds in '04, 2004](#); [Meal kits with meat included capture most of the segment's sales, 2004](#); [Microwave packages cook up consumer convenience, 2004](#)).

While the uses of PLA are limited, this is a critical step in the evolution to develop alternatives to petroleum based packaging materials. [Lingle \(2005\)](#) noted that the cost of this material for beverage containers is now very comparable to conventional plastic resin materials. Additionally, the material could be run on conventional packaging machines at lower temperatures than traditional polyethylene materials.

##### 4.3.2. Low-oxygen fresh meat packaging

In the aforementioned review of fresh meat packaging trends in the US, it was noted that there continues to be a greater movement of fresh meat in a case ready format. The basic designs of case ready red meat have not evolved significantly over the last 5–10 years. The majority of products have been and continues to be offered in a high oxygen environment (approximately 80% oxygen) in order to maintain bloom, with at least 20% carbon dioxide to prevent microbial growth. Whether these gasses were placed in the primary package or in a master bag surrounding the primary package, the basic technology has been unchanged for a number of years. This technology has been successful for a number of larger retailers, as the shelf life provided by this pack-



age has been sufficient in a controlled distribution system.

Low oxygen packaging systems have been readily available for usage in the US, but not as widely implemented as the high oxygen counterparts. Vacuum packaging continues to be in many cases, the most cost effective packaging strategy. A recent innovation in vacuum packaging has been the evolution of shrinkable films in use with horizontal form-fill-seal machinery (Salvage & Lipsky, 2004). This offering addresses one of the major drawbacks of form-fill-seal packages for fresh meat, that being the excessive film and wrinkles often noted in these packages. This technology will continue to evolve as it offers many advantages to traditional form-fill-seal operations as well as to vacuum bag applications.

Merriman, DelDuca, Luthra, and Goulette (2003) developed another low-oxygen packaging alternative to high oxygen. In this system, a small amount of carbon monoxide ( $\text{CO} < 0.4\%$ ) was used in a secondary package surrounding the primary package, which was covered with traditional non-barrier PVC wrap. While the use of carbon monoxide in meat packaging is hardly new, this technology was novel as it was the first to be incorporated into a secondary packaging system. This was a critical element that allowed this package to gain FDA acceptance for use in 2002 (FDA, 2002).

The use of carbon monoxide in the primary package for fresh meat had only been practiced in Norway since 1985 (Sorheim, Nissen, & Nesbakken, 1999). Concern has been expressed in the US in the past that such a system would mask spoilage that could occur in fresh meat products. In 2004, this assumption was challenged in the US. A finding was issued (FDA, 2004) that low levels of CO did not mask spoilage that could occur in a package of fresh meat. Indicators of spoilage are color, offensive odors and offensive flavors. This FDA decision noted that while color did not degrade in a package containing CO, offensive odors could still form in the presence of CO. This is supported by the findings of researchers that have found that low levels of CO are not inhibitory to the growth of spoilage organisms (Sorheim et al., 1999).

The use of CO in the primary package of fresh meat in the US is a major breakthrough. This will allow for the wider distribution of case ready products and adequate shelf life needed to achieve distribution of these products. Additionally, low oxygen packaging benefits (reduced flavor degradation due to oxidative rancidity) is a major advantage that will improve the consumers eating experience. This evolution will enable the US meat industry to meet the needs of a larger group of retailers, in a packaging format that is less packaging and labor intense. As with vacuum packaging and other low oxygen formats, hygiene and temperature control will be critical to presenting a product to the consumer that is not spoiled. However, by using CO for its color

stabilization properties, we can achieve an acceptable appearance and flavor for the consumer with optimal distribution life for the retailer.

## 5. Conclusions

It is critical that we understand the factors that will have the largest influence on the evolution of meat packaging. The demand for convenience foods will continue to be fueled by the aging of our population, the diminished cooking skills of the typical consumer and the reduced time available for home preparation of meals. The ability of materials to offer flexibility in primary processing as well as reheating at home will be critical. Increased costs of petroleum will continue to drive the demands for bio-based packaging materials. Additionally, the demand for pre-packaged fresh meat will continue to grow, but it is critical that packaging formats that enable wider distribution of these products evolve. Low-oxygen packaging technologies will continue to evolve as long as they can successfully and economically enable the wider distribution of centrally packaged fresh meat.

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