Film Properties Required for Thermo-Formed and Thermal Processed Meat Packages

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Introduction

Thermo-formed films are used for packaging a wide variety of processed meat items. These meats are perishable and the packaging systems and films used are designed to retain the product's flavors, color and moisture, as well as preventing oxygen and potential off flavors from entering from the outside.

A large percentage of the processed meat is sold through supermarkets, and packaging is one of the most important factors in this type of merchandising. These meats are distributed and displayed in a manner that calls for keeping the meat sanitary and wholesome for 60 days or longer. In the supermarket, a package may be handled several times and there is no way to control the cleanliness of the customers.

Supermarket merchandising calls for packaging using tough high-barrier films, as well as efficient high-speed packaging machines capable of removing oxygen and providing a controlled atmosphere inside the package.

Packaging Systems

A packaging system is made up of packaging materials, a packaging machine and a process. There are many packaging techniques available to the meat packer. However, the majority of processed meat is packaged on machines that require two different types of laminated films:

1. A non-forming film
2. A forming film

Figure 1

NONFORMED FILM

FORMED FILM

Figure 1. Typical processed meat package.

The packaging system generally employs a machine which performs most of the following steps:

1. Heats the forming film.
2. Forms it into a cavity of the desired size.
3. Provides a loading area — so product can be placed in the formed cavity.
4. Brings the non-formed film in place over the formed film containing the product.
5. Pulls a vacuum to remove air inside the package.
6. Introduces an inert gas, such as nitrogen, into the package if desired.
7. Hermetically seals the package. This is done with heat seal bar that melts the two sealant layers and welds them together under pressure.
8. Cuts or trims the films to provide individual packages.

The packaging system is extremely important. Oxygen causes processed meats to fade as well as turn rancid. Fading is noticed by the consumer and can result in the package being passed by and a more appealing brand being selected. On many products, oxygen must be removed during mixing and blending and the packaging machine must be operated in a manner that efficiently removes oxygen. A high-barrier film cannot be expected to do the best job of preserving the meat if the packaging machine is not designed and operated properly.

Packaging Films

Meat packaging films are generally multi-layer structures and a variety of polymer resins and coatings are utilized by the industry. They usually contain three or more layers, with each layer contributing a specific property to the structure (Fig. 2).

Layer A. The outside layer must be scuff- and abrasive-resistant.
Layer B. The middle layer generally provides the barrier to oxygen.
Layer C. The sealant layer must be capable of being melted and welded under pressure to the sealant layer of the other film to make a gas-tight seal.

All of the materials used must be in compliance with Federal Food & Drug regulations relating to materials suitable for packaging food. Also, the details on all materials used in meat and poultry packaging films are cleared with the Food Safety and Inspection Service section of the United States Department of Agriculture. Film manufacturing firms have letters from the USDA on file indicating by trade name that each composite film is acceptable for packaging meat and poultry products.

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Figure 2. Composite polymer film.

Resistance to Oxygen Transmission

Most processed meat is packaged in such a way that the oxygen in the package is reduced by having the product under vacuum or by a system that pulls a vacuum and relieves the vacuum with an inert gas such as nitrogen.

The packaging film must keep atmospheric oxygen from getting back into the package. The ability of different films to slow down the transmission of oxygen is dependent on a number of factors, such as the type of polymer, thickness, ambient temperature, humidity, etc.

Oxygen transmission values for almost all polymer films used for food packaging are available in the literature. The values are generally determined at 73°F, 0% R.H., and are reported as the milliliters of oxygen transmitted through 100 sq. inches (or 1 sq. meter) in 24 hours.

Of the films used for packaging processed meat, the most used transparent oxygen barriers are polyvinylidene chloride (saran) and ethylene vinyl alcohol (EVOH). Typical oxygen transmission values for these and some of the other polymer films being used for meat packaging are:

Table 1. Typical Oxygen Transmission Values

<table>
<thead>
<tr>
<th>Material</th>
<th>ml O₂/100 sq. in. 24 hrs. 73°F, 0% RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene Vinyl Alcohol (EVOH)</td>
<td>.1</td>
</tr>
<tr>
<td>Saran (PVDC) Coatings</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>1 mil nylon</td>
<td>2.3</td>
</tr>
<tr>
<td>0.5 mil polyester</td>
<td>9</td>
</tr>
<tr>
<td>.75 mil oriented polypropylene</td>
<td>200</td>
</tr>
<tr>
<td>2 mil sealant (EVA or Surlyn)</td>
<td>300</td>
</tr>
</tbody>
</table>

In any discussion of meat packaging, it is important to know the relative oxygen barrier properties of the polymer films and coatings being considered for the packaging film structure. However, these data are only a starting point. The oxygen transmission of the finished processed meat package is a complicated subject and a number of factors must be considered. A few of the factors that influence the oxygen barrier of the finished package are:

1. Films for packaging processed meat are generally a combination of various polymer films. Each layer in the finished film will contribute something to the barrier properties of the finished structure.
2. Some of the polymer layers in the film structure will vary in initial thickness.
3. The forming film will be considerably thinner after forming than it was originally. This thinning is not uniform and varies with the size and shape of the cavity, as well as the technique used to do the thermo-forming. Thin films permit more oxygen to pass through and enter the package. Each layer in the packaging film will be thinner after forming.
4. The entire package will be handled in packaging, boxing, shipping and merchandising. Any abuse will tend to harm the barrier properties.
5. The amount of moisture in the air can change the rate of oxygen transmission for certain packaging films.
6. Processed meats are generally stored at refrigerated temperatures. Less oxygen is transmitted through all polymer films as the temperature is reduced.

The effect of temperature on oxygen permeability is substantial. At 75°F, oxygen is transmitted through films approximately five (5) times as fast as it is transmitted at refrigeration (38-40°F) temperature.

Protection from Moisture Loss

Water vapor transmission values for essentially all of the polymer films used for packaging are published and available in the literature. Measurements are generally made at 100°F and 90% R.H., and are reported as gm/24 hr./100 sq. inches (or 1 sq. meter).

Table 2. Typical Water Vapor Transmission Value

<table>
<thead>
<tr>
<th>Material</th>
<th>g/24 hrs./100 Sq. In. 100°F-90% R.H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saran Coating</td>
<td>.9</td>
</tr>
<tr>
<td>Nylon 1 mil</td>
<td>High</td>
</tr>
<tr>
<td>Polyester 0.5 mil</td>
<td>2.8</td>
</tr>
<tr>
<td>Oriented Polypropylene .75 mil</td>
<td>0.4</td>
</tr>
<tr>
<td>Polyethylene (EVA) 2 mil</td>
<td>5-.7</td>
</tr>
<tr>
<td>Surlyn 2 mil</td>
<td>7-1.1</td>
</tr>
</tbody>
</table>

Polyethylene, Surlyn and oriented polypropylene films are very good barriers to moisture vapor. They permit considerable oxygen to be transmitted but are very resistant to water vapor.

Summer sausage is sometimes distributed, displayed and sold in the natural casing — without any additional protective packaging. The natural casing is not designed to be a good moisture barrier, and retailers have told us that such unpackaged summer sausage chubs must be reweighed every two or three days. They find that the item has lost enough weight to cost them $0.06-$0.08 between each weighing.
Data obtained in the laboratory demonstrated that after only three (3) days there was a 5% weight loss under refrigerated conditions and a 7.5% weight loss at room temperature with chubs in natural casing. Chubs packaged in a barrier film lost no weight. Assuming a retail selling price of $2.75 per pound; after three (3) days at refrigerated conditions, the summer sausage chub in the natural casing lost $0.11 in weight while the packaged chub lost no weight or money.

A 12 oz. summer sausage chub can be packaged in high quality barrier film for approximately $0.05 for film cost. The packaging pays for itself quickly, and there will be less oxidation of the product.

Laminated films used provide good oxygen barrier and hermetic seals provide very good insurance against loss of moisture through the package. However, care must be taken in selection of the proper packaging system, to insure that the moisture does not leave the product and condense as a liquid inside the package.

There are films and packaging techniques which seal any excess film flush to the edge of the product, regardless of the contour. This technique is being used on all types of meats, fresh, frozen and processed. Liquids or juices are kept in the product. There is no free space in the package for liquids to go.

Non-Forming Film

The most widely used non-forming film is a structure consisting of oriented polyester-saran-sealant (Fig. 3).

The polyester layer is usually half mil (0.0005") in thickness. The sealant layer is usually 2 to 3 mils (0.002-0.003") in thickness.

The non-forming film is frequently printed. Any printing is generally buried in the structure — i.e. placed between the saran and the sealant.

Forming Film

The forming film structure used for the largest number of processed meat packaging applications is nylon/saran/sealant (Fig. 4).

The gauge of the nylon and the gauge of the sealant are adjusted, depending on the size and shape of the cavity the film must be thermo-formed into to accommodate the product. The total thickness will vary from approximately 2.75 mils for products such as bacon to 11 mils or more for items such as large hams.

There is another popular class of forming films that are referred to in the industry as semi-rigid films. Semi-rigid films were developed for use where the finished package of processed meat is displayed in the stores by hanging, on pegs. For these applications, a stiffer structure is used — generally consisting of 7.5 - 12.0 mil semi-rigid polyester sheet combined with a barrier layer and a sealant.

In order to allow for the thinning that takes place in thermo-forming, the starting film must have sufficient material to insure that the side walls and corners of the shaped package have adequate thickness to provide the desired protection.

Each layer in the formed web structure has its specific purpose:

1. The polyester is resistant to the temperature needed to melt the sealant, and is scuff- and abrasion-resistant.
2. The saran layer provides the barrier to oxygen.
3. The sealant must be capable of being melted at a relatively low temperature and make a hermetic bond to the sealant layer of the formed film.
desired size and shape; yet be resistant to temperatures needed to melt the sealant. It must also be scuff- and abrasion-resistant.

2. The barrier layer provides the main resistance to oxygen transmission.

3. The sealant must be capable of being melted at a relatively low temperature and make a hermetic bond to the sealant layer of the non-formed film.

The process of heating and forming a film into a cavity produces a shaped film that is considerably thinner than the original flat film. The degree of thinning and uniformity of the shaped film is a complicated subject and will depend on a number of factors such as:

1. The type and original thickness of the forming film.
2. The size of the area being formed.
3. The depth and contour of the cavity.
4. The procedure used to heat and draw or push the heated film into the cavity.

Forming Films for Thermal Processing

Perhaps the most demanding requirement for forming films is for those applications where the thermal processing (or cooking) is done in the same package, used for shipping and merchandising. There are about 30 cook-in lines for hams in the United States and about 14 cook-in lines for poultry products.

These applications are some of the most demanding for forming films, because the film must shrink with the product as the product is cooked and cooled. In addition, the film must have a good appearance and be tough enough to stand abuse in shipping and handling.

The most important characteristic of these films is ability to shrink. Films formed on a conventional processed meat packaging machine by vacuum alone do not shrink to an acceptable degree. To have shrink in the film, we must form at lower temperatures. To do this forming at the critical temperature, the packaging machines are designed with plugs to assist in getting the film in the cavity properly.

Ham

After packaging, hams are generally cooked in stainless molds in the shape of the final product. The molds protect the film during the cooking time. Film structures of nylon/sealant or nylon/barrier/sealant are used (Figure 4). The sealant is usually an ionomer (Surlyn) that gives a slight bond to the product, which aids in preventing purge during thermal processing.

Poultry

The technology of cooking boneless turkey breasts in a package used for distribution is quite different from cooking boneless hams. The level of salt is much lower, often the skin is attached, and the breasts are not cooked in molds but are cooked on racks with live steam. In this case, the film is the mold, its shrink shapes the product and tightens the internal texture. Relatively low forming temperatures with plug assist are used to get the desired shrink properties.

The type of nylon 6 used for processed meats forming films is moisture-sensitive and is not always satisfactory if in contact with live steam for extended periods of time.

Furthermore, Surlyn sealant used for ham adheres so tightly to turkey skin that the skin often stays with the film when the package is opened.

A forming film for boneless turkey breasts may use a special less moisture-sensitive nylon or a construction of polypropylene/nylon/polyethylene.

With the structure in Figure 5, the polypropylene protects the nylon layer from the steam used for cooking.

For poultry products, the sealant is usually a special polyethylene. It must hold up under the thermal processing temperatures and not adhere to the product.

Other Products

There is considerable activity now on thermal processing other products in the package that will be used for distribution and display. Some of these products, such as corned beef and roast beef, should be appearing in the market place soon.

Sealants

The selection of the proper sealant to use on a packaging film for meat is very important. The sealant layer is generally the thickest element in the lamination, and should be specified with the objective of obtaining the best overall performance.

The four sealants in common use for meat films are:
1. Low density polyethylene (poly)
2. Ethylene-vinyl acetate (EVA)
3. Ionomer (Surlyn)
4. Linear low density poly (LLDPE)
The relative properties of these sealants are:

*Polyethylene (Low Density)*
- Lowest Cost

*Ethylene-vinyl acetate (EVA)*
- Broad heat seal range.
- Seals through minor contamination.

*Ionomer (Surlyn)*
- Broad heat seal range.
- Seals through minor contamination.
- Superior hot tack.
- Lower heat seal temperature.
- Lower forming temperature.

*Linear Low Density Poly (LLDPE)*
- Poor in forming.
- Superior hot tack.
- Superior flex crack resistance.
- Higher minimum seal temperature.
- Poorer in sealing through grease.

**Hot tack** is the ability of a polymer to have strength when hot. Packaging machines are running at higher speeds, and there is less time for the hot hermetic seals to cool. The advancing motion of the machine can put stress on the films and may open up the seals at local stress points. Surlyn, LLDPE and other special polyethylene seals have superior strength when hot and will usually give fewer off-line package leakers than the other sealants, especially under extreme packaging machine conditions. Surlyn, LLDPE and other special polyethylene seals have superior strength when hot and will usually give fewer off-line package leakers than the other sealants, especially under extreme packaging machine conditions. Thermal processing in the package calls for polymers with good hot seal strength to withstand the pressure and temperature at the processing temperature.

It is important that the forming and non-forming film have the same sealant. If one attempts to weld polyethylene to Surlyn, the seals will be weak and are likely to peel open if stressed.

Another innovation that is growing rapidly is the use of coextruded sealants.

By the coextruding technique, it is possible to make a sealant film that is white on one side and yellow on the other. However, the big volume is in coextruding clear polymers because we can select and coextrude two polymers, and combine the desirable properties of each polymer.

For example, we can use Surlyn as the direct sealant and back it up with an oven tougher resin. This gives us hot tack and additional toughness, which can be very important in packaging a product that contains tough sharp particles, such as pepper corns.

**Conclusion**

The packaging and processing of processed meats, especially those processed in the package, is a complicated subject. Only the packaging systems and packaging films that are used for the largest number of applications have been discussed. Certain liberties have been taken in presenting technical data, in order to emphasize the general principles involved. Each processed meat product presents certain unique problems from a packaging standpoint. The packaging method and packaging film must be selected with care if the product is to reach the consumer with optimum quality.

**References**