



MEAT PACKAGING GUIDE

How advanced testing and validation of packaging helps to meet product safety, sustainability and quality demands.

TABLE OF CONTENTS

The importance of meat packaging	3
New packaging types and materials	4
The trend is clear: Reduce. Reuse. Recycle.	6
Meat packaging solutions	8
Product integrity	10
Gas mixing	11
Headspace gas analysis	12
On-line gas analysis	13
Testing reduces costs	14
Detecting and locating leaks	15
Summary	18
References	19

THE IMPORTANCE OF MEAT PACKAGING

Packaging plays a crucial role in helping to ensure the safety, quality, visual appeal and shelf life of meat products. Effective packaging protects meat products by acting as a barrier against microbial contamination and environmental factors that can lead to spoilage. By preventing exposure to contaminants, packaging helps to maintain freshness for an extended period of time and ensure that the product is safe for consumption.

Meat degrades over time, due to a combination of biological, chemical and environmental factors, but various packaging techniques can be employed to slow down the degradation process. By controlling the internal environment of the package, these methods inhibit the growth of organisms and oxidative reactions that cause spoilage, thereby extending the shelf life of the

product and minimizing food waste. Packaging also preserves the meat's color, texture and overall appearance, which are critical factors that influence consumer purchasing decisions.

Packaging provides structural support and containment, ensuring that meat products can withstand the rigors of transportation and handling without physical damage, while also making it easier to store and display. Furthermore, packaging offers a platform for labeling, providing consumers with information – such as product type, weight, nutritional content and expiration dates – that is essential from a regulatory and compliance viewpoint. This transparency helps consumers make informed choices and use the products safely.

NEW PACKAGING TYPES AND MATERIALS

SUSTAINABLE PACKAGING MATERIALS

New sustainability regulations are significantly impacting companies involved in meat packaging. This prompts them to implement more sustainable practices to meet evolving environmental standards and consumer expectations. This changing landscape is driving organizations to innovate and develop new types of meat packaging. This new packaging must address both sustainability and performance challenges, particularly the issues of product safety and environmental

impact. For example, biodegradable and recyclable materials are being optimized for permeability, balancing environmental benefits with product performance.

Permeability refers to the passage of the gas mixture and water vapor through packaging materials. Effective packaging minimizes unwanted permeation to preserve the meat's freshness and quality. High-performance materials are being designed to offer improved oxygen and moisture barriers, which are critical for reducing spoilage and maintaining the color, texture and taste of meat.



[Learn more](#)

Permeation testing is carried out by packaging developers on packaging materials to test the amount of oxygen or water vapour that can move through the material over time. Knowing the permeation rates of different packaging materials helps food manufacturers select well-suited packaging solutions and define safe shelf life times for their products.

*With its high precision and throughput, **OX-TRAN 2/28** offers both the accurate, repeatable results required for packaging development and it can keep up with the high volume quality control demands of manufacturers evaluating their new packaging materials.*

NEW PACKAGING TYPES AND MATERIALS (CONT'D)

MONO-MATERIALS

Mono-materials are packaging solutions made from a single type of polymer, designed to improve recyclability and reduce waste compared to multi-layer, multi-material laminates. Mono-materials simplify the recycling process because they eliminate the need to separate different materials.

Mono-materials generally have a lower performance rate than multi-layered barriers, so they require more stringent quality control monitoring to ensure they perform as intended. However, advanced processing techniques and coatings can help mono-materials achieve the necessary barrier properties traditionally offered by complex multi-material packaging.

Polyethylene (PE)-based and polypropylene (PP)-based films are being engineered for use as mono-material alternatives. For example, in the race for sustainability, new PE-films are being developed from renewable and biodegradable resources like plant starches and agricultural waste (rice hulls and coconut shells). Coatings and additives can enhance the functional properties of these mono-materials without compromising their recyclability.



By combining advancements in permeation control and sustainable designs, the meat packaging industry is moving towards solutions that balance environmental responsibility with the rigorous demands of product preservation.

THE TREND IS CLEAR: REDUCE. REUSE. RECYCLE.

Consumer demand is a significant driver in the increased use of sustainable packaging within the food industry, particularly in the meat sector. Studies indicate that consumers are willing to pay more for products with sustainable packaging, especially in categories such as fresh meat and poultry. For example, a 2023 report by Trivium Packaging revealed that 82% of consumers are willing to pay more for sustainable packaging, an increase from previous years. This trend is particularly strong among younger consumers aged 18–24, with 90% expressing this willingness.

To help meet this demand for more sustainable packaging, suppliers have been adopting different strategies, facilitated by the introduction of new materials and solutions. Reduce. Reuse. Recycle. Those are the 3 concepts summing up the main drivers and challenges for packaging professionals.

The introduction of these 'new' packaging materials has proven to be effective in protecting meat products from mechanical strains, but it increases the challenges in ensuring barrier properties and seal integrity. During the packaging process, materials are subjected to mechanical and thermal stresses. It becomes extremely important to know how the packaging material will react, not only immediately after the packaging process, but throughout the entire supply chain. Even if a package is initially hermetic, after a few days, or weeks, it can lose its seal integrity due to thermal exposure, humidity, or other physical factors such as UV or visible light. Compromised packaging can lead to undesired changes in the sensory, nutritional and hygienic characteristics of food, thereby leading to an unsustainable and uneconomic waste of food, materials and resources. In addition, it greatly increases the risk of negative brand reputation and dangerous food-borne diseases.

THE TREND IS CLEAR (CONT'D)

REDUCE. REUSE. RECYCLE.

COMMON SOLUTIONS

As packaging developers work to reduce the overall amount of material used and increase the use of recycled and recyclable materials, several trends are emerging as viable solutions:

- Reduce thickness of plastics
- Use mono-materials and functional coatings
- Introduce new bio-based, bio-sourced compostable materials
- Use recycled materials
- Paper-based materials, sometimes combined with other materials and coating (different sources, including plastic)

MEAT PACKAGING SOLUTIONS

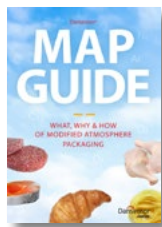
Utilizing appropriate packaging solutions is essential for presenting safe, high-quality meat products to consumers, and two of the most widely used methods are modified atmosphere packaging (MAP) and skin-packaging.

Modified Atmosphere Packaging

Meat packaging typically contains a certain amount of space that is not occupied by the product. This 'empty' space is known as the headspace. MAP is the process of inserting a pre-defined mixture of oxygen (O₂), carbon dioxide (CO₂) and nitrogen (N₂) into the headspace to help preserve the product.

You can learn more about MAP in our MAP Guide.

[Download here](#) →



Skin-packaging

With the skin-packaging technique, meat products are placed on a specially designed tray or a flat rigid base, such as plastic or cardboard. This base is then covered with a

barrier film material, which tightly conforms to the shape of the meat, creating a vacuum-like effect. This process removes most of the air around the product, but it presents the meat in a more attractive way than traditional vacuum packing.

EXTENDING SHELF LIFE

Because MAP involves filling the headspace with a carefully engineered gas mixture, specifically tailored to inhibit bacterial growth and slow down spoilage, this creates an optimized environment that enables the meat to remain fresh for longer. This not only helps to preserve its appearance, but also significantly extends its shelf life, by anything from seven to 21 days. Skin-packaging also helps to extend shelf life, but is less effective at maintaining the desired color and texture of certain meat products, particularly red meat.

MEAT PACKAGING SOLUTIONS (CONT'D)



Sustainability benefits

As previously mentioned, increased sustainability is becoming ever more important within the food industry, not only because of evolving regulatory requirements and environmental pressures, but also because of consumer expectations. MAP is considered to be a sustainable packaging solution for meat products, due to several factors. For example, the extended shelf life achieved with MAP reduces food waste across the supply chain and at the consumer level. The lightweight and stackable nature of MAP packages also optimizes transport efficiency, reducing fuel consumption and emissions during distribution and delivery.

In addition, MAP can incorporate bio-degradable or recyclable films developed from renewable resources, making the packaging more environmentally friendly, as well as enhancing its visual appeal in comparison to skin-packaging. Furthermore, the use of mono-materials in MAP can enhance the sustainability of meat packaging compared to when multi-materials are used.



	MAP	Skin-packaging	Vacuum packed
Made of recyclable mono-materials*	✓	✗	✓
Made of recycled materials*	✓	✗	✓
Easy to recycle*	✓	✓	✓
Attractive presentation	✓	✓	✗
Maintain fresh, red color	✓	✗	✗
Displays nicely in store	✓	✓	✗
Minimal space (storage and shipping)	✗	✓	✓

* Use of recycled or recyclable materials is possible. The infrastructure for recycling specific materials varies from place to place.

PRODUCT INTEGRITY



WHY COLOUR MATTERS

Countless studies indicate that color is more important than any other attribute when consumers select meat products, especially red meat. Consumers typically associate a bright, cherry-red color in red meat with freshness and quality. Deviations from this color can lead to perceptions of spoilage

or inferior quality, thereby reducing the likelihood of purchase. The color of the product is determined by the concentration and chemical form of the meat pigment myoglobin, the morphology of the muscle structure and the muscle's ability to absorb or scatter incident light. Maintaining the desired meat color through effective packaging solutions is crucial for meeting consumer expectations and enhancing product appeal. Vacuum-packaged and skin-packaged meat generally has a purplish-red color as a result of the removal of O_2 from the package. However, with MAP, the headspace contains a high percentage of O_2 , which enables the meat to maintain the bright, cherry-red color consumers associate with freshness.



SELECTING THE RIGHT HEADSPACE GAS RATIO

Within MAP applications the ratio of O_2 , CO_2 and N_2 inserted into the headspace varies depending on the type of product being packaged. O_2 is often excluded from the headspace because it causes oxidative deterioration of foods. However, it is important to include O_2 in the headspace for red meat products, because it can inhibit anaerobic organism growth, and maintain freshness and natural coloring.

Achieving the optimal balance between O_2 and CO_2 is essential to maintain the meat's visual appeal while ensuring its safety and longevity.

The industry recommends using a gas mixture of 70% O_2 and 30% CO_2 for retail raw red meats. This high concentration of O_2 serves to preserve the desired color of the meat, as this is a key factor in consumer purchasing decisions. The inclusion of CO_2 in the gas mixture helps to inhibit microbial growth, thereby extending the shelf life of a product.

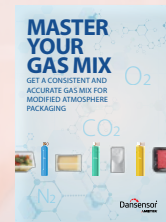
GAS MIXING

As previously stated, controlling and maintaining the correct MAP headspace gas mix is crucial for ensuring product freshness, quality and safety; extending shelf life; minimizing food waste; and retaining color and aroma. It also ensures packaging integrity, as incorrect gas levels can lead to package collapse or swelling, which may damage the product and reduce consumer confidence. The required gas mix can be created on-site or can also be supplied pre-mixed in containers or cylinders. Both methods are widely used to supply gas to MAP packaging lines.

To enhance the efficiency and accuracy of gas mixing in MAP processes, gas mixture changes can be automated, which contributes to more consistent packaging outcomes and operational efficiency. This enables the seamless exchange of gas mixtures to accommodate different packaging requirements, ensuring optimal gas composition for various products. This adaptability not only improves a product's shelf life and enhances quality but also streamlines the packaging process by reducing downtime associated with manual adjustments to the gas mix.

To learn more about MAP gas mixes, please refer to our guide, *Master Your Gas Mix*.

[Download here](#) →



MONEY-SAVING ON-LINE SOLUTIONS



An optional GasSave functionality is available on **Dansensor**® MAP Check 3 continuous gas analyzer. By precisely monitoring and adjusting the gas content on flow packaging machines, GasSave can significantly reduce gas consumption – often by 20-50% – providing major cost savings without compromising package quality.

Precisely blend, customize gas mixtures on-site with **Dansensor** MAP Mix Proventus®. Save money and increase flexibility compared to using pre-mixed gases. Supply adjustable mixtures directly to the packaging line (for flow packers) or to a buffer tank (for thermoformers or tray sealers).

[Learn more](#)

HEADSPACE GAS ANALYSIS

Implementing MAP technology requires the introduction of internal quality control procedures to ensure that the desired gas mixture is actually present in the headspace of the package. Regular manual spot testing is essential for maintaining the quality and safety of MAP meat products, ensuring that consumers receive fresh and properly preserved meat. A certain number of packages per hour are manually tested, based on the packaging line speed and other variables. This is a typical quality control approach using a headspace gas analyzer, which should be selected based on its sensor accuracy and data handling capability, to ensure data traceability. Headspace analysis ensures that the residual O₂ in a product complies with predefined limits.

THE CHALLENGE OF REPACKAGING

Repackaging meat after manual spot testing is permissible, but companies must strictly follow food safety protocols, regulatory requirements and labeling guidelines to ensure that the product remains safe and high-quality for consumers. If repackaging cannot be done under controlled conditions, the tested product may need to be discarded to avoid food safety risks. To address this challenge, organizations can employ non-destructive testing methods that preserve package integrity and reduce waste.

Learn more about the importance of headspace in our Headspace Guide.

[Download here](#) →



[Learn more](#)

Headspace gas analyzers, such as the robust and reliable **Dansensor CheckMate 4** and **CheckPoint® 4**, play an important part in quality control processes for MAP products by detecting instances where packaging requirements are compromised. These analyzers have a wide range of applications, including:

- Accurate residual O₂ headspace gas analysis
- O₂ headspace gas analysis in the presence of high CO₂
- MAP audit applications
- MAP quality control

ON-LINE GAS ANALYSIS

The alternative to manual testing is to utilize an on-line gas analyzer. This is an instrument that monitors the gas mixture and O₂ levels inside each package. The analyzer will alert the operator or automatically shut down the line if any parameters fall outside the preset limits. It gives you full control of your process and full traceability by delivering production data. Some on-line gas analyzers have smart 'gas save' functionality that controls the flow of the gases and keeps the residual O₂ at the right level.

Although you need an on-line gas analyzer for each packaging line – as opposed to a

headspace gas analyzer that can work across lines – there are many advantages to utilizing these devices. An on-line gas analyzer is a cost-effective solution which minimizes the use of excess packaging gas and reduces the need for time-consuming repackaging of products.



The Dansensor series of on-line gas analyzers are equipped with user-friendly touch screen interfaces and offer excellent data-logging and traceability options, which make them suitable for:

- MAP quality assurance
- Control of gas flushing processes
- Streamlining MAP processes

MAP Check 3 Vacuum ensures packages in tray sealers and thermoformers are flushed with just the right amount of gas in the correct ratio.



[Learn more](#)

TESTING REDUCES COSTS



Periodically testing MAP headspace can lead to cost savings in several ways:

- **Preventing production downtime** – Regular headspace analysis ensures that the gas mixture within packages meets predefined standards. By identifying deviations early, companies can address issues promptly, preventing extended periods of production downtime.
- **Avoiding expensive recalls** – Accurate headspace testing helps maintain product quality by preventing issues such as microbial growth and loss of freshness. This proactive quality control reduces the risk of distributing substandard products, thereby minimizing the likelihood of costly product recalls.
- **Complying with retailers' requirements** – Many retailers mandate strict quality standards for packaged goods. Implementing routine headspace analysis demonstrates adherence to these standards, ensuring that the residual oxygen levels in products comply with predefined limits. This compliance is vital for maintaining retailer partnerships and market access.
- **Minimizing excess gas consumption** – Regular headspace analysis ensures that the gas mixture inside the package is accurate, preventing the overuse of gases. This precise control reduces unnecessary gas consumption, leading to cost savings.
- **Reducing packaging material waste** – By consistently monitoring the headspace, manufacturers can quickly identify and address issues such as incorrect gas mixtures or leaks. This proactive approach minimizes the number of defective packages, thereby reducing waste of packaging materials.

DETECTING AND LOCATING LEAKS

Maintaining seal integrity is a vital part of MAP quality control. Leaks in meat packaging can compromise the seal integrity, leading to the loss of the protective atmosphere inside the package. This results in a reduced shelf life for the meat product. Proper leak detection is therefore vital

in helping to ensure that the protective environment of the packaging is preserved, so that the product quality can be maintained and its shelf life extended. By implementing a leak detection test in a Hazard Analysis and Critical Control Point (HACCP) plan, leaks can be promptly detected and the root cause fixed.

THE ROOT CAUSE OF LEAKS

There are two basic types of packaging leaks. The first is random leaks, which are the most difficult to predict and control. Random leaks can be created by food contamination on the sealing areas, or a sudden impact or jolt during handling, transportation or storage.

The second type is systematic leaks, which are recurring issues that often stem from consistent flaws in the packaging process or materials. Key causes can include wrong settings of the packaging line, e.g., misalignment between lid and tray, folding or overlapping layers, inadequate sealing parameters such as temperature and time, a defect in the packaging film or laminates, or a defect in the package machine welding bar. Systematic leaks can create a huge amount of damage, returns and waste if not quickly detected.

DETECTING AND LOCATING LEAKS (CONT'D)

Are all leaks equal?

There are many factors to be considered when defining or deciding which leak size is critical. You need detailed knowledge about the main chemical reactions and bacteria profile of your product. What are the kinetics of those reactions, which factors accelerate bacterial growth and how will they influence the shelf life of your product? You also need to know and predict the interaction between your product, packaging material and MAP gases in ambient, chilled and extreme temperature conditions. One of the most common factors affecting shelf life is the presence (or absence) of O₂. This will trigger oxidation and/or discoloration reactions. O₂ presence or absence will also determine the growth of different types of bacteria.

PREVENTING LEAKS

Some simple actions can be taken to prevent packaging leaks:

- Keep the welding bars perfectly clean
- Properly store and protect the packaging materials
- Check the sealing parameters, such as temperature and time
- Check the sealing areas
- Avoid meat products touching or depositing oil, fat, grease or particles on seal areas



[Learn more](#)

*By performing non-destructive leak tests on single or multiple packages, e.g. with **Dansensor LeakPointer® 3 and 3+**, you can detect leaks as small as 50 microns. This ensures products remain fresh until their best before date and offers vital protection for your brand integrity.*

*You can also use the **Leak Simulation Kit** to test and define acceptable leak levels. The kit is easy to use and helps to simulate various predefined hole sizes in packages to test their shelf life.*

DETECTING AND LOCATING LEAKS (CONT'D)

The need for a shelf life study

Conducting a proper shelf life study will help define how much O₂ the product can tolerate or needs. Assuming the package has the required barrier properties, conducting an O₂-dependent shelf life study that correlates leaks and O₂ % ingress in the headspace of the package is possible by creating holes using a standardized needle of known size. Other factors that affect shelf life are the position and shape of the hole, as well as the overlap of package layers which can create a weak seal. These factors will affect the speed of O₂ ingress and MAP gas replacement.



Sometimes it is evident to customers that a package is leaking even before they open it. Other times it is less obvious.

LEAK DETECTION STRATEGIES

There are several approaches to leak detection:

- Bubble test (water bath)
- Trace gas (CO₂)
- Pressure/vacuum decay

Learn more about the importance of detecting and locating leaks in our Leak and Seal Integrity Guide. [Download here](#) →



SUMMARY

Packaging plays a vital role in maintaining the safety, quality and shelf life of meat products by acting as a barrier against contamination and environmental factors. Techniques such as MAP and skin-packing are used to slow spoilage, preserve appearance and extend shelf life. MAP optimizes the package's internal gas mixture, using O₂, CO₂ and N₂ to inhibit bacterial growth and maintain freshness. For red meats, higher O₂ levels preserve the bright red color that influences consumer preferences.

Sustainability is a growing focus, with MAP emerging as a greener solution due to its ability to reduce food waste and incorporate recyclable or biodegradable materials. Innovations such as mono-

material packaging enhance environmental responsibility while maintaining product quality. Advanced testing methods, such as leak detection and headspace analysis ensure packaging integrity and reduce product recalls and waste of product.

Automated systems for gas mixing and quality control, including on-line gas analyzers, streamline operations, improve efficiency and minimize costs. These tools also provide precise monitoring to prevent issues such as excess gas use or leaks, reducing downtime and waste. Overall, advancements in packaging and testing enhance meat product safety, sustainability and consumer satisfaction.

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[Consumer visual preference and value for beef steaks differing in marbling level and color](#)

McKinsey & Company - Sustainability in packaging 2023: Inside the minds of global consumers.

[Sustainability in packaging 2023: Inside the minds of global consumers](#)



LET US MEAT

At AMETEK MOCON, we prioritize understanding our customers and their challenges. Through four decades of experience and close collaborations, we have aimed to deliver excellence in every aspect of our work. With our wide range of quality control and permeation instruments, we empower companies to ensure longer shelf life for their products, reduce packaging waste, and develop sustainable packaging solutions.

When you include AMETEK MOCON instruments in your packaging development and quality control processes, you can be assured that your test results are accurate, traceable and compliant.

We can help improve the packaging of your products and protect your brand integrity.

[Contact us and learn more](#)

