

Food Fact Finder

A guide to recommended gas mixtures, storage temperatures, achievable shelf-lives, principal spoilage mechanisms and organisms, possible food hazards, typical MAP machines, typical types of packages, and examples of typical MAP materials.

SPECIALISED GAS TECHNOLOGIES AUSTRALIA PTY LTD

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The **SGTA Food Fact Finder** is a practical reference for food manufacturers and processors using Modified Atmosphere Packaging (MAP) in Australia and New Zealand.

The guide provides recommended gas mixtures, storage temperatures, indicative shelf-lives, common spoilage mechanisms, potential food-safety hazards and examples of suitable packaging equipment, formats and materials across a broad range of food categories.

It is intended as a starting point for product development, packaging selection and process evaluation—not as a substitute for technical assessment, food-safety controls or shelf-life testing.

Gas mixtures and shelf-lives are indicative only and must be validated for the specific product, packaging system, processing conditions and storage temperature.





Raw Red Meat

The two principal spoilage mechanisms affecting the shelf-life of raw red meat are microbial growth and oxidation of the red oxymyoglobin pigment.

When red meat is maintained under appropriate chilled conditions, an important factor affecting its acceptable shelf-life is the oxidation of red oxymyoglobin to its brown oxidised form, metmyoglobin. High concentrations of O_2 are therefore commonly used in retail modified atmosphere packaging to maintain the desirable bright red colour for longer. Highly pigmented red meats, such as venison and kangaroo, may require higher concentrations of O_2 or product-specific packaging validation.

Aerobic spoilage bacteria, particularly Pseudomonas species, are inhibited by CO_2. To provide the combined benefits of colour stability and microbial inhibition, gas mixtures containing approximately 20–30% CO_2 and 70–80% O_2 are commonly recommended. Under suitable processing and chilled-storage conditions, MAP may extend the shelf-life of retail red meat from approximately 2–4 days in air to 5–8 days or longer. A gas-to-product ratio of approximately 2:1 is often recommended.

Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity throughout processing, packaging, distribution and retail display is essential for supporting product safety and achieving the intended shelf-life.

Raw red meat can support the growth of a range of spoilage organisms and foodborne pathogens. These products are generally cooked before consumption, and adequate cooking considerably reduces the risk associated with vegetative bacterial cells. However, modified atmosphere packaging does not make an unsafe product safe and must be used alongside validated food-safety, temperature-control and cooking procedures.

Raw Red Meat

Food Items

Beef, lamb, pork, veal, goat, venison and kangaroo

Recommended Gas Mix

Retail: 70–80% O_2, 20–30% CO_2
Bulk: 65% O_2, 35% CO_2

Product Exceptions:
Pork: 80% CO_2, 20% N_2
Venison: 80% O_2, 20% CO_2

Primal: 50% CO_2, 50% N_2
Primal Pork: 80% CO_2, 20% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: -1°C to +2°C

Achievable Shelf-Life

In Air: approximately 2–4 days
In MAP: approximately 5–8 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds.

Pigment oxidation and lipid oxidation may also affect colour, flavour and overall product quality.

Potential Food-Safety Hazards

Shiga toxin-producing E. coli (STEC), Salmonella species, Listeria monocytogenes, Staphylococcus aureus and Clostridium species.

Yersinia enterocolitica may be associated with pork.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Vacuum-skin packaging equipment

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Barrier tray and lidding film or vacuum-skin pack

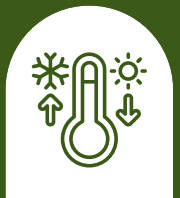
Bulk and Primal: Vacuum bag, bag-in-box or master pack

Examples of Typical MAP Materials

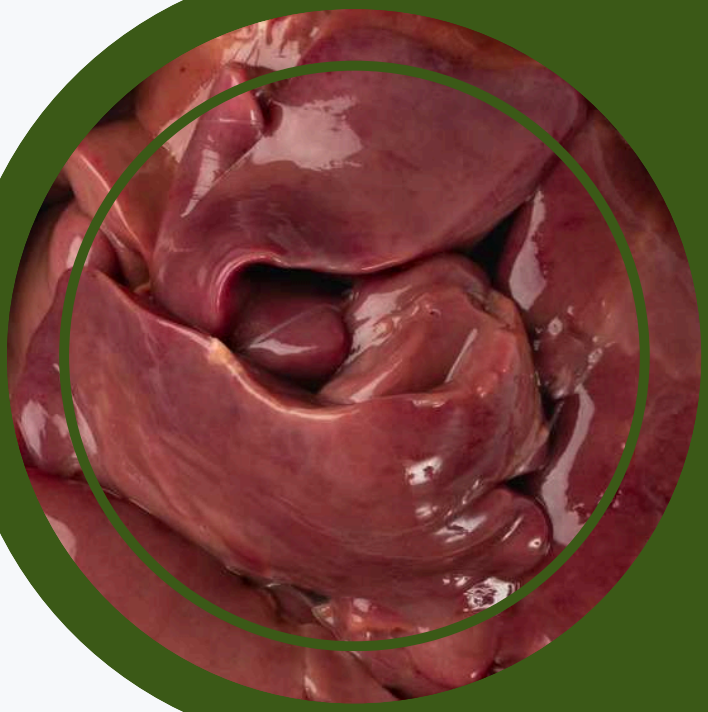
Trays:
- APET/PE
- EPS/EVOH/PE

Lidding Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk and Primal:
- PA/PE
- PA/EVOH/PE







Raw Edible Offal

The two principal spoilage mechanisms affecting the shelf-life of raw edible offal are microbial growth and oxidation of the red pigment to its brown oxidised form. High concentrations of O_2 are therefore commonly used in modified atmosphere packaging to help maintain the desirable red colour for longer.

Aerobic spoilage bacteria, particularly Pseudomonas species, are inhibited by CO_2. To provide the combined benefits of colour stability and microbial inhibition, a gas mixture containing approximately 80% O_2 and 20% CO_2 is commonly recommended. Under appropriate processing and chilled-storage conditions, MAP may extend the shelf-life of raw edible offal from approximately 2–6 days in air to 4–8 days. A gas-to-product ratio of approximately 2:1 is often recommended.

Some offal products, particularly liver, kidney and sweetbreads, are susceptible to excessive drip loss, especially in the presence of CO_2. For this reason, the CO_2 concentration is generally limited to approximately 20%. Appropriate package design and absorbent materials can also help manage excess moisture.

Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity throughout processing, packaging, distribution and retail display is essential for supporting product safety and achieving the intended shelf-life.

Raw edible offal provides a nutrient-rich environment that can support a wide range of spoilage organisms and foodborne pathogens. These products are generally cooked before consumption, and adequate cooking considerably reduces the risk associated with vegetative bacterial cells. However, MAP does not make an unsafe product safe and must be used alongside validated food-safety, temperature-control and cooking procedures.

Raw Edible Offal

Food Items

Liver, kidney, heart, tongue, tripe, oxtail and sweetbreads

Recommended Gas Mix

Retail & Bulk: 80% O_2, 20% CO_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: −1°C to +2°C

Achievable Shelf-Life

In Air: approximately 2–6 days
In MAP: approximately 4–8 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Micrococci, Enterobacteriaceae, yeasts and moulds

Pigment oxidation and lipid oxidation may also affect colour, flavour and overall product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes and Shiga toxin-producing E. coli (STEC)

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Three-web thermoform-fill-seal
- Vacuum-skin packaging equipment

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Barrier tray and lidding film or vacuum-skin pack

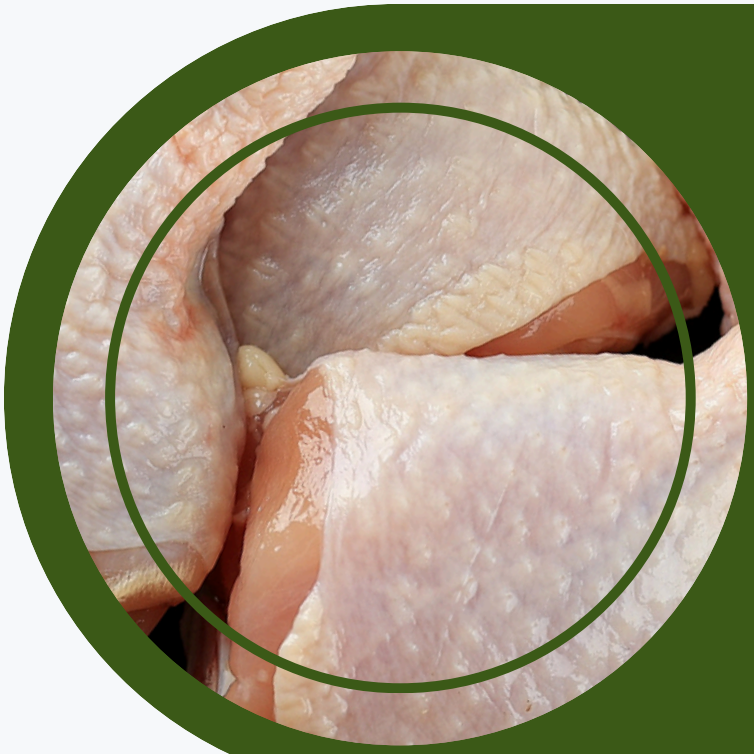
Bulk and Primal: Vacuum bag, bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- EPS/EVOH/PE

Lidding Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk and Primal:
- PA/PE
- PA/EVOH/PE



Raw Poultry & Game Birds

For chilled raw poultry and game birds, the principal spoilage mechanism is microbial growth, particularly the growth of Pseudomonas and Achromobacter species. These aerobic spoilage bacteria can be effectively inhibited by including CO_2 in modified atmosphere packaging.

CO_2 concentrations above 20% are generally required to significantly extend the shelf-life of raw poultry. In retail packs, the proportion of CO_2 should generally not exceed approximately 35%, as higher concentrations may cause excessive drip loss or pack collapse. A mixture containing approximately 30% CO_2 and 70% N_2 is commonly recommended.

Pack collapse is less problematic in bulk master packs, where 100% CO_2 may be used. The appropriate gas-to-product ratio and package headspace must be validated for the particular product and packaging system.

Skin-off poultry, dark poultry meat and poultry mince may require a different approach when maintaining a redder appearance is important. For these products, a high-oxygen mixture containing approximately 70% O_2 and 30% CO_2 may be used to provide both colour stability and microbial inhibition.

The achievable shelf-life of MAP poultry depends on the species, cut, fat content, initial microbial load, gas mixture, packaging system and storage temperature. Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity is essential throughout processing, packaging, distribution and retail display.

Raw poultry may contain foodborne pathogens and must be handled carefully to prevent cross-contamination. MAP does not make an unsafe product safe, and adequate cooking remains essential before consumption.

Raw Poultry & Game Birds

Food Items

Chicken, turkey, duck, quail, goose, pheasant, skin-off poultry, dark poultry meat and poultry mince

Recommended Gas Mix

Standard retail packs: 30% CO_2, 70% N_2
Standard bulk packs: 100% CO_2

Skin-off, dark poultry and poultry mince:
Retail and bulk: 70% O_2, 30% CO_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: -1°C to +2°C

Achievable Shelf-Life

Standard Poultry:
In air: approximately 4–7 days
In MAP: approximately 10–21 days

Skin-Off Poultry and Poultry Mince:
In air: approximately 3–5 days
In MAP: approximately 7–14 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Achromobacter species, Enterobacteriaceae, yeasts and moulds.

Excessive drip loss, pack collapse and colour deterioration may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes and Shiga toxin-producing E. coli (STEC)

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Barrier tray and lidding film
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE



Raw Fish & Seafood

The principal spoilage mechanisms affecting raw fish and seafood are microbial growth, enzymatic activity and oxidation. Fish and seafood are highly perishable because of their high water activity, generally neutral pH and naturally occurring autolytic enzymes, which can rapidly produce undesirable odours, flavours and texture changes.

The microbial load of fish is influenced by the harvesting environment, capture method, handling, transport, evisceration and retention of the skin. Microbial activity breaks down fish proteins and produces undesirable odours. Oily fish are also susceptible to oxidative rancidity because of their relatively high levels of unsaturated fat.

MAP can delay microbial spoilage and oxidative rancidity and is particularly effective for extending the shelf-life of white fish. For white fish, crustaceans and molluscs, a mixture containing approximately 30% O_2, 40% CO_2 and 30% N_2 is commonly recommended. For oily fish, a mixture containing approximately 40% CO_2 and 60% N_2 is preferred because excluding O_2 helps inhibit oxidative rancidity.

CO_2 inhibits common aerobic spoilage bacteria, including Pseudomonas species. However, excessive CO_2 may cause pack collapse, drip loss and undesirable acidic flavours, particularly in cold-eating seafood products.

The inclusion of O_2 in white fish, crustacean and mollusc packs helps maintain appearance and reduce conditions favourable to non-proteolytic Clostridium botulinum. A gas-to-product ratio of approximately 2:1 is commonly recommended.

Only high-quality fish and seafood should be used for MAP. Achievable shelf-life depends on the species, fat content, initial microbial load, gas mixture, packaging system and storage temperature. Rapid chilling, strict temperature control, good hygiene and careful handling throughout the harvest-to-consumption chain are essential.

MAP does not control hazards such as histamine, ciguatoxins or marine biotoxins. These hazards must be managed through approved harvesting, sourcing, processing and temperature-control procedures.

Raw Low-Fat White Fish & Seafood Food Items

Barramundi, bream, blue cod, blue grenadier/hoki, flathead, flounder, gurnard, grouper, hake, hapuku, John Dory, ling, monkfish, snapper and whiting

Recommended Gas Mix

Retail: 30% O_2, 40% CO_2, 30% N_2
Bulk: 70% CO_2, 30% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: −1°C to +2°C

Achievable Shelf-Life

In air: approximately 2–3 days
In MAP: approximately 4–6 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, Shewanella species, Photobacterium species and Aeromonas species.

Microbial activity, enzymatic breakdown, drip loss and changes in odour, flavour and texture may affect product quality.

Potential Food-Safety Hazards

Non-proteolytic Clostridium botulinum types E, B and F, Vibrio parahaemolyticus, Salmonella species and Listeria monocytogenes.

Ciguatoxins may also be relevant to certain tropical reef fish.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Barrier tray and lidding film
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE

Raw High-Fat Oily Fish & Seafood

Food Items

Salmon, ocean trout, tuna, mackerel, sardines, kingfish, swordfish, eel and trevally

Recommended Gas Mix

Retail: 40% CO_2, 60% N_2
Bulk: 70% CO_2, 30% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: -1°C to +2°C

Achievable Shelf-Life

In air: approximately 2–3 days
In MAP: approximately 4–6 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, Shewanella species, Photobacterium species and Aeromonas species.

Oxidative rancidity, microbial activity, enzymatic breakdown and changes in odour, flavour and texture may affect product quality.

Potential Food-Safety Hazards

Non-proteolytic Clostridium botulinum types E, B and F, Vibrio parahaemolyticus, Salmonella species and Listeria monocytogenes.

Histamine formation may occur in susceptible species, including tuna, mackerel and sardines, when temperature control is inadequate.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

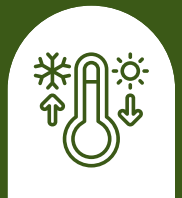
Retail: Barrier tray and lidding film
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE





Crustaceans and Molluscs

Food Items

Abalone/pāua, clams, pipis, crab, rock lobster/crayfish, cuttlefish, mussels, octopus, oysters, prawns, scallops, sea urchin and squid

Recommended Gas Mix

Retail: 30% O_2, 40% CO_2, 30% N_2
Bulk: 70% CO_2, 30% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: −1°C to +2°C

Achievable Shelf-Life

In air: approximately 2–3 days
In MAP: approximately 4–6 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, Shewanella species, Photobacterium species and Aeromonas species.

Microbial activity, enzymatic breakdown, drip loss and changes in odour, flavour and texture may affect product quality.

Potential Food-Safety Hazards

Non-proteolytic Clostridium botulinum types E, B and F, Vibrio parahaemolyticus, Salmonella species, Listeria monocytogenes, norovirus and hepatitis A. Marine biotoxins may be present in bivalve molluscs and are not controlled or removed by MAP.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Barrier tray and lidding film
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE



Cooked, Cured & Processed Meat Products

The principal spoilage mechanisms affecting cooked, cured and processed meat products are microbial growth, colour changes and oxidative rancidity.

In cooked, uncured meat products, an adequate heating process should destroy vegetative bacterial cells, inactivate degradative enzymes and stabilise the cooked colour. Subsequent problems generally result from post-process contamination, inadequate temperature control or poor hygiene and handling practices.

Some uncooked processed meat products, including certain sausages, may contain permitted sulphites such as sodium metabisulphite. These preservatives can inhibit a range of spoilage organisms. Their use and declaration must comply with the Australia New Zealand Food Standards Code.

Cured meat products, whether cooked or uncooked, owe their characteristic pink colour to nitrite, which interacts with myoglobin to form nitrosylmyoglobin. Although this pigment is relatively stable, it is susceptible to oxidative bleaching, particularly when exposed to light. Cured meat products should therefore be packaged with minimal residual oxygen.

Salt, nitrite and other permitted preservatives can inhibit many foodborne bacteria. However, this protection may be reduced in products formulated with lower levels of salt, nitrite or other preservatives. Any change in product formulation should be carefully assessed and supported by appropriate food-safety and shelf-life validation.

Cooked meat products without added preservatives may present a risk of Clostridium botulinum growth when packed under anaerobic conditions and stored at incorrect chilled temperatures. Meat products containing appreciable levels of unsaturated fat may also be affected by oxidative rancidity. MAP using CO_2 and N_2, together with effective oxygen removal, can help inhibit microbial spoilage, colour deterioration and rancidity.

Cooked, Cured & Processed Meat Products

Food Items

Bacon, burgers, charcuterie and small goods, cooked and cured sausages, corned beef, ham, luncheon meats, jerky, sliced meats, pastrami, pâté, pepperoni, roast meats, salami, smoked meats and terrines

Recommended Gas Mix

Retail: 30–40% CO_2, 60–70% N_2
Bulk: 50% CO_2, 50% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: −1°C to +2°C

Achievable Shelf-Life

Cooked and Cured Meats:
In Air: approximately 1–3 weeks
In MAP: approximately 3–7 weeks

Salami and Similar Products:
In Air: approximately 3–6 months
In MAP: approximately 4–8 months

Shelf-life must be validated for the specific product, formulation, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds Oxidative rancidity and cured-meat colour changes from red or pink to brown, grey or green may also affect product quality.

Potential Food-Safety Hazards

Clostridium botulinum, Salmonella species, Staphylococcus aureus, Listeria monocytogenes and Shiga toxin-producing E. coli (STEC)

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack

Bulk and Primal: Vacuum bag, bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding and Pillow-Pack Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE



Cooked, Cured & Processed Fish & Seafood Products

The principal spoilage mechanisms affecting cooked, cured and processed fish and seafood products are microbial growth and oxidative rancidity.

For cooked products, an adequate heating process should destroy vegetative bacterial cells and inactivate degradative enzymes. Subsequent spoilage is therefore primarily caused by post-cooking contamination, microbial growth and oxidative rancidity. These effects can be minimised through good hygiene and handling practices and MAP using CO_2 and N_2. A gas-to-product ratio of approximately 2:1 is commonly recommended.

Cured and processed fish and seafood products may contain salt or other permitted preservatives that inhibit a range of spoilage organisms. However, fish and seafood generally contain relatively high levels of unsaturated fat and remain susceptible to oxidative rancidity. Excluding O_2 and using an appropriate CO_2/N_2 mixture can help reduce rancidity and undesirable changes in flavour and aroma.

Food-safety hazards may result from contamination after cooking, curing or processing. Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity is essential throughout processing, packaging, distribution and retail display.

Reduced water activity and the addition of salt can inhibit many foodborne bacteria, including Clostridium botulinum. However, this protection may be reduced in products formulated with lower levels of salt or other preservatives. Any change in formulation should be supported by appropriate food-safety and shelf-life validation.

Cooked fish and seafood products without added preservatives may present a greater risk of Clostridium botulinum growth when packaged under anaerobic conditions and stored at incorrect chilled temperatures. MAP does not make an unsafe product safe and must be used alongside validated processing, hygiene and temperature-control procedures.

Food Items

Cold and hot smoked fish, smoked salmon, trout and mackerel, cooked prawns, crab, rock lobster/crayfish and mussels, salted anchovies, salt cod, fish roe and caviar, seafood pâté and fish terrines

Recommended Gas Mix

Retail: 30% CO_2, 70% N_2
Bulk: 70% CO_2, 30% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +3°C

Achievable Shelf-Life

Standard Poultry:
In air: approximately 5–10 days
In MAP: approximately 7–21 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, Shewanella species, Photobacterium species and Aeromonas species.

Oxidative rancidity and changes in odour, flavour, colour and texture may also affect product quality.

Potential Food-Safety Hazards

Non-proteolytic Clostridium botulinum types E, B and F, Vibrio parahaemolyticus, Salmonella species, Staphylococcus aureus and Listeria monocytogenes.

Histamine may remain a hazard in susceptible fish when temperature control before processing has been inadequate. Marine biotoxins may also remain present in shellfish and are not controlled by MAP.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE



Cooked, Cured & Processed Poultry & Game Bird Products

The principal spoilage mechanism affecting cooked, cured and processed poultry and game bird products is microbial growth.

For cooked products, an adequate heating process should destroy vegetative bacterial cells and inactivate degradative enzymes. Subsequent spoilage is therefore primarily caused by post-cooking contamination. This can be minimised through good hygiene and handling practices and MAP using CO_2 and N_2. A gas-to-product ratio of approximately 2:1 is commonly recommended.

Cured and processed poultry products may contain salt or other permitted preservatives that inhibit a range of spoilage organisms. However, the protection provided by salt, reduced water activity and preservatives may be reduced when product formulations are changed.

Food-safety hazards may result from contamination after cooking, curing or processing. Ready-to-eat poultry products are particularly susceptible to post-process contamination with Listeria monocytogenes if appropriate hygiene and environmental controls are not maintained.

Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity is essential throughout processing, packaging, distribution and retail display. Any change in salt content, preservatives, processing conditions or product formulation should be supported by appropriate food-safety and shelf-life validation.

MAP can delay microbial spoilage but does not make an unsafe product safe. It must be used alongside validated cooking, cooling, hygiene and temperature-control procedures.

Food Items

Cooked chicken, turkey and duck, chicken and turkey rolls, sliced poultry, roast poultry, smoked chicken, turkey and duck, cured poultry, poultry pâté, turkey bacon and processed game birds

Recommended Gas Mix

Retail: 30–40% CO_2, 60–70% N_2
Bulk: 70% CO_2, 30% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +3°C

Achievable Shelf-Life

In air: approximately 5–10 days
In MAP: approximately 7–21 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds.

Post-process contamination, microbial growth and changes in odour, flavour, colour and texture may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Campylobacter species and pathogenic E. coli

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk and Primal:
- Vacuum chamber
- Gas-flush or master-pack systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films:
- PET/PE-EVOH-PE
- OPA/PE-EVOH-PE
- OPP/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE





Ready Meals & Other Cook-Chill Products

Cook-chill is a food-processing system in which food is hygienically prepared, cooked or pasteurised, rapidly chilled and stored under controlled refrigeration before reheating or serving.

Potentially hazardous cooked food should be cooled from 60°C to 21°C within two hours and then from 21°C to 5°C within a further four hours. An alternative cooling process may be used only where it can be demonstrated to keep the food safe.

The principal spoilage mechanism affecting ready meals and other cook-chill products is microbial growth, primarily caused by post-cooking contamination or inadequate temperature control. An appropriate cooking process should destroy vegetative bacterial cells and inactivate degradative enzymes. However, heat-resistant spores from Clostridium and Bacillus species may survive and germinate if cooling is too slow or recommended chilled temperatures are not maintained.

Other food-safety hazards may arise through post-cooking contamination, poor hygiene and handling practices or inadequate package-seal integrity. Strict control of cooking, cooling, hygiene, handling and storage temperature is therefore essential throughout production, distribution and retail display.

Additional barriers to microbial growth, including acidification, permitted preservatives, reduced water activity and shorter validated shelf-lives, may be required depending on the product formulation.

MAP can significantly extend the shelf-life of ready meals and cook-chill products. CO_2 and N_2 mixtures can delay microbial spoilage, oxidative deterioration and the development of warmed-over flavours. A gas-to-product ratio of approximately 2:1 is commonly recommended.

Because ready meals contain widely varying combinations of ingredients, no single gas mixture or shelf-life is appropriate for every product. Each formulation, process, packaging system and intended shelf-life must be assessed and validated individually.

Ready Meals & Other Cook-Chill Products

Food Items

Chilled ready meals containing meat, poultry, fish, seafood, pasta, rice or vegetables, casseroles, curries, pasta dishes, soups and sauces

Recommended Gas Mix

Retail and Bulk: 30–50% CO_2, 50–70% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +3°C

Cooling Guidance

60°C to 21°C: within two hours
21°C to 5°C: within a further four hours

Achievable Shelf-Life

In air: approximately 2-5 days
In MAP: approximately 5-10 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds.

Post-process contamination, oxidative deterioration, moisture migration and changes in odour, flavour, colour and texture may also affect product quality.

Potential Food-Safety Hazards

Clostridium botulinum, Clostridium perfringens, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Bacillus cereus and pathogenic E. coli

Yersinia enterocolitica may be relevant to products containing pork.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal
- N_2 sparging systems for pumpable products

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

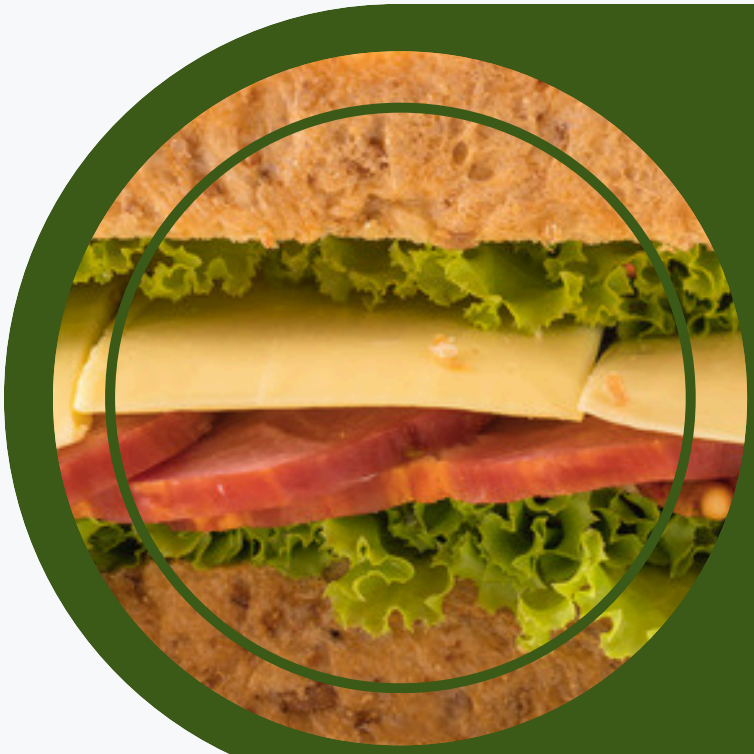
Retail: Barrier tray and lidding film, pouch, pot or tub
Bulk: Bag-in-box, master pack or barrier pouch

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films and Pouches:
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE



Combination Products

Combination products contain two or more food components with different physical, chemical and microbiological characteristics. Because the ingredients can interact within the same package, only general recommendations can be provided for gas mixtures, spoilage mechanisms, food-safety hazards and achievable shelf-life.

The MAP system must be selected according to the most perishable or safety-sensitive component. Manufacturers should conduct detailed product assessments and shelf-life trials to determine the appropriate gas mixture, packaging system and storage conditions.
The principal spoilage mechanisms affecting combination products are microbial growth and oxidative rancidity. CO_2 and N_2 mixtures can inhibit microbial spoilage and delay the development of rancidity, helping extend product shelf-life.

Staling may remain a significant problem in combination products containing bread, pastry or other bakery components. MAP generally has little effect on the rate of staling, so achievable shelf-life extensions for some bakery-based products may be limited.

Moisture migration between components can also affect product quality. This may cause pastry or crumb coatings to soften, fillings to dry out or texture differences between individual components to deteriorate. MAP does not prevent moisture migration, so appropriate product formulation, component separation and packaging design may be required.

Many combination products contain cooked ingredients. Food-safety hazards are therefore commonly associated with inadequate cooking, cooling, post-cooking contamination or poor package-seal integrity.

Maintaining appropriate chilled temperatures, good hygiene and careful handling throughout processing, packaging, distribution and retail display is essential. Each product formulation and intended shelf-life must be assessed and validated individually.

Combination Products

Food Items

Battered or breaded fish, meat, poultry and seafood, burritos, enchiladas, falafel, filled wraps and rolls, pasta dishes, pies, pasties, pizza, quiche, sandwiches, kebabs, satay, sausage rolls, spring rolls, tacos and stuffed flatbreads

Recommended Gas Mix

Retail: 30% CO_2, 70% N_2
Bulk: 50% CO_2, 50% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +3°C

Cooling Guidance

60°C to 21°C: within two hours
21°C to 5°C: within a further four hours

Achievable Shelf-Life

In air: approximately 2-7 days
In MAP: approximately 3-21 days

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds.

Microbial growth, oxidative rancidity, staling, moisture migration and changes in texture may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Bacillus cereus and pathogenic E. coli

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films and Pouches:
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE





Fresh Pasta Products

The principal spoilage mechanisms affecting fresh pasta are yeast and mould growth. The relatively low water activity of some pasta products restricts the growth of many bacteria but may still allow yeasts and moulds to develop.

MAP can significantly extend the shelf-life of fresh pasta. CO_2 and N_2 mixtures are commonly used to inhibit microbial growth and undesirable oxidative reactions. A gas-to-product ratio of approximately 2:1 is often recommended.

Pasta varieties with lower water activity generally achieve longer shelf-lives in both air and MAP. However, the composition and moisture content of the product must be considered when selecting the gas mixture and intended shelf-life.

For green pasta containing spinach or other coloured ingredients, protection from light may be required to reduce oxidative discolouration. Printed, pigmented or metallised barrier films can help prevent the colour from changing from green to brown or grey.

Filled pasta products require additional consideration because meat, cheese, seafood or vegetable fillings may have different spoilage characteristics and food-safety hazards from the surrounding pasta. The gas mixture and shelf-life should be determined according to the most perishable component.

Maintaining appropriate chilled temperatures, good hygiene, careful handling and package-seal integrity is essential throughout manufacturing, packaging, distribution and retail display. MAP does not make an unsafe product safe, and the formulation, filling, processing conditions and intended shelf-life must be assessed and validated individually.

Fresh Pasta Products

Food Items

Fresh spaghetti, fettuccine, linguine, tagliatelle, pasta shells, lasagne sheets, ravioli, tortellini and gnocchi

Recommended Gas Mix

Retail and Bulk: 50% CO_2, 50% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +5°C

Achievable Shelf-Life

In air: approximately 1-2 weeks
In MAP: approximately 3-4 weeks

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Yeasts and moulds.

Colour deterioration, moisture migration, filling spoilage and changes in texture may also affect product quality.

Potential Food-Safety Hazards

Staphylococcus aureus and Bacillus species.

Listeria monocytogenes, Salmonella species and other hazards may also be relevant to pasta containing meat, cheese, seafood or vegetable fillings.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal
- Vertical form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack
Bulk: Bag-in-box or master pack

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films and Pillow-Pack Films:
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE



Bakery Products

The principal spoilage mechanisms affecting bakery products are mould growth, staling and moisture migration. Yeasts may also cause spoilage in certain filled, iced or higher-moisture products.

Many bakery products have a water activity below 0.96, which restricts the growth of most bacteria. However, some products may still support Staphylococcus aureus, Bacillus species or other foodborne microorganisms, particularly when they contain dairy, egg, cream, custard or other high-moisture fillings.

MAP can significantly extend the shelf-life of suitable bakery products. Because moulds require oxygen to grow, they can be effectively inhibited using CO_2 and N_2 mixtures. A gas-to-product ratio of approximately 2:1 is often recommended.

Barrier packaging materials can reduce moisture loss from the package. However, MAP cannot prevent moisture migration between different components of a product. Migration from fillings, toppings or fruit into pastry, cake or bread may cause undesirable softening, drying or separation.

MAP also has little effect on the rate of staling. Chilled temperatures can accelerate starch retrogradation, so bakery products that do not require refrigeration are generally stored at ambient temperature. In products intended to be served hot, such as pizza bases and some breads, reheating can partially reverse the effects of staling.

Bakery products containing perishable fillings or toppings must be stored under appropriate temperature control. Good hygiene, careful handling and package-seal integrity remain essential throughout production, packaging, distribution and retail display.

Each product must be assessed individually because water activity, formulation, filling, packaging system and storage temperature can significantly affect both food safety and achievable shelf-life.

Bakery Products

Food Items

Bread, buns, bagels, croissants, crumpets, naan, pita bread, wraps and tortillas, par-baked bread, pizza bases, muffins, pancakes, waffles, cakes, fruit bread, fruit cake, fruit pies and tarts

Recommended Gas Mix

Retail and Bulk: 50–100% CO_2, 0–50% N_2

Storage Temperature

Standard Bakery Products: Ambient according to product requirements

Products with Perishable Fillings or Toppings: Food-Safety Guidance: 5°C or colder
Recommended for Chilled MAP: 0°C to +5°C

Achievable Shelf-Life

In air: approximately 4-14 days
In MAP: approximately 4-12 weeks

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Yeasts and moulds.

Staling, moisture migration, physical separation and changes in texture may also affect product quality.

Potential Food-Safety Hazards

Staphylococcus aureus and Bacillus species.

Salmonella species, Listeria monocytogenes and other hazards may also be relevant to products containing egg, dairy, cream, custard or other perishable fillings.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack or tray inside a pillow pack
Bulk: Bag-in-box

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films and Pillow-Pack Films:
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE



Dairy Products

Cream and cream-containing products may be adversely affected by CO_2, which can cause acidification and produce an undesirable sharp flavour. N_2 is therefore preferred for these products. By excluding air, N_2 can also help inhibit aerobic microbial growth and oxidative rancidity. A gas-to-product ratio of approximately 2:1 is commonly recommended.

Butter, yoghurt and similar dairy products are not always MAP packed but may benefit from N_2 where oxidative protection is required.

Food-safety hazards associated with dairy products are primarily related to inadequate pasteurisation or contamination during or after processing. Effective pasteurisation, appropriate chilled storage, good hygiene and package-seal integrity are essential throughout production, distribution and retail display.

Dairy Products

Food Items

Butter, cream, custard, fresh cheese, grated cheese, hard and semi-hard cheese, sliced cheese, soft cheese, margarine and yoghurt

Recommended Gas Mix

Hard Cheese Except Mould-Ripened Cheese:
Retail and Bulk: 100% CO_2

Grated and Soft Cheese Except Mould-Ripened Cheese:
Retail and Bulk: 30% CO_2, 70% N_2

Other Dairy Products:
Retail and Bulk: 100% N_2

Aerosol Cream: N_2O

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +5°C

Achievable Shelf-Life

In air: approximately 1-4 weeks
In MAP: approximately 2-12 weeks

Shelf-life must be validated for the specific product, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds
Oxidative rancidity, acidification, physical separation, moisture loss and texture changes may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Bacillus species and pathogenic E. coli

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal
- Vertical form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack, tub or pot
Bulk: Bag-in-box

Examples of Typical MAP Materials

Trays:
- APET/PE
- HDPE
- EPS/EVOH/PE

Lidding Films and Pillow-Pack Films:
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE
- MPET/PE
- MOPP/PE

Bulk:
- PA/PE
- PA/EVOH/PE





Dried Food Products

The principal spoilage mechanism affecting dried foods containing unsaturated fats is oxidative rancidity. Products including cereals, snack foods, nuts, cocoa powder and milk powder may develop undesirable flavours and odours when exposed to oxygen.

Oxidative rancidity can be effectively inhibited by MAP using N_2. A gas-to-product ratio of approximately 2:1 is often recommended.

Because dried foods may achieve very long shelf-lives, the packaging materials must provide effective barriers against oxygen and moisture. Metallised and other high-barrier films are commonly used for this purpose.

Some dried products, including milk powders and other oxidation-sensitive powdered foods, may require extremely low residual O_2 levels. Where required, oxygen scavengers may be incorporated into the package to provide additional protection. Residual oxygen targets must be established and validated for the individual product and packaging system.

The low water activity of dried foods prevents the growth of most bacteria, yeasts and moulds. However, foodborne microorganisms may survive for extended periods without growing. They may present a hazard when the product is reconstituted or used as an ingredient in a food with higher water activity.

Moisture entering the package can also cause caking, loss of crispness, changes in texture and increased potential for microbial spoilage. Effective package-seal integrity is therefore essential.
Strict hygiene and handling controls must be maintained throughout processing and packaging. MAP does not remove contamination already present in the product, and the intended shelf-life must be supported by appropriate product and package validation.

Food Items

Coffee, tea, cocoa powder, milk powder, dried fruit, dried herbs and spices, dried beans and lentils, cereals and grains, flour, nuts, potato crisps and snack foods, dried mushrooms and vegetables, dried pasta and powdered ingredients

Recommended Gas Mix

Retail and Bulk: 100% N_2

Storage Temperature

Recommended: Cool, dry ambient storage

Achievable Shelf-Life

In Air: approximately 4–8 months
In MAP: approximately 1–2 years

Shelf-life must be validated for the specific product, moisture content, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, Brochothrix species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds Oxidative rancidity, acidification, physical separation, moisture loss and texture changes may also affect product quality.

Potential Food-Safety Hazards

Foodborne microorganisms may survive in low-water-activity dried foods even though they cannot grow.

Salmonella species, Bacillus species and other microorganisms may present a hazard after reconstitution or when the dried product is added to higher-water-activity foods.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal
- Vertical form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: High-barrier pouch, pillow pack or tray and lidding film
Bulk: Bag-in-box or high-barrier bulk bag

Examples of Typical MAP Materials

Films and Pouches:
- MPET/PE
- MOPP/PE
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE
- Metallised barrier liners



Cooked Vegetables & Prepared Salads

The principal spoilage mechanisms affecting cooked vegetable products are microbial growth, oxidative deterioration and changes in texture. MAP using CO_2 and N_2 can inhibit microbial spoilage and significantly extend product shelf-life. A gas-to-product ratio of approximately 2:1 is commonly recommended.

For cooked vegetable products, an adequate heating process should destroy vegetative bacterial cells and inactivate degradative enzymes. Subsequent spoilage is therefore primarily caused by post-cooking contamination, inadequate cooling or poor temperature control. Heat-resistant spores may survive cooking and germinate if the product is cooled too slowly or stored at incorrect chilled temperatures.

Prepared salads may be affected by microbial growth, enzymatic browning, moisture migration and physical separation of dressings or other ingredients.

Some acidified salads have a pH below 4.0, which inhibits the growth of most foodborne bacteria. However, acidity must be measured and validated for the finished product and should not be assumed simply because a dressing has been added. Acid-tolerant lactic acid bacteria, yeasts and moulds may still cause spoilage.

Food-safety hazards may result from contaminated raw ingredients, inadequate cooking or cooling, post-process contamination, poor hygiene or inadequate package-seal integrity.

Strict control of cooking, cooling, temperature, hygiene and handling must be maintained throughout production, packaging, distribution and retail display. Because these products vary considerably in formulation, acidity and moisture content, each gas mixture and intended shelf-life must be assessed and validated individually.

Cooked Vegetables & Prepared Salads

Food Items

Coleslaw, potato salad, pasta salad, rice salad, cooked beans, beetroot and potatoes, vegetable bakes, casseroles and curries, vegetable pasta, stuffed vegetables, fritters, vegetarian patties and vegetable burgers

Recommended Gas Mix

Retail and Bulk: 30–50% CO_2, 50–70% N_2

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended for MAP: 0°C to +3°C

Achievable Shelf-Life

In Air: approximately 3–14 days
In MAP: approximately 7–21 days

Shelf-life must be validated for the specific ingredients, formulation, acidity, process, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Enterobacteriaceae, yeasts and moulds.

Enzymatic browning, oxidative deterioration, moisture migration, physical separation and texture changes may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Bacillus species and pathogenic E. coli

Typical MAP Machines

- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack, tub or pot
Bulk: Bag-in-box

Examples of Typical MAP Materials

Films and Pouches:
- MPET/PE
- MOPP/PE
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE
- Metallised barrier liners



Liquid Food & Beverage Products

The principal spoilage mechanisms affecting perishable chilled liquids, including fruit and vegetable juices, milk, liquid yoghurt and other dairy beverages, are microbial growth, oxidative deterioration and physical separation. Souring is also a principal spoilage mechanism affecting milk and some dairy-based beverages.

Ambient-stable beverages, including beer, cider, carbonated soft drinks, cordials, mineral water, wine and spirits, may also be affected by selected microbial spoilage and oxidative off-flavours. Perishable chilled liquid products may support the growth of foodborne microorganisms if pasteurisation, hygiene or temperature control is inadequate. Strict control of processing, temperature, hygiene and handling must therefore be maintained throughout filling, distribution and storage.

Liquid food and beverage products are generally not packed using conventional MAP machinery. Specialised filling systems use N_2 or CO_2 sparging, blanketing or headspace flushing to control the atmosphere within the product and package.

Sparging involves bubbling N_2 or CO_2 through the liquid to reduce dissolved O_2. This can help limit oxidative deterioration and support flavour, colour and product stability. N_2 is commonly used for still and oxidation-sensitive liquids, while CO_2 is used for carbonated beverages.

Gas treatment does not replace pasteurisation or other validated preservation processes. The appropriate gas, residual O_2 level, package format and intended shelf-life must be established for the specific beverage, processing method and storage conditions.

Liquid Food & Beverage Products

Food Items

Fruit and vegetable juices, milk, liquid yoghurt, dairy beverages and plant-based beverages

Recommended Gas Mix

Still and Oxidation-Sensitive Liquids:
100% N_2

N_2 sparging or headspace flushing may be used to reduce dissolved and residual O_2.

Storage Temperature

Food-Safety Guidance: 5°C or colder
Recommended: 0°C to +3°C

Achievable Shelf-Life

Milk:
In Air: approximately 3 days
With Gas-Assisted Packaging:
approximately 4–7 days

Fruit and Vegetable Juices:
In Air: approximately 1 week
With Gas-Assisted Packaging:
approximately 2–3 weeks

Liquid Yoghurt:
In Air: approximately 10 days
With Gas-Assisted Packaging:
approximately 2–3 weeks
Shelf-life must be validated for the specific product, processing method, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Lactic acid bacteria, Streptococcus species, Bacillus species, yeasts and moulds.

Souring, oxidation, physical separation and changes in flavour, colour or texture may also affect product quality.

Potential Food-Safety Hazards

Listeria monocytogenes and Staphylococcus aureus.

Salmonella species, pathogenic E. coli and other hazards may also be relevant where pasteurisation, processing or post-process hygiene is inadequate.

Typical MAP Machines

- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal

Bulk:
- Vacuum chamber
- Gas-flush or bulk-filling systems

Typical Types of Package

Retail: Tray and lidding film, pillow pack, tub or pot
Bulk: Bag-in-box

Examples of Typical MAP Materials

Films and Pouches:
- MPET/PE
- MOPP/PE
- PET/PE-EVOH-PE
- PA/PE-EVOH-PE

Bulk:
- PA/PE
- PA/EVOH/PE
- Metallised barrier liners

Ambient-Stable Beverages & Oils

Food Items

Beer, cider, carbonated soft drinks, cordials, mineral water, edible oils, wine, spirits and liqueurs

Recommended Gas Mix

Still and Oxidation-Sensitive Products: 100% N_2
Carbonated Beverages: 100% CO_2

N_2 or CO_2 sparging, blanketing or headspace flushing may be used according to the product requirements.

Storage Temperature

Recommended: Ambient according to product requirements
Products sensitive to heat or light should be stored under appropriately controlled conditions.

Achievable Shelf-Life

Standard Packaging: approximately 6 months
With Gas-Assisted Packaging: up to 1 year

Shelf-life must be validated for the specific product, processing method, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Yeasts and moulds

Oxidative off-flavours, loss of carbonation and changes in aroma, flavour or colour may also affect product quality.

Potential Food-Safety Hazards

Food-safety hazards are generally restricted by product acidity, alcohol content, carbonation or validated processing.

Appropriate hygiene, processing and package-seal controls remain essential.

Typical MAP Machines

- Specialised beverage-filling equipment
- In-line N_2 or CO_2 sparging systems
- Headspace-flushing and blanketing systems
- Carbonation systems

Typical Types of Package

Retail: Glass or plastic bottle, aluminium or steel can, carton or bag-in-box

Bulk: Keg, barrel, intermediate bulk container or stainless steel tank

Examples of Typical MAP Materials

Retail:
- Glass
- PET or HDPE
- Aluminium
- Steel
- Barrier-coated cartonboard
- High-barrier flexible liners

Bulk:
- Stainless steel
- Aluminium
- Food-grade barrels and kegs



Fresh Whole & Prepared Fruit & Vegetable Products

The principal spoilage mechanisms affecting whole and prepared fresh produce are microbial growth, enzymatic browning and moisture loss. MAP using reduced O_2 and increased CO_2 can inhibit these effects while also slowing respiration, ripening, ethylene production, softening and chlorophyll degradation.

Unlike most other perishable foods, fresh fruit and vegetables continue to respire after harvesting and packaging. Aerobic respiration consumes O_2 and produces CO_2 and water vapour. If the O_2 concentration becomes too low, anaerobic respiration may begin, producing undesirable odours, flavours and rapid deterioration.

Fresh produce must therefore be packaged in films with permeability characteristics matched to the product's respiration rate. An impermeable film may allow O_2 to fall to unsafe or damaging levels. A film that is excessively permeable may produce little atmospheric modification and allow moisture loss, wilting and shrivelling.

When the correct film is selected, an equilibrium modified atmosphere can develop as the transmission of O_2 and CO_2 through the package balances the product's respiration rate. This atmosphere may develop passively without introducing a gas mixture.

Active gas flushing with approximately 5% O_2, 5% CO_2 and 90% N_2 may establish a beneficial atmosphere more quickly. This can help delay enzymatic browning before a passive equilibrium develops. A gas-to-product ratio of approximately 2:1 is commonly recommended.

The appropriate atmosphere depends on the commodity, variety, maturity, preparation method, respiration rate, storage temperature and film permeability. Only high-quality produce should be used for MAP.

Hygienic preparation, approved washing or sanitisation processes, effective dewatering, temperature control and careful handling are essential throughout processing, packaging, distribution and retail display.

Food Items

Apples, avocado, berries, citrus, grapes, kiwifruit, mangoes, melons, pears, pineapple, stone fruit, prepared fruit salads, asparagus, beans, broccoli, cabbage, carrots, cauliflower, cucumber, leafy greens, mushrooms, capsicum, prepared salads, spinach, sweetcorn and tomatoes

Recommended Gas Mix

Active Gas Flushing:
Retail and Bulk: 5% O_2, 5% CO_2, 90% N_2

Passive Equilibrium MAP:
No initial gas flush may be required when film permeability is correctly matched to the product's respiration rate.

Storage Temperature

Product-Specific: generally 0°C to +13°C depending on the commodity
Fresh-Cut Products: 5°C or colder where required by the validated food-safety system.

Achievable Shelf-Life

In Air: approximately 2–7 days
In MAP: approximately 5–35 days

Shelf-life must be validated for the specific commodity, maturity, preparation method, respiration rate, package and storage conditions.

Principal Spoilage Organisms & Mechanisms

Pseudomonas species, lactic acid bacteria, Erwinia species, Enterobacteriaceae, yeasts and moulds.

Enzymatic browning, moisture loss, wilting, softening, anaerobic fermentation and physiological disorders may also affect product quality.

Potential Food-Safety Hazards

Clostridium species, Salmonella species, Staphylococcus aureus, Listeria monocytogenes, Bacillus species and pathogenic E. coli.

MAP does not remove contamination introduced during growing, harvesting, washing, preparation or packaging.

Typical MAP Machines

Retail:
- Thermoform-fill-seal
- Preformed tray sealer
- Horizontal form-fill-seal
- Vertical form-fill-seal

Bulk:
- Gas-flush or bulk-packing systems

Typical Types of Package

Retail: Tray and lidding film, breathable pouch, pillow pack or microperforated bag

Bulk: Lined carton, bag-in-box

Examples of Typical MAP Materials

Retail and Bulk:
- OPP
- OPP/PE
- PE
- EVA
- Microperforated films
- Breathable produce films



Definitions and Terminology

MAP and Food Terminology

Modified Atmosphere Packaging (MAP)
A packaging method in which the normal atmosphere surrounding a food is replaced or modified using a selected gas or gas mixture. MAP can slow spoilage and help maintain product quality but does not replace correct food handling, hygiene or temperature control.

Achievable Shelf-Life
The estimated period for which a product may remain safe and retain acceptable quality under the specified processing, packaging and storage conditions. Shelf-life must be validated for each product and packaging system.

In Air
The approximate shelf-life of a product stored in conventional packaging without a modified atmosphere.

Gas Mixture
A controlled combination of gases used inside a package. The principal gases used in MAP are carbon dioxide, nitrogen and oxygen.

Carbon Dioxide (CO_2)
A gas used primarily to inhibit many aerobic spoilage bacteria and moulds. Carbon dioxide can dissolve into foods containing moisture or fat, potentially causing pack collapse, drip loss or flavour changes when used at excessive levels.

MAP and Food Terminology

Nitrogen (N_2)
An inert gas used to displace oxygen, reduce oxidation and act as a filling or balance gas. Nitrogen can also help prevent package collapse when carbon dioxide is absorbed by the food.

Oxygen (O_2)
A gas generally restricted in MAP because it supports oxidation and the growth of aerobic microorganisms. Controlled amounts may be used to maintain the colour of red meat, support the respiration of fresh produce or inhibit certain anaerobic microorganisms.

Gas-to-Product Ratio
The approximate volume of gas within a package compared with the volume or weight of the food. Adequate headspace is required to maintain the intended gas mixture throughout the product's shelf-life.

Headspace
The unfilled space inside a sealed package surrounding or sitting above the food.

Residual Oxygen
The oxygen remaining inside a package after evacuation or gas flushing. Excessive residual oxygen can reduce the effectiveness of MAP.

Gas Flushing
The process of introducing a selected gas or gas mixture into a package to displace the surrounding air before sealing.

Vacuum Packaging
A packaging method in which air is removed before the package is sealed. Unlike MAP, a separate gas mixture is not normally introduced.

Equilibrium Modified Atmosphere Packaging (EMAP)
A system commonly used for fresh fruit and vegetables in which the respiration of the produce and the permeability of the packaging film establish a balanced atmosphere inside the package.

Respiration
The continuing biological process through which fresh fruit and vegetables consume oxygen and release carbon dioxide, water and heat after harvest.

Aerobic Microorganisms
Microorganisms that require oxygen to grow.

Anaerobic Microorganisms
Microorganisms that can grow without oxygen. Some may grow under vacuum or low-oxygen MAP conditions if other controls are inadequate.

MAP and Food Terminology

Spoilage Organisms
Microorganisms that cause undesirable changes in a food's odour, flavour, colour, texture or appearance. Spoilage does not always mean that a food contains a food-safety hazard.

Food-Safety Hazard
A biological, chemical or physical agent with the potential to cause illness or injury.

Oxidation
A chemical reaction involving oxygen that can cause colour loss, flavour deterioration, nutrient loss or rancidity.

Oxidative Rancidity
The deterioration of fats and oils through oxidation, producing undesirable flavours and odours.

Water Activity
A measure of the water available within a food to support microbial growth and chemical reactions. Foods with low water activity may prevent microbial growth, although microorganisms can sometimes survive in them.

Seal Integrity
The ability of a package seal to remain complete and leak-free throughout handling, storage and distribution. Poor seal integrity can allow air or microorganisms to enter the package.

Shelf-Life Validation
The documented assessment used to confirm that a food remains safe and of acceptable quality for its intended shelf-life under defined processing, packaging, distribution and storage conditions.

Packaging, Machinery and Materials

Retail Pack
A package intended for display and sale directly to the consumer.

Bulk Pack
A larger package used for food-service, processing, storage or distribution rather than individual retail sale.

Master Pack
An outer gas-flushed or modified-atmosphere package containing multiple individually wrapped or retail-ready packs.

Bag-in-Box
A flexible barrier bag placed inside a protective outer box, commonly used for bulk products.

Tray and Lidding Film
A rigid or semi-rigid tray sealed with a flexible top film.

Pillow Pack
A flexible package formed and sealed around the product, usually from a continuous roll of film.

Thermoform-Fill-Seal
A packaging process that heats and forms a base film into trays or pockets, fills them with product, modifies the atmosphere and seals them with a top film.

Preformed Tray Sealer
A machine that places a lidding film over a filled, ready-made tray. Air may be removed and replaced with a selected gas mixture before sealing.

Horizontal Form-Fill-Seal
A machine that forms flexible film horizontally around a product before gas flushing and sealing. It is also commonly described as a flow-wrapper.

Vertical Form-Fill-Seal
A machine that forms film into a vertical tube, fills it with a loose, powdered, granular or dried product, introduces gas where required and seals the package.

Vacuum Chamber
A machine that removes air from a package inside an enclosed chamber before vacuum sealing or introducing a selected gas mixture.

Snorkel System
A system that inserts retractable nozzles into a bag to remove air and introduce gas before heat sealing.

Sparging
The introduction of gas through a liquid to remove dissolved oxygen or modify its gas content.

Blanketing
The use of gas to cover the surface of a liquid or food and reduce its contact with air.

Barrier Material
A packaging material designed to limit the movement of oxygen, carbon dioxide, moisture or aromas through the package.

Permeable Film
A film that allows gases or water vapour to pass through at a controlled rate. It is commonly used for respiring fresh produce.

Microperforated Film
A film containing very small openings that provide controlled gas transmission for fresh fruit and vegetables.

Packaging, Machinery and Materials

Laminated Film
A packaging structure made by bonding two or more material layers together to combine their individual properties.

Coextruded Film
A multilayer film produced by extruding two or more materials simultaneously.

Antifog Film
A film containing a coating or additive that reduces the formation of visible water droplets inside the package.

Material Abbreviations
APET – Amorphous polyethylene terephthalate
CPET – Crystalline polyethylene terephthalate
EPS – Expanded polystyrene
EVA – Ethylene vinyl acetate
EVOH – Ethylene vinyl alcohol
HDPE – High-density polyethylene
LDPE – Low-density polyethylene
LLDPE – Linear low-density polyethylene
MOPP – Metallised oriented polypropylene
MPET – Metallised polyethylene terephthalate
OPA – Oriented polyamide
OPP – Oriented polypropylene
PA – Polyamide, commonly known as nylon
PE – Polyethylene
PET – Polyethylene terephthalate, commonly known as polyester
PLA – Polylactic acid
PP – Polypropylene
PS – Polystyrene
PVC – Polyvinyl chloride
PVdC – Polyvinylidene chloride

Understanding Material Structures

A slash separates the individual layers within a multilayer packaging structure. For example, PET/PE-EVOH-PE identifies a structure combining PET with polyethylene and an EVOH barrier layer. The precise construction and order of the layers should be confirmed with the packaging supplier.

At-a-Glance Guide to Typical Retail MAP Gas Mixtures

A quick-reference starting point for common food categories

O_2 OXYGEN | CO_2 CARBON DIOXIDE | N_2 NITROGEN

Raw Red Meat
O_2: 70–80%
CO_2: 20–30%
N_2: 0%

Raw Edible Offal
O_2: 80%
CO_2: 20%
N_2: 0%

Raw Poultry and Game Birds
Standard Retail:
O_2: 0%
CO_2: 30%
N_2: 70%

Raw Fish and Seafood
Low-Fat White Fish, Crustaceans and Molluscs:
O_2: 30%
CO_2: 40%
N_2: 30%

Raw Fish and Seafood
High-Fat Oily Fish:
O_2: 0%
CO_2: 40%
N_2: 60%

Cooked, Cured and Processed Meat Products
O_2: 0%
CO_2: 30–40%
N_2: 60–70%

Cooked, Cured and Processed Fish and Seafood Products
O_2: 0%
CO_2: 30%
N_2: 70%

Cooked, Cured and Processed Poultry and Game Bird Products
O_2: 0%
CO_2: 30–40%
N_2: 60–70%

Ready Meals and Other Cook-Chill Products
O_2: 0%
CO_2: 30–50%
N_2: 50–70%

Combination Products
O_2: 0%
CO_2: 30%
N_2: 70%

Fresh Pasta Products
O_2: 0%
CO_2: 50%
N_2: 50%

Bakery Products
O_2: 0%
CO_2: 50–100%
N_2: 0–50%

Dairy Products
Hard Cheese:
O_2: 0%
CO_2: 100%
N_2: 0%

Dairy Products
Grated and Soft Cheese:
O_2: 0%
CO_2: 30%
N_2: 70%

Other Dairy Products
O_2: 0%
CO_2: 0%
N_2: 100%

Other Dairy Products
Aerosol Cream
O_2: 0%
CO_2: 0%
N_2O

Principal retail gas mixtures are shown. Refer to the individual food-category pages for bulk mixtures, product variations and exceptions.

At-a-Glance Guide to Typical Retail MAP Gas Mixtures

A quick-reference starting point for common food categories

O_2 OXYGEN | CO_2 CARBON DIOXIDE | N_2 NITROGEN

Dried Food Products
- O_2: 0%
- CO_2: 0%
- N_2: 100%

Cooked Vegetables and Prepared Salads
- O_2: 0%
- CO_2: 50%
- N_2: 50–70%

Liquid Food and Beverage Products
Still and Oxidation-Sensitive Products:
- O_2: 0%
- CO_2: 0%
- N_2: 100%

Liquid Food and Beverage Products
Carbonated Beverages:
- O_2: 0%
- CO_2: 100%
- N_2: 0%

Fresh Whole and Prepared Fruit and Vegetables
Active Gas Flushing:
- O_2: 5%
- CO_2: 5%
- N_2: 90%

Fresh Produce Passive Equilibrium MAP:
No initial gas flush may be required *.

*When film permeability is matched to the product's respiration rate.

Principal retail gas mixtures are shown. Refer to the individual food-category pages for bulk mixtures, product variations and exceptions.

At-a-Glance Guide to Typical Bulk MAP Gas Mixtures

A quick-reference starting point for common food categories

O_2 OXYGEN | CO_2 CARBON DIOXIDE | N_2 NITROGEN

Raw Red Meat Standard Bulk:	O_2: 65%	CO_2: 35%	N_2: 0%
Raw Red Meat Pork:	O_2: 0%	CO_2: 80%	N_2: 20%
Raw Red Meat Venison:	O_2: 80%	CO_2: 20%	N_2: 0%
Raw Red Meat Primal Cuts:	O_2: 0%	CO_2: 50%	N_2: 50%
Raw Red Meat Primal Pork:	O_2: 0%	CO_2: 80%	N_2: 20%
Raw Edible Offal	O_2: 80%	CO_2: 20%	N_2: 0%
Raw Poultry and Game Birds Standard Bulk:	O_2: 0%	CO_2: 100%	N_2: 0%
Selected Raw Reddish Poultry, Skin-Off Poultry and Poultry Mince	O_2: 70%	CO_2: 30%	N_2: 0%
Raw Fish and Seafood White Fish, Oily Fish, Crustaceans and Molluscs:	O_2: 0%	CO_2: 70%	N_2: 30%
Cooked, Cured and Processed Meat Products	O_2: 0%	CO_2: 50%	N_2: 50%
Cooked, Cured and Processed Fish and Seafood Products	O_2: 0%	CO_2: 70%	N_2: 30%
Cooked, Cured and Processed Poultry and Game Bird Products	O_2: 0%	CO_2: 70%	N_2: 30%
Ready Meals and Other Cook-Chill Products	O_2: 0%	CO_2: 30–50%	N_2: 50–70%
Combination Products	O_2: 0%	CO_2: 50%	N_2: 50%
Fresh Pasta Products	O_2: 0%	CO_2: 50%	N_2: 50%
Bakery Products	O_2: 0%	CO_2: 50 – 100%	N_2: 0–50%

Principal bulk gas mixtures are shown. Refer to the individual food-category pages for bulk mixtures, product variations and exceptions.

At-a-Glance Guide to Typical Bulk MAP Gas Mixtures

A quick-reference starting point for common food categories

O_2 OXYGEN | CO_2 CARBON DIOXIDE | N_2 NITROGEN

Dairy Products
Hard Cheese:
- O_2: 0%
- CO_2: 100%
- N_2: 0%

Dairy Products
Grated and Soft Cheese:
- O_2: 0%
- CO_2: 30%
- N_2: 70%

Other Dairy Products
- O_2: 0%
- CO_2: 0%
- N_2: 100%

Dried Food Products
- O_2: 0%
- CO_2: 0%
- N_2: 100%

Cooked Vegetables and Prepared Salads
- O_2: 0%
- CO_2: 30–50%
- N_2: 50–70%

Liquid Food and Beverage Products
Still and Oxidation-Sensitive Products:
- O_2: 0%
- CO_2: 0%
- N_2: 100%

Liquid Food and Beverage Products
Carbonated Beverages:
- O_2: 0%
- CO_2: 100%
- N_2: 0%

Fresh Whole and Prepared Fruit and Vegetables
Active Gas Flushing:
- O_2: 5%
- CO_2: 5%
- N_2: 90%

Fresh Produce Passive Equilibrium MAP:
No initial gas flush may be required *.

*When film permeability is matched to the product's respiration rate.

Principal bulk gas mixtures are shown. Refer to the individual food-category pages for bulk mixtures, product variations and exceptions.

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Is Your MAP Process Performing as It Should?

SGTA can help you verify gas composition, seal integrity and packaging performance.

Talk to Our MAP Specialists

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