MAPAX™ – The Optimal Solution of Modified Atmosphere

A G A C R E A T E S N E W O P P O R T U N I T I E S

Why you should read about modified atmosphere

Modified Atmosphere Packaging, or MAP, is a method for extending shelf-life, preserving the high quality of foodstuffs, and improving overall cost-effectiveness. It can do all this because it

- increases sales by satisfying the growing demand by consumers for naturally preserved food quality, without additives and preservatives
- increases shelf-life quality in the distribution chain by extra days or even weeks, which increases the availability of fresh food to consumers
- reduces the return of spoiled foodstuffs
- enhances production efficiency and distribution by cutting costs
- increases sales volumes because new products can be offered on new markets.

To achieve these benefits, consideration must be paid to a number of factors. It is this overall concept – designated MAPAX™ from AGA – that is the subject of this booklet. That is why we recommend that you continue reading.

TM MAPAX is a trademark of AGA AB and is registered or applied for in several countries.

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The recipe for protecting food quality

Savoury stuffed lamb chops, steaming mashed potatoes, fresh vegetables, mixed salads.... A decade or so ago, preparing a meal could take hours. Very soon, one will only have to ponder the offerings of the nearest store's chilled-food counter, turn on the kitchen's microwave oven a few minutes – and dinner is ready to enjoy.

The packaging of fresh food, both semi-prepared and prepared dishes, have become a firmly anchored concept in the minds of modern-day consumers. They want to see food on their plates with the same freshness as when it was first prepared.

This intensified interest in fresh foodstuffs is a strong driving force behind the development of new shelf-life-enhancing methods, whereby artificial additives and preservatives no longer are acceptable. Nowadays, efforts are being made to meet consumer demands for naturally preserved food quality, handled and processed as little as possible.

MAP – the winning food preservation technology of the 1990s

Using gases as a preservative method has been used for more than 50 years to store and distribute animal carcasses and bulk products such as meats and fruits. A relatively new preservative technology for enhancing the shelf-life of consumer food products is Modified Atmosphere Packaging (MAP). It utilizes gases in packaging to maintain quality from the producer to the consumer. MAP has been developed by large-scale food-processors and wholesalers, and it is, internationally, the fastest growing method for preserving the inherent quality of foodstuffs. Modified atmosphere very likely will become the winning method of the 1990s as a natural way to preserve the original quality of foodstuffs. In Western Europe, the number of MAP food products doubled between 1987 and 1989. The trend continues as strong during the 1990s.

Contents in brief

- Consumer demand for fresh foods with naturally preserved quality leads to new shelf-life-enhancing methods.
- MAP technology is expanding rapidly.

Modi½ed atmosphere gives bene½ts throughout

By packaging foodstuffs in a modified atmosphere, it is possible to extend high quality and shelf-life by days or even weeks. Products that previously could not be stored fresh throughout the distribution chain can now be offered in shops without sacrificing quality.

High quality boosts sales

For the consumer, modified atmosphere packaging means that product quality will be high and consistent, so that the assortment in the food store will be fresh every day of the week.

Maintaining high food quality for a few extra days or even weeks increases the availability of fresh products to the consumer and can dramatically boost sales. Examples taken from the fish industry show that maintaining quality a few extra days can triple sales.

Reduced spoilage and returns

Fresh food that is not sold in time is returned. This is a big-scale problem that seriously affects productivity.

MAP makes it possible for products to retain a safe level of quality. The result is reduced spoilage and fewer returns.

Production and distribution become more rational and profitable

Enhanced shelf-life quality also means that production – and the entire logistics chain from the time that the raw material is brought in until the distribution trucks drive out – can be arranged more rationally and with greater flexibility.

The number of deliveries can be reduced, and the geographical distribution, increased.

Enhanced shelf-life also means that fluctuations in the availability of certain raw materials, due, for instance, to seasonal variations, can be evened out. Equipment and employment can be dimensioned for mean production rate instead of occasional peaks.

Increased profitability – through completely new products

Modified atmospheres open up new opportunities for the sale of new products on new markets. MAP makes it possible, for instance, to offer fresh pizza or ready-mixed salads in the shops.

Contents in brief

- Fresh product sales increase dramatically with MAP.
- An improved economy due to fewer product returns and a more effective production.
- It is possible to market new products with great demand using MAP.

Fresh food in modified atmosphere.

Natural spoilage must be retarded to keep good quality

Food is a biological, sensitive substance. Original freshness and shelf-life are affected by the inherent properties of the product as much as by external factors.

Internal factors affecting quality are

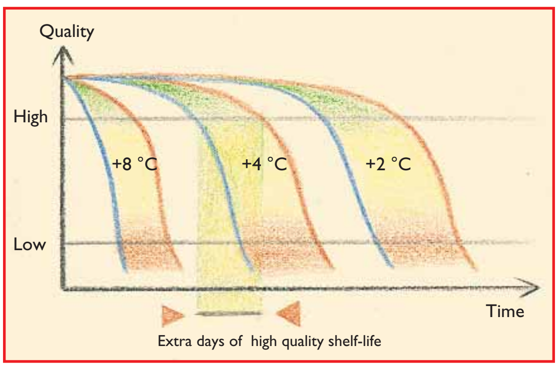
- the type and quantity of microorganisms
- water activity (a_w)
- pH
- cell respiration
- food composition.

External factors affecting the inherent quality are such things as

- the temperature
- hygienic conditions
- gas atmosphere
- process methods.

It is therefore of critical importance to the shelf-life how the product is handled in the processing stage, on the filling line or during chilling prior to packaging.

High quality shelf-life is extended when microbial deterioration is inhibited.



Spoilage starts immediately

It is primarily microbial and chemical/biochemical deterioration that destroys food.

Microbial deterioration starts immediately after harvesting or slaughtering. The presence of microorganisms can be traced to the raw materials, the ingredients and the environment. Microorganisms are found everywhere in our surroundings, e.g. on our skin, on tools and in the air. For this reason, good hygienic conditions must be maintained throughout the processing chain.

The ways in which microorganisms bring about spoilage vary depending on the type of organism and the foodstuff itself.

Basically, microorganisms can be divided into two categories: aerobic and anaerobic. Aerobic organisms require the presence of oxygen (O_2) to survive and multiple. Anaerobic organisms, on the other hand, grow in the absence of oxygen.

Aerobic microorganisms include *Pseudomonas*, *Acinetobacter* and *Moraxella*, which spoils food by decomposing and producing substances that give bad taste and odour.

Anaerobic microorganisms include *Clostridium* and *Lactobacillus*. *Clostridium*, when foodstuffs are handled incorrectly, can generate a toxin. *Lactobacillus*, on the other hand, is a harmless bacterium that turns the food sour by producing lactic acid.

Low temperature a highly effective inhibitor

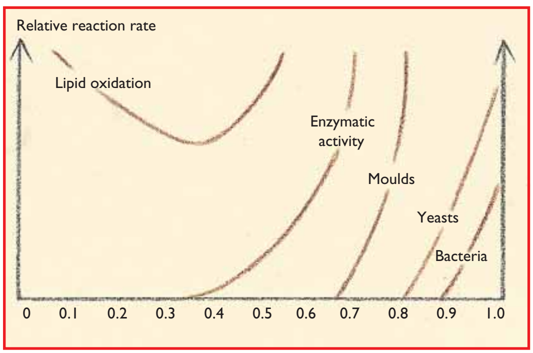
Temperature is one of the most important factors controlling microbiological activity. Most microorganisms multiple optimally in the 20 to 30 °C range and show reduced growth at lower temperatures. Careful temperature monitoring is therefore vital during all food handling and distribution stages.

Chilling alone, however, will not solve all microbiological problems. There are some psychrophilic bacteria, e.g. *Pseudomonas*, that multiple at relatively low temperatures. For such organisms, other defences must be resorted to, such as a modified atmosphere.

Oxygen causes chemical breakdown

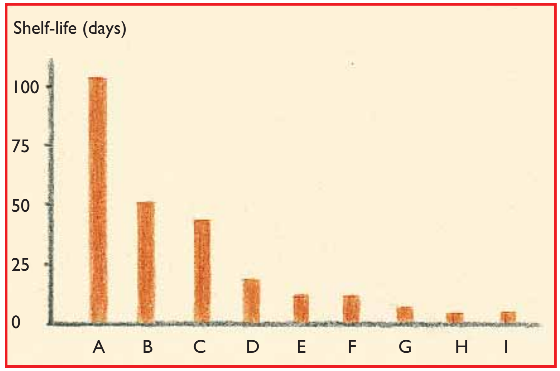
The chemical reactions may be oxidation of vitamins or lipids or caused by enzymes.

The chemical breakdown of lipids is the primary process in dry or dehydrated foodstuffs and in high-fat fish. This is due to the oxidation of unsaturated fats in the presence of atmospheric oxygen, causing the product to turn rancid.



Chemical and biological reaction vs. water activity.

Microbiological shelf-life of fresh beef at different temperatures and atmospheres.



A = 100% CO_2 1 °C
B = Vacuum 1 °C
C = 100% CO_2 4-5 °C
D = Vacuum 4-5 °C
E = 10-20% CO_2 2-10% O_2 rest N_2 4 °C
F = 15% CO_2 40% O_2 rest N_2 4 °C
G = 50-60% CO_2 40-50% O_2 4 °C
H = Air 4 °C
I = 100% O_2 1-3 °C

Enzymatic reactions caused by, for example, polyphenol oxidase bring about the brown-colouring of sliced fruits and vegetables.

Oxygen is however important in maintaining the red colour of cut meats.

From food preservation to the protection of natural quality

Present developments are moving away from the previous preservative methods that physically or chemically alter the product toward less severe methods that leave the product unchanged.

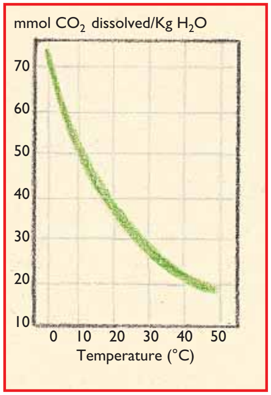
The methods that represent the ultimate attempt to protect the inherent quality of a food product extend from processes such as high-pressure and microwave methods to various packaging techniques, e.g. oxygen absorption, vacuum, sous-vide techniques and MAP.

MAP is a natural shelf-life-enhancing method that is growing rapidly on an international scale. It often complements other methods.

Contents in brief

- Foodstuffs are sensitive products that immediately begin to spoil after harvesting or slaughter owing to microbial and/or physical and chemical deterioration.
- Low temperature retards the deterioration process.
- New, less severe preservative methods protect the original quality of the foodstuffs.

Modified atmosphere – the most natural way to retain high quality



CO_2 solubility in water.

Solubility in water at Pgas = 100 KPa litre/kilogram at +20°C.	
Argon, Ar	0.033
Hydrogen, H_2	0.018
Carbon dioxide, CO_2	0.878
Nitrous oxide, N_2O	0.610
Nitrogen, N_2	0.015
Oxygen, O_2	0.030

The correct gas mixture in modified atmosphere packaging maintains high quality by retaining the original taste, texture and appearance of the foodstuff.

The gas atmosphere must be chosen with due consideration to the particular foodstuff and its properties. For low-fat, high-moisture-content products, it is especially the growth of microorganisms that is to be inhibited. Should the product, instead, have a high-fat content and low water activity, oxidation protection is the most important.

The MAP gas mixtures usually consist of the normal air gases: carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2). A certain amount of microorganism growth inhibition can also be achieved with the help of other gases such as nitrous oxide, argon or hydrogen.

Each of the gases has its own unique properties that affect its interaction with the foodstuffs. The gases are used in mixed atmospheres having suitable proportions or by themselves.

Carbon dioxide content important for results

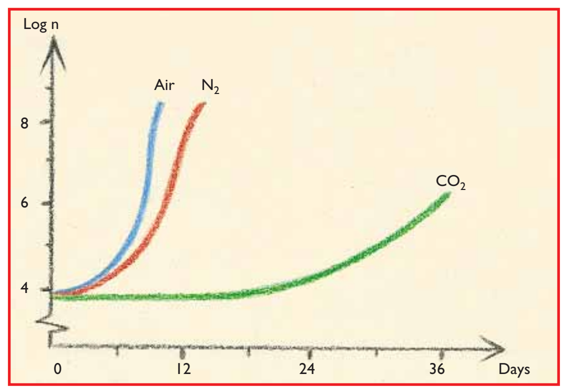
Carbon dioxide is the most important gas in the field of MAP technology. Most microorganisms such as mould and the most common aerobic bacteria are strongly affected by carbon dioxide. The growth of anaerobic microorganisms, on the other hand, is less affected by this gas atmosphere.

Carbon dioxide inhibits microbial activity by effectively dissolving into the food's liquid phase, thereby reducing its pH and by penetrating biological membranes, causing changes in permeability and function.

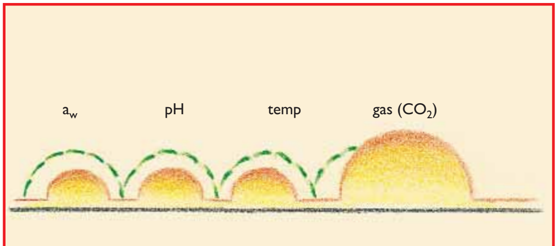
Nitrogen – inert and stabilizing

Nitrogen is an inert gas. It is primarily used to replace oxygen in packaging and thereby prevents oxidation.

Owing to its low solubility in water, nitrogen also helps to prevent package collapse by maintaining internal volume.



Bacterial growth on fresh pork in different atmospheres at +4 °C.



CO_2 provides an extra hurdle for chilled food safety.

Oxygen level should be as low as possible

For most foodstuffs, the package should contain as little oxygen as possible to retard the growth of aerobic microorganisms and reduce the degree of oxidation.

There are, however, exceptions. Oxygen helps to preserve the oxygenated form of myoglobin, which gives meat its red colour. Oxygen is required for fruit and vegetable respiration.

Contents in brief

- Gases mainly used in MAP are carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2).
- The unique properties of the gases are utilized in modified atmosphere packaging.
- Carbon dioxide is the most important gas in preserving product quality for chilled food.

Ulf Rönner, Ph.D., Senior Scientist
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"In future, consumers will demand food products of high quality that are natural, fresh and minimally processed.

The response of food producers will be to invest in new technologies to meet this demand.

A possible scenario, in which MAP has a role to play, may be a minimal processing of food using microfiltration, irradiation, ultrasound or high pressure followed by MAP technology, resulting in better food safety and shelf-life compared with today's products.

Food producers have a need to better understand the safety margins of products when a new technology such as MAP is used.

The main components in stabilizing food with MAP is the use of gases. The primary gases are CO_2, N_2 and O_2 either alone or in mixtures.

Carbon dioxide has bacteriostatic and fungistatic properties and acts as a preservative in products. The effect of CO_2 is increased at low temperatures because of its enhanced solubility in water.

The main sites of action for CO_2 appear to be the biological membranes and cytoplasmic enzymes

The degree of growth inhibition offered by CO_2 differs widely depending on the species of microorganisms and environmental parameters and hurdles such as pH, a_w, salt and sugar.

When applying MAP to food products, the producer needs to consider many external and internal factors in order to retain high quality during product storage."

Many questions to answer in choosing packaging materials

Packaging materials are of decisive importance for food quality and shelf-life. Many sophisticated packaging solutions have been developed to prevent rapid deterioration caused by oxygen, light and bacteria or by foreign odour and taste substances that come into contact with the product.

The manufacturer of foodstuffs faced with choosing suitable packaging designs and materials has many important decisions to make. What does the product require in the way of packaging as protection against quality deterioration from microbial growth, oxidation, dehydration, etc.? What barrier properties does the packaging provide against oxygen, light and volatile substances? What water vapour transmission rate should the packaging have? What applies with regard to the material's transparency, sealing ability, anti-fogging properties, microwavability or price?

Various material properties combined

Packaging materials used with all forms of MAP foods (with the exception of fruits and vegetables) should have high barrier characteristics. Polymers used include polyester, polypropylene, polystyrene, polyvinyl chloride, nylon, ethylene vinyl acetate and ethylene vinyl alcohol polymers. These are usually laminated or co-extruded with polyethylene, which is in direct contact with the food and is the heat-sealing medium.

Research work strives to use environment-friendly materials both for manufacture and for subsequent combustion as well as for an optimization of the packaging material, so that the amount of material is minimized. That is why PVC is being replaced more and more by other materials such as APET or PS/EVOH and PVdC is being replaced by EVOH or OPA.

Below is a list of some typical materials used with products. The exact composition of the film is adapted to the individual product and to the type of package required.

In order that a modified atmosphere will be retained during the lifetime of the package, several different plastic materials are often combined into a multi-layered structure, each layer having its own function (page 13). Different plastic materials can therefore be chosen and combined to achieve

- mechanical strength
- water vapour barriers to prevent weight loss and dehydration
- gas barrier
- gas permeability
- anti-fogging properties (the inside of the material should have a surface that does not allow the formation of water droplets, which reduce transparency)
- sealing properties, i.e. capable of sealing into a tight package while retaining material properties even along the weld seam.

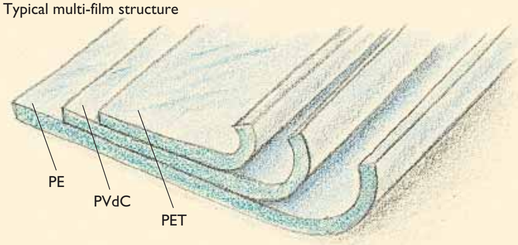
Primary function of various basic materials

APET......................rigidity, O_2 barrier
CPET......................rigidity, high temperature resistance, O_2 barrier
EVA........................ sealing layers
EVOH....................O_2 barrier
HDPE.....................moisture barrier, rigidity, microwave capability, sealing layers
LDPE......................sealing layers
OPET.....................high temperature resistance, flexibility, puncture resistance
OPP........................ moisture barrier, flexibility, puncture resistance
PA...........................high temperature resistance, flexibility, toughness, forming strength, some O_2 barrier
PAN....................... O_2 barrier
PET.........................rigidity, some O_2 barrier
PP...........................moisture barrier, rigidity, microwave capability
PS............................ rigidity
PVC........................rigidity, O_2 barrier
PVdC..................... moisture barrier, O_2 barrier

Abbreviations

APET........................... amorphous polyester
CPET........................... crystallized polyethylene terephthalate
EVA............................. ethylene-vinyl acetate
EVOH.......................... ethylene-vinyl alcohol
HDPE........................... high density polyethylene
LDPE........................... low density polyethylene

Typical multi-film structure



Abbreviations cont.

OPET......................... oriented polyethylene-terephthalate
OPP.............................oriented polypropylene
PA................................polyamide (nylon)
PAN.............................acrylonitrile
PE................................ polyethylene (polyester)
PET.............................. polyethylene terephthalate (polyester)
PP.................................polypropylene
PS.................................polystyrene
PVC.............................polyvinyl chloride
PVdC..........................polyvinylidene chloride

Contents in brief

- Properties of materials are important in maintaining quality.
- Different materials can have different major properties, such as permeability, mouldability and puncture strength.
- Materials can be combined in to a multi-layered structure.

There is a packaging machine for every need

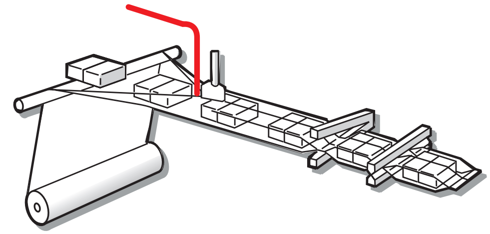
There are five main groups of packaging machines used with MAP technology depending on the type of product. Although these machines are based on different principles, the basic working operation is the same. First, a package is formed (or prefabricated packages are used) and filled with the product. Then, the air in the package is replaced by a modified atmosphere. Finally, the package is sealed. These three steps take place either manually or automatically.

The methods used to modify the atmosphere include gas flushing or vacuum extraction and then gas injection.

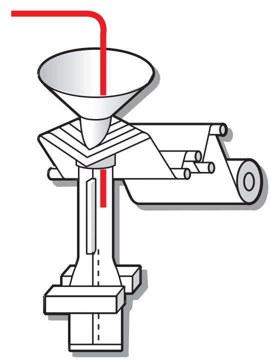
In gas flushing, the air inside the package is replaced by a continuous gas stream that dilutes the air surrounding the food product before the package is sealed. Since this dilution is continuous, the packaging rate can be high.

In the vacuum process, air is extracted from the package and the resultant vacuum is broken by injection with the desired gas mixture. Since this is a two-step process, its speed is slower than that of the gas flushing method. Because the air is almost totally removed, however, the efficiency of this process with respect to residual oxygen levels is better than in the case of gas flushing.

Horizontal flow-pack

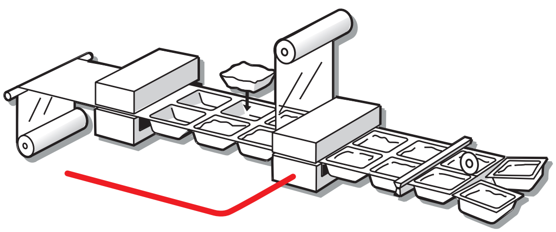


The foodstuffs are fed into a horizontal flowing tube that is constantly formed by the packaging machine. The tube is sealed and cut off along both sides of the product. Gas is flushed into the resultant bag purging the air. This equipment works fast and uses less complicated film material than the deep-drawing machine. Typical foods are bakery products, sausages, cheese, pizza and green salads.



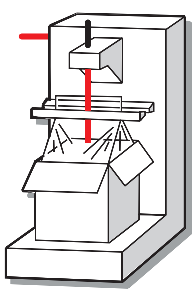
Vertical flow-pack

A film is formed into a tube that is pinched together at one end and sealed over an injection pipe. The product is portioned out into the tube, which is then sealed at the other end and cut off. Gas is continually being fed through the tube to purge the air. This machine is mostly used for powdered and bulk products such as coffee and peanuts as well as diced foodstuffs.



Deep-drawing machine

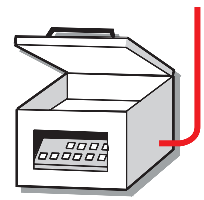
Film is heat formed into a tray on a lower conveyor belt and the product is then added. Air is extracted, gas injected and the loaded package is sealed by welding on a film from an upper conveyor belt. This machine is suitable for foodstuffs such as meat, fish and prepared food.



Bag-sealing machine bag-in-box

Prefabricated bags are used that are filled with the product. A snorkel probe is introduced into the bag and air is extracted. Gas is then fed in, the snorkel is removed, and the bag is sealed. Such equipment is used for large packages of, for example, meat, poultry and fish.

Vacuum chamber machine



Prefabricated bags or trays are used into which the product is inserted. The packages are placed in a chamber from which the air is extracted and the pressure then equalized with gas. The packages are then sealed by welding. This machine type is suitable for small production volumes at a relatively low cost.

Contents in brief

- Several types of machines are available on the market for MAP.
- The machine designs are based on two techniques: gas flushing and vacuum suction followed by gas injection.
- The choice of machine is governed by the packaged product, the packaging material and the production volume.

A gas supply adapted to every application

AGA supplies the MAP gases: carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2) – either pre-mixed in cylinders under high pressure or as separate gases in cylinders or insulated tanks for subsequent mixing at the packaging machine. The MAP gases are in accordance with the proposed EEC directive on food additives.

N_2 and O_2 are separated from the air and CO_2 is taken from natural wells or as a by-product from, for instance, fermentation processes or ammonia production.

In many cases, it may be more effective and practical to produce nitrogen on site using PSA (Pressure Swing Adsorption) or a permeable membrane plant.

Careful evaluation behind each choice

The supply option that may be best depends on the type of foodstuff, the production volume, the packaging line, and also whether the gas is to be used anywhere else in production.

It may be highly preferable to have pre-mixed gases supplied if production is relatively limited or if a new production facility is being started up. When production rates increase, and if different products are to be packaged, it may be more suitable and economic to switch over to mixing gases on site. Then a mixer is used and the gases are supplied from cylinders, tanks or PSA/membrane systems.

Each application must be evaluated separately before decisions can be taken regarding the supply options and gas mixtures. For quality assurance, regularly checking the gas mixture in the ready packages after sealing is recommended.

AGA a reliable supplier

AGA can build a gas centre and network for the safe, reliable and economic distribution of gases to the various points of use in a production line or factory. AGA can provide assistance in gathering data and in conducting trial runs as well as in full operation and fine tuning. Owing to its close collaboration with customers, AGA is often given total responsibility for the supply of gases, including the building and maintenance of a customer's internal gas distribution network.

Continuous training of a customer's personnel and an active participation in a customer's product and process development is frequently included.

Contents in brief

- AGA offers optimal supply methods paying heed to such things as production volumes.
- The gases are supplied either pre-mixed or for mixing on site.
- AGA assumes total responsibility for the gas supply.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MAPAX™ meets customer needs for different applications

MAPAX from AGA can be defined as an optimal gas mixture and gas supply based on the necessary data about foodstuffs, gases and packaging.

MAPAX takes into consideration:

- the handling and processing of the product
- the types and quantity of microorganisms
- the level of hygiene
- the delay before packaging
- the temperature
- the properties of the packaging material, e.g. permeability
- the free gas volume of the package
- the gas mixture.

Accumulated know-how supports choice of application solution

In order to be able to recommend the right MAPAX solution for the application in question, AGA acts as more than a mere supplier of gas. MAPAX from AGA is based on close cooperation between the suppliers of the packaging material, the packaging machines and the gases.

The purpose of this collaboration between suppliers is to be able to meet demands for an efficient and cost-effective packaging of foodstuffs, with retained product quality throughout the entire distribution chain and ending as an attractive display in the chilled-food counter.

The goal of this cooperation, by exploiting the advantages of MAP technology in the right way and by adapting methods to each application, is also to be able to offer solutions that make it possible for the manufacturer to develop new products for sale on new markets.

Research generates necessary know-how

Modified atmosphere technology is a fast-growing field. This is clearly proven by the intensive research work in progress throughout Europe. Projects are currently underway, for instance, at research institutes at Campden RA in the UK, the Swedish Institute for Food Research (SIK), the Technical Research Centre of Finland (VTT), Hochschule Bremerhaven in Germany and the Institute of Food Technology in Norway that involve product quality and product safety within the field of MAP.

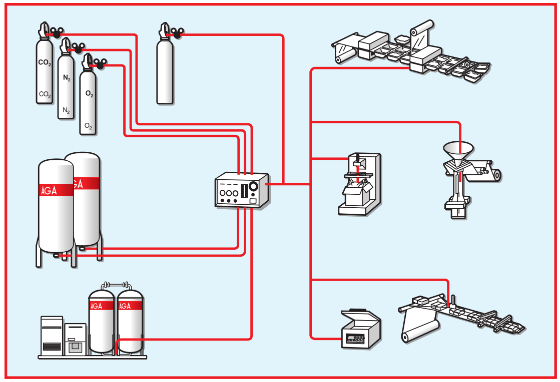
AGA works closely with such research institutes. In the laboratories of SIK, for example, various simulations are carried out to determine the potential hazards from microorganisms. Such studies provide the information necessary for determining safe shelf-life intervals.

Because AGA has access to know-how dealing with how different bacteria are affected by the combination of temperature/atmosphere and other such parameters as permeability, a MAPAX solution can be offered that will ensure maximum microbiological security for each foodstuff.

Practical experience gives confirmed safety solutions

AGA has customers in the food processing industry round the world. Valuable contacts have been established with several leading companies that package their products in modified atmospheres.

For a number of years, AGA has had the advantage of accumulating experience and know-how from applications for which MAPAX has proved to be the answer. The collaboration with the food processing industry has contributed greatly to facilitating the choice of a suitable atmosphere and packaging material for individual applications.



MAPAX offers a complete menu of solutions.

Contents in brief

- MAP results depend on numerous factors such as the properties of the foodstuffs, the packaging and the gases.
- MAPAX is a MAP solution adapted to each application.
- MAPAX is founded on accumulated knowledge and experience.

The right MAPAX solution suitable for meat and meat products

Meat and meat products are particularly susceptible to bacterial growth owing to their high water activity.

Meat is sterile from the start, but when cut apart, the surfaces exposed to the ambient air offer excellent breeding grounds for most bacteria. Minced meat is naturally even more exposed. For this reason, hygiene in processing and prepackaging is vitally important – keeping tools and equipment clean – to minimize the introduction of microorganisms into the product.

Carbon dioxide effectively solves the biggest problem

Carbon dioxide, generally speaking, has a strong inhibiting effect on the growth of bacteria, of which the aerobic genus *Pseudomonas* presents the greatest problem for fresh meat.

Red meat requires oxygen

A special problem arises with red meats such as beef in regard to colour changes caused by the oxidation of the red pigment. The atmosphere for fresh meat therefore normally contains high concentrations of oxygen (60–80%) in order to retain the red colour by ensuring high oxygen levels in the meat's myoglobin. Highly pigmented meats such as from beef thus require higher oxygen concentrations than do low pigmented meats such as pork.

With the right mixtures, the practical shelf-life of consumer-packed meats can be extended from 2–4 days to 5–8 days at +4 °C. If master-packs are used in distribution, high CO_2 levels can be used, thereby increasing shelf-life.

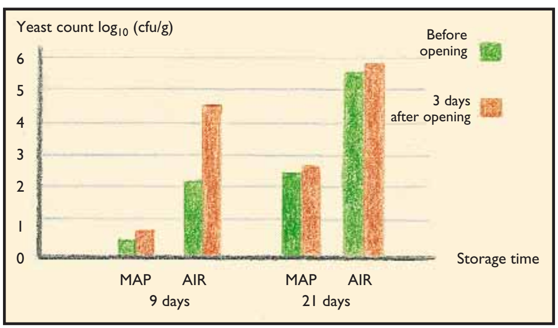
Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	Typical shelf-life MAP	Typical material*	Typical machine	Storage temp.
Red meat	80% O_2+20% CO_2	100-200 ml / 100 g meat	2-4 days	5-8 days	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+2 -+3 °C
Poultry meat	50-80% CO_2 + 20-50% N_2	100-200 ml / 100 g meat	7 days	16-21 days	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+2 -+3 °C
Sausages	20% CO_2+80% N_2	50-100 ml / 100 g prod.	2-4 days	4-5 weeks	OPET/PVdC/PE-PVC/PE PA/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C
Sliced cooked meat products	20% CO_2+80% N_2	50-100 ml / 100 g prod.	2-4 days	4-5 weeks	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+4 -+6 °C

* PVC is being replaced by APET or PS/EVOH
PVdC is being replaced by EVOH or OPA

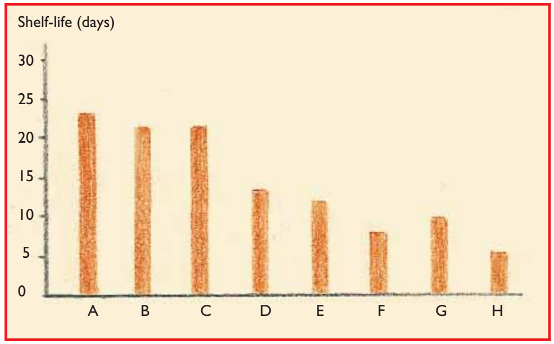
Meat products have a different microflora

Deterioration of meat products are most commonly caused by microbial spoilage. Due to the processing operations, for instance marinating, drying, smoking, fermentation, curing and cooking, the microflora in meat products differs from that in raw meat and the spoilage mechanisms are thereby different.

This affects the gas composition used in the package. In order not to turn the products sour, the concentration of carbon dioxide is usually low (20–50%).



CO_2 also has residual inhibitory effect after opening the MAP package. The yeast count of cooked minced meat steaks immediately after opening and after three days from the opening. MAP = 20% CO_2 + 80% N_2.
Air = conventional air package



Microbiological shelf-life of chicken at different atmosphere/temperature combinations.

A = 100% CO_2 1 °C
B = 10 – 30% CO_2 rest N_2 1 °C
C = Vacuum 1 °C
D = 100% CO_2 4 – 6 °C
E = Vacuum 4 – 6 °C
F = 10 – 30% CO_2 rest N_2 4 – 6 °C
G = Air 1°C
H = Air 4 – 6 °C

Shelf-life of poultry is highly affected

Poultry is very susceptible to bacterial spoilage, evaporation loss, off-odour, discoloration and biochemical deterioration. The sterile poultry tissue becomes contaminated during the evisceration process.

The practical shelf-life of gas-packed poultry is about 16 to 21 days. The head-space volume should be nearly as large as the product volume.

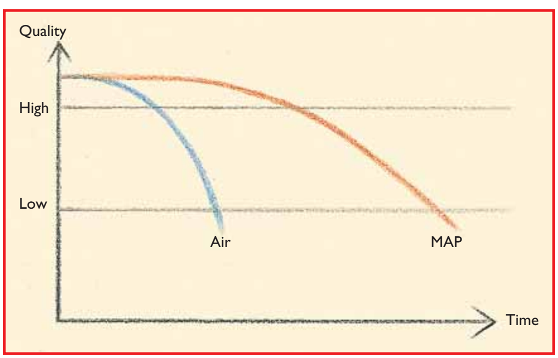
Contents in brief

- Carbon dioxide inhibits the growth of the main spoilage organism, *Pseudomonas,* for fresh meat.
- Oxygen preserves the red colour of meat.
- Gas-packaged poultry can retain its high quality for about three weeks.

The right MAPAX solution suitable for ½sh and seafood

Fresh fish rapidly lose their original quality due to microbial growth and enzymatic processes. The sensitivity of fish and seafood is caused by their high water activity, neutral pH (at which microorganisms thrive best) and the presence of enzymes, which rapidly undermine both taste and smell. The breakdown of proteins by microorganisms gives rise to unpleasant odours. The oxidation of unsaturated fats in high-fat fish such as salmon, herring and mackerel also results in unappetizing taste and smell. Fish such as herring and trout can turn rancid even before microbial deterioration is detectable.

In order to maintain the high quality of fresh fish products, it is absolutely necessary to maintain the temperatures as close to 0 °C as possible. In combination with the right gas mixture, shelf-life can be extended a few important extra days. One condition, naturally, is an unbroken chain of refrigeration. Cod, flounder, plaice, haddock and whiting are examples of fish that can be stored at 0 °C twice as long in a modified atmosphere as in air.



Fish such as cod and plaice can retain their high quality twice as long in the correct modified atmosphere at 0 °C.

Carbon dioxide a prerequisite for retained quality

The presence of carbon dioxide is necessary to inhibit the growth of common aerobic bacteria such as *Pseudomonas*, *Acinetobacter* and *Moraxella*. At levels above 20% in big enough package volumes, growth is primarily inhibited in fish because carbon dioxide reduces the pH level of the tissue surface. The carbon dioxide concentration is normally 50% in practical situations.

Depending on the storage temperature (0–2 °C), modified atmosphere packaging prolongs the shelf-life by 3 to 5 days compared with the shelf-life of raw fish in a tray with film overwrap.

Excessively high concentrations can produce undesirable after-effects in the form of lost tissue liquid or, in the case of crabs, an acidic or sour taste.

Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	MAP	Typical material*	Typical machine	Storage temp.
Fatty fish	60-70% CO_2+ 30-40% N_2	200-300 ml / 100 g fish	3-5 days	5-9 days	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+0 - +3 °C
Lean fish	30-40% O_2+ 30-70% CO_2+ 0-30% N_2	200-300 ml / 100 g fish	3-5 days	5-9 days	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+0 -+3 °C
Cooked fish products	20% CO_2+80% N_2	50-100 ml / 100 g prod.	2-4 days	4-5 weeks	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+4 -+6 °C

* PVC is being replaced by APET or PS/EVOH
PVdC is being replaced by EVOH or OPA

Oxygen keeps colour

Oxygen can be used as a component of a modified atmosphere to avoid colour changes and pigment fading in fish and seafood. The gas is also used to prevent the growth of anaerobic microorganisms such as *Clostridium*, which can produce toxin. The risk, however, for *Clostridium* growth in correctly modified atmosphere packed fish with short shelf-life is negligible. If the temperature is kept below +3 °C, there can be no growth.

To combat rancidity, oxygen should not be used in packages of high-fat fish. In such a case, nitrogen is more suitable.

Contents in brief

- Fresh fish have an extremely short shelf-life.
- CO_2 levels of 40–60% in suitable packages are normally used.
- MAP normally gives 20–50% extended shelf-life compared to air.

The right MAPAX solution suitable for dairy products

Microbial growth and rancidity are the primary causes of the quality deterioration in dairy products.

The type of breakdown depends on the characteristics of the particular product. Hard cheeses with relatively low water activity are normally affected by the growth of moulds, whereas products with high water activity such as cream and soft cheeses are more susceptible to fermentation and rancidity.

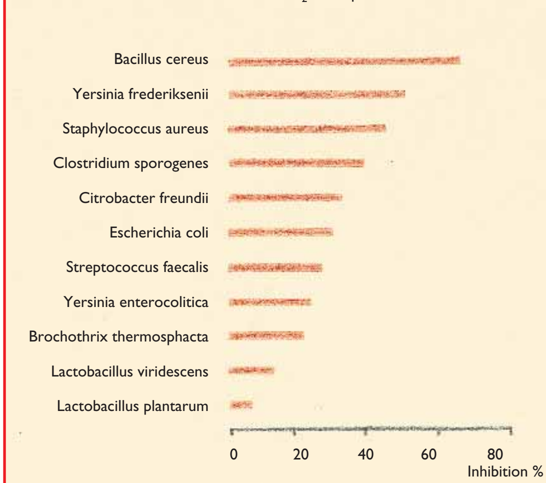
Lactobacillus, which is much used in the dairy industry, may also be a problem by turning products sour by lowering their pH. This may further be intensified by the fact that cottage cheese packages, for example, contain incorrect gas atmospheres with excessive levels of carbon dioxide.

Mould prevented by carbon dioxide

In the packaging of hard cheese, carbon dioxide is used first and foremost. It effectively stops or reduces microbial activity and contributes to retaining texture. Carbon dioxide concentrations of 20% already strongly affect the growth of mould fungi. Lactic acid bacteria, a natural constituent of cheese, is affected very little by the surrounding atmosphere (see below).

Soft cheeses are also packaged in atmospheres of increased carbon dioxide levels and low oxygen levels to inhibit bacterial growth and rancidity.

Inhibition for various bacteria in 100% CO_2 atmosphere.



Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	MAP	Typical material*	Typical machine	Storage temp.
Hard cheeses	80-100% CO_2+ 0-20% N_2	50-100 ml / 100 g cheese	2-3 weeks	4-10 weeks	OPA/PE-PA/PE PA/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C
Hard cheeses (sliced)	80-90% CO_2 + 10-20% N_2	50-100 ml / 100 g cheese	2-3 weeks	4-10 weeks	OPA/PE-PA/PE PA/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C
Soft cheeses	20-40% CO_2+ 60-80% N_2	50-100 ml / 100 g cheese	4-14 days	1-3 weeks	OPA/PE-PA/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C

* PVC is being replaced by APET or PS/EVOH, PVdC is being replaced by EVOH or OPA

In packaging for hard cheeses, the carbon dioxide level is up to 100% and for soft cheeses, the level is usually restricted to 20–40%. The reason for this is to prevent the package from collapsing under atmospheric pressure as the carbon dioxide dissolves into the contained water.

Value-added cheese, such as grated or sliced cheddar, are also packed in modified atmosphere. Grated cheese is usually packed in an atmosphere of 70% N_2 and 30% CO_2. The use of only 30% CO_2 avoids package collapse.

Cultured products a new application

Cultured products, such as cottage cheese and yoghurt, have not been packed in modified atmospheres until recently. But the demands for longer lives has led to its use.

The shelf-life of cottage cheese packed under carbon dioxide can be extended by a week.

Nitrogen stops sour cream

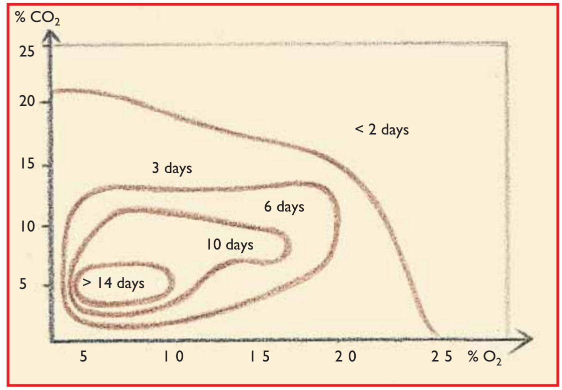
Cream and dairy products containing cream rapidly turn sour in carbon dioxide atmospheres. The gas is therefore replaced by nitrogen. By keeping out oxygen, nitrogen prevents rancidity and the growth of aerobic bacteria.

Contents in brief

- Cheeses are particularly susceptible to mould growth.
- Growth is inhibited by carbon dioxide. Concentrations of between 20 and 100% are used in retail packaging.
- Nitrogen replaces carbon dioxide in packages containing products that easily turn sour, e.g. cream.

The right MAPAX solution suitable for fruits and vegetables

Packaging material of the correct permeability must be chosen for the successful MAP of fresh produce. If produce is sealed in an insufficiently permeable film, undesirable anaerobic conditions (<1% O_2 and >20% CO_2) will develop with subsequent deterioration in quality. Conversely, if produce is sealed in a film of excessive permeability, little or no modified atmosphere will result and moisture loss will also lead to accelerated deterioration in quality. Examples of materials that can be used for MAP of fresh produce are microporous film or LDPE/OPP.



The limits of optimal gas mixtures for fruits and vegetables.

Optimal equilibrium modified atmosphere prolongs shelf-life

The key to successful MAP of fresh produce is to use a packaging film of correct intermediary permeability where a desirable equilibrium modified atmosphere (EMA) is established when the rate of oxygen and carbon dioxide transmission through the pack equals the produce respiration rate. Typically, optimal EMAs of 3–10% O_2 and 3–10% CO_2 can dramatically increase the shelf-life of fruits and vegetables.

The EMA thus attained is influenced by numerous factors such as respiration rate,

Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	Typical shelf-life MAP	Typical material*	Typical machine	Storage temp.
Lettuce	3-10% CO_2+3-10% O_2+ 80-94%N_2	100 -200 ml / 100 g prod.	2-5 days	5-10 days	LDPE/OPP	Horizontal flow-pack Deep-draw machine	+3-+5 °C
Mushroom	3-10% CO_2+3-10% O_2+ 80-94%N_2	100 -200 ml / 100 g prod.	2-3 days	5-6 days	LDPE/OPP	Horizontal flow-pack Deep-draw machine	+3-+5 °C
Pre-peeled potato	40-60% CO_2+ 40-60%N_2	100 -200 ml / 100 g prod.	0.5 hours Vacuum 2 days	10 days	OPET/PVdC/PE-PVC/PE PA/PE	Deep-draw machine Snorkel-vac	+3-+5 °C

* PVC is being replaced by APET or PS/EVOH
PVdC is being replaced by EVOH or OPA

temperature, packaging film, pack volume, fill weight and light. Respiration rate is affected by the variety, size, maturity and severity of produce preparation. Consequently, determination of the optimal EMA of a particular produce item is a complex problem that can only be solved through practical experimental tests.

Beneficial MAP of fresh produce can be attained by either sealing the produce in air or gas flushing with 3–10% O_2 /3–10% CO_2/ 80–90% N_2. As previously explained, modified atmospheres evolve within an air-sealed pack because of produce respiration. There may be circumstances, however, when it is desirable to gas flush so that a beneficial EMA is established more quickly. For example, enzymic browning of salad vegetables can be delayed by gas flushing compared with air packing. Practical experimental tests should be undertaken to demonstrate this.

Different conditions may apply for peeled potatoes and apples, which should not be packed with oxygen because of enzymic reactions that bring about brown-discolouring. Pre-peeled potatoes, for example, can be packed in 20% CO_2 + 80% N_2 with a prolonged shelf-life from 0.5 hour to 7–8 days at +4 to +5 °C.

Contents in brief

- Fruits and vegetables respire in packages.
- EMAs are generated within sealed produce packs.
- Good hygiene and handling, correct temperature and appropriate packaging materials are vital for successful MAP.

Brian P.F. Day M.Sc.
Senior Research Officer, Department of Product and Packaging Technology, Campden Food and Drink Research Association

"The effective MAP of fresh produce is complicated by the fact that, unlike other chilled perishable foods, fresh produce continues to respire after harvesting. The depletion of oxygen and elevation of carbon dioxide are natural consequences of respiration when fresh produce is stored in a sealed package. Such modification of the atmosphere results in a decrease in the respiration rate resulting in an extended quality shelf-life.

The principal spoilage mechanisms affecting whole and prepared fresh produce (slice, cut, peeled, etc.) are microbial growth, enzymic browning and moisture loss. Correct use of MAP is very effective at inhibiting these spoilage mechanisms in addition to extending shelf-life by reducing respiration, ripening, softening and chlorophyll breakdown of fresh produce.

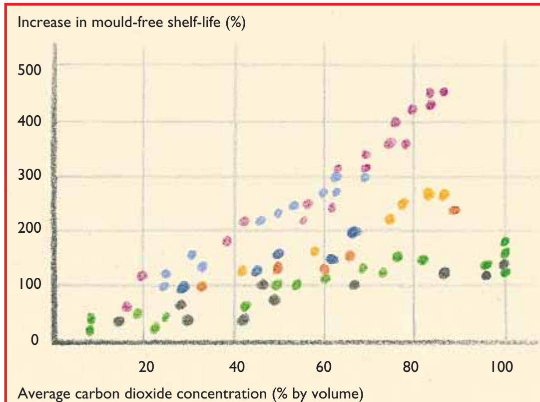
Only fruits and vegetables of the highest initial quality should be used for MAP. Hygienic and gentle handling during harvesting, storage, preparation, packaging and distribution, at the correct chilled temperature, is of vital importance in ensuring the safety and extended shelf-life of modified atmosphere packaged produce."

The right MAPAX solution suitable for dry foods and bakery products

Dry foodstuffs such as flour, potato chips, peanuts, coffee and spices as well as powdered milk and cocoa products contain more-or-less unsaturated fats. These products are thus sensitive to oxidation and rancidity. High quality shelf-life is therefore totally dependent on the oxygen concentrations in the packaging. Even small amounts of oxygen may destroy quality and make the products impossible to sell. Packages containing particularly sensitive dry foodstuffs such as powdered milk for babies should have oxygen levels of less than 0.2%.

The detrimental processes can be effectively inhibited by replacing the oxygen in the package with nitrogen or carbon dioxide. A prerequisite for maintaining an optimal modified atmosphere is naturally that the package is provided with oxygen and moisture barriers.

How the products were initially protected from oxygen is also decisive. It may be necessary to reduce the oxygen level in the processing of the product.



Product	ERH* (%)	Storage temp (°C)	Product	ERH* (%)	Storage temp (°C)
Madiera cake	85	21	Fruit pies	95	27
Madiera cake	83	27	Rye bread slices	92	21
Crumpets	94	27	Part baked rolls	88	21
Part baked bread	91	21	*ERH=Equilibrium Relitive Humidity		

Carbon dioxide slows mould growth on bread

The main spoilage factors for bakery products are mould growth and chemical breakdown. Fermentation may cause problems in filled bakery. Since the water activity of bakery products is low, the growth of microorganisms other than mould is seldom a problem.

Mould growth is an aerobic microorganism, it can be effectively controlled by carbon dioxide together with low residual oxygen levels (less than 1%), which subsequently

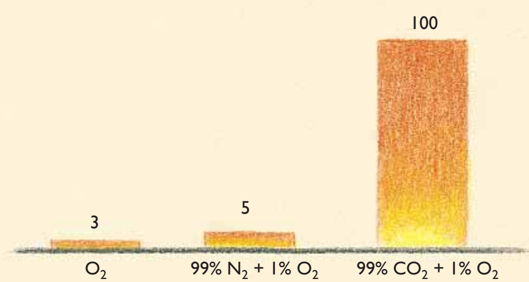
Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	Typical shelf-life MAP	Typical material*	Typical machine	Storage temp.
Pies	50-70% CO_2+ 30-50% N_2	50-100 ml / 100 g prod.	3-5 days	2-3 weeks	OPET/PVdC/PE-PVC/PE PA/PE or OPET/PVdC/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C
Cakes	20-40% CO_2+ 60-80% N_2	50-100 ml / 100 g prod.	max. some weeks	even one year	OPET/PVdC/PE-PVC/PE OPET met./PE	Deep-draw machine Flow-pack	+20 -+25 °C
Rye wheat bread	20-40% CO_2+ 60-80% N_2	50-100 ml / 100 g prod.	max. some days	2 weeks	OPET/PVdC/PE-PVC/PE PA/PE or OPET/PVdC/PE	Deep-draw machine Flow-pack	+20 -+25 °C
Prebaked bread	80-100% CO_2+ 0-20% N_2	50-100 ml / 100 g prod.	5 days	20 days	OPET/PVdC/PE-PVC/PE PA/PE or OPET/PVdC/PE	Deep-draw machine Flow-pack	+20 -+25 °C

* PVC is being replaced by APET or PS/EVOH
PVdC is being replaced by EVOH or OPA

extends shelf-life by many valuable days. MAP is especially suitable for rye bread, sweet bakery products, different pies and prebaked bread.

For Danish pastry and other iced bakery products, excessive levels of carbon dioxide can worsen the appearance of the icing by dissolving into the contained fat and causing it to "melt away". If the carbon dioxide concentration is balanced by nitrogen, the product's appearance remains unchanged.

The loss or adsorption of moisture in bakery products is prevented by a barrier material.



Time (days) to reach mould development on toast at various atmospheres and +20 °C. The toast was initially infected by mould.

Contents in brief

- Oxygen concentrations, even in small amounts, can cause dry foodstuffs to oxidize.
- Oxygen is replaced by nitrogen or carbon dioxide to maintain high quality.
- Carbon dioxide inhibits the growth of mould on bread.

The right MAPAX solution suitable for prepared foods

The deterioration of prepared foods varies considerably with the product. If meat is one of the main ingredients as in ravioli or lasagna, it is spoiled differently than, for instance, the pasta.

A major difficulty associated with prepared foods is the introduction of microbial contamination during the manufacturing process. This therefore places stringent demands on hygiene as well as on the raw materials during the production process.

The most serious breakdown processes are caused by the growth of microorganisms and by oxidation and sometimes also by staling – leading to rancidity, discoloration and loss of taste. A fresh pizza, for example, left out in the open air at +4 to +6 °C, is spoiled in about a week. High quality can be kept extra weeks by packaging the product in a modified atmosphere having a low oxygen concentration and high carbon dioxide level. In the case of pizza, the concentration of oxygen should be less than 1%.

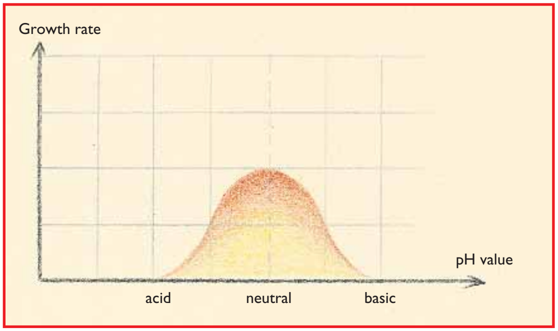
The relationship between carbon dioxide and nitrogen in prepared food packages mainly depends on the moisture content of the product, but also on the composition of the food. This determines the speed of microbial growth, oxidation and enzymatic activity. The higher the water activity, the higher the carbon dioxide concentration in the package.

Multi-ingredient products have special demands

Each product in the area of prepared foods represents a complex problem. Particularly difficult are such varying combinations as

Product	Gas mixture	Gas volume / Product weight	Typical shelf-life Air	Typical shelf-life MAP	Typical material**	Typical machine	Storage temp.
Pizza	30-60% CO_2+ 40-70% N_2	50-100 ml / 100 g prod.	1-2 weeks	2-5 weeks*	OPET/PVdC/PE-PVC/PE OPA/PE	Deep-draw machine Horizontal flow-pack	+4 -+6 °C
French fries	70-80% CO_2+ 20-30% N_2	50-100 ml / 100 g prod.	3 - 4 days	1-3 weeks	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+4 -+6 °C
Salads with sauce	100% N_2	50-100 ml / 100 g prod.	1-2 weeks	2-3 weeks	OPET/PVdC/PE-PVC/PE	Deep-draw machine	+4 -+6 °C
Cooked minced meat products (steaks,balls)	20% CO_2+80% N_2	50-100 ml / 100 g prod	1-2 weeks	4-5 weeks	OPET/PVdC/PE-PVC/PE OPA/PE	Deep-draw machine flow-pack	+4 -+6 °C

** PVC is being replaced by APET or PS/EVOH
PVdC is being replaced by EVOH or OPA



Growth of microbes as a function of the medium.

sandwiches, filled pasta, salads, pizza and spring rolls.

Since several different ingredients, each with its own special inherent properties, make up the product, in-depth know-how is required regarding the right gas mixture that will best inhibit deterioration and maintain quality. Modified atmosphere packaging is an important hurdle and safety measure, since prepared foods in the wrong environments can spoil very fast, for example, such as is the case with food products having neutral pH value (see above).

Contents in brief

- Prepared foods constitute a complex area owing to internal differences in the process of deterioration and in final preparation.
- Water activity and food composition are decisive factors with regard to shelf-life.
- Products with many various ingredients are particularly susceptible to spoilage.

Raija Ahvenainen, Ph.D., Senior Scientist.
VTT Food Research Laboratory, Finland

"MAP is an effective, economical and optimal method in improving the quality and shelf-life of most prepared foods. MAP has, particularly with regard to the microbiological deteroration of prepared foods, a most remarkable retarding effect on yeast and mould growth and naturally on the sensory changes caused by these microbes.

The optimal gas composition is very dependent on the product, and it should be tested when starting to package a new product in gas, even when some changes in the recipe are made. As for multi-component foods, the components and gas mixture should be chosen in such a way that MAP is optimal for every component.

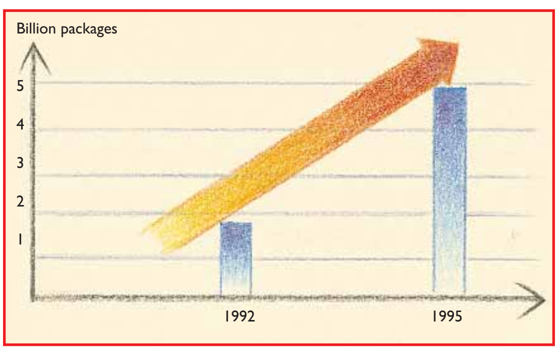
The inhibition of mould growth is best assured by using carbon dioxide mixed with nitrogen. A carbon dioxide concentration of 20–30% mixed with nitrogen gas is sufficient and even optimal for many products. With regard to pizza and other baked products (pies etc.), at least 20%, but preferably more carbon dioxide, is required. The residual oxygen concentration should be below 1% immediately after packaging.

As far as packaging material is concerned, the materials conventionally used in vacuum packaging by deep-draw packaging machines, and in air packaging by different tray systems are also suitable for MAP of prepared foods. No high barrier materials including an EVOH or a PVdC layer are necessary, but the microwavability of the packaging materials is becoming more and more important."

Why does MAP represent the food preservation technology of the 90s?

Developments internationally are clear. Modified atmospheres have a definite future. In the UK, which is the oldest and, up to now, biggest market for MAP products in Europe, Marketing Strategies for Industry (MSI) predicts that MAP use will increase dramatically between 1993 and 1995. The 1.93 billion packages with modified atmosphere sold in the UK in 1992 is expected to increase by a billion packages annually up to 1995.

In the USA, the MAP trend is somewhat more recent, but the American market is expected to swiftly pass the European market when it comes to exploiting the technology. Market studies reveal that the US market for MAP products will grow, by the end of 1993, to three billion units.



MAP packages sold in UK.

Modified Atmosphere Packaging – a proven recipe

The packaging of foodstuffs in modified atmosphere increases the chances of a sale. Food stores will keep customers who might otherwise "defect" to shops that sell fresh fish, fresh meat and other fresh produce over the counter. A few days or even weeks of extra shelf-life also opens the door to the sale of new products on new markets.

One example to be mentioned is the great success experienced by the chain Marks & Spencer in the UK in recent years involving fresh meats and meat products, seafood, pasta, poultry, bread and bakery products.

The success story of MAP continues round the world. Today, no other method for enhancing shelf-life quality can offer so many benefits throughout the entire processing chain as does modified atmosphere packaging. Modified atmosphere technology provides careful treatment of foodstuffs and retains their inherent quality as long as possible.

Furthermore, MAP technology is cost-effective. Costs for equipment, packaging material and gases can be kept to a minimum, and a packaging machine can be used for many different products.

MAPAX – the optimal solution of MAP

AGA, one of the world's leading suppliers of gas to the food industry, invites you to discuss the many advantages of modified atmosphere technology – designated MAPAX. The overall concept is adapted to every application and is based on the necessary data about foodstuffs, gases and packaging.

The choice of application solution arises from a vast accumulation of knowledge and experience. AGA works closely with research institutes throughout Europe as well as with large-scale worldwide food industries.

AGA's access to in-depth know-how and practical experience gives rise to confirmed solutions for each foodstuff and guarantees a cost-effective packaging of products, with retained quality throughout the entire distribution chain and ending as an attractive display in the chilled-food counter.

It is therefore quite natural that the growth of modified atmosphere technology is substantial. This not only applies to large-scale food industries, but also to a very large extent to smaller manufacturers, distributors, catering companies and restaurants.

AGA invites you to discuss the many advantages of modified atmosphere technology.

Contents in brief

4 The use of MAP will increase dramatically in future.
4 MAPAX from AGA is shaped by customer demand.
4 MAPAX is used more and more by large-scale food industries as well as by smaller producers, wholesalers and retailers.

Glossary

A

Acinetobacter
A genera of common food-borne bacteria. They are classified as aerobic Gram-negative short rods.

Aerobic organism
An organism that normally grows in the presence of air (20% oxygen).

Anaerobic organism
An organism that normally grows in the absence of air (20% oxygen) or oxygen. Anaerobes can be 'strict' (obligate) anaerobes, i.e. they can be killed by oxygen, or 'facultative' anaerobes, i.e. they can grow under either aerobic or anaerobic conditions.

Anti-fogging properties
Film manufacturers produce a high surface tension with hydrophilic properties that allows moisture to completely wet the surface in order to avoid fogging.

B

Bacteriostatic effect
Capable of inhibiting bacterial growth without killing.

Biochemical process
Process or phenomenon in living organism or in biological system described in chemical terms.

C

CA
Controlled Atmosphere

Carbon dioxide
CO_2 has a slightly acidic odour. It dissolves easily in water and thereby inhibits growth of many microorganisms. Air contains approximately 0.03% carbon dioxide.

Catalyst
A substance that regulates the rate of a chemical reaction and itself remains unchanged.

Clostridium
A genus of which the bacteria are classified as Gram-positive rods, anaerobic endospore formers with a fermentative mode of metabolism.

Controlled atmosphere
The atmosphere surrounding a food is changed and is then controlled during storage.

E

EMA
Equilibrium Modified Atmosphere

Enzymatic reaction
Chemical reactions catalysed by enzymes.

Enzyme
Globular protein that is the catalyst of a biological system.

ERH
Equilibrium Relative Humidity.

F

Fermentation
Anaerobic energy-yielding metabolism of cells.

G

Gas flushing
Flushing with gas or a gas mixture to establish a modified atmosphere.

I

Inert gas
A gas that does not react with other substances under normal temperatures and pressures.

L

Lactic acid bacteria
Gram-positive bacteria, usually non-motile, nonsporulating bacteria that produce lactic acid as a major or sole product of fermentativemetabolism. All rod-shaped lactic acid bacteria are placed in one genus called Lactobacillus.

M

MAP
Modified Atmosphere Packaging. This means altering the composition of the atmosphere inside a package from that of normal air .

MAPAX™
MAPAX is a tailor-made MAP solution based on data about the food, the gases and the packaging.

Master-pack
Consumer packages (overwraps) are packed in a big flexible pack that is gas flushed.

Membrane
A membrane consists of numerous layers of very thin polymer film, bundled into fibres. It is used to produce nitrogen on-site by exploiting the variations in velocity at which different gas molecules pass through polymer materials.

Mesophilic bacteria
Organisms living in the temperature range around that of warm-blooded animals. This means those that grow well between 20 °C and 45 °C.

Microorganism
All microscopic forms of life, which includes such forms as bacteria, fungi, viruses, Protozoa and algae.

Glossary

Modified atmosphere
An atmosphere differing from that of normal air. Normally, the oxygen content is reduced and the carbon dioxide content is increased.

Moraxella
A genus of aerobic Gram-negative rod or coccoid-shaped bacteria that are present in mucous membranes of man and/or animals.

Mould
Aerobic food-spoilage microorganisms. They tolerate low water-activity and low pH.

Myoglobin
The principal pigment in fresh meat. The form it takes is of prime importance in determining the colour of the meat.

N

Nitrogen
N_2 is an inert gas with low solubility in water. Air contains approximately 78% nitrogen.

Nutritional content
Expresses the amount of nourishing compounds, e.g. carbohydrates, fats, proteins and vitamins.

O

Oxidation
This means the removal of an electron, whereas reduction means the addition of an electron. In general, the process of removing hydrogen atoms or of adding oxygen atoms is referred to as oxidation.

Oxygen
O_2 is a very reactive gas with low solubility in water. Air contains approximately 21% oxygen.

P

pH
Express acidity (pH 0–6), neutrality (pH 7) and alkalinity (pH 8–14).

PSA
Pressure Swing Adsorption. This technology is used to produce nitrogen on-site. It is based on the ability of activated carbon under certain conditions to capture and retain oxygen from the air, while allowing nitrogen to pass through.

Protein
Macromolecules built up of amino acids with peptide bonds.

Pseudomonas
A genus of an aerobic Gram-negative rod-shaped bacteria, ecologically important organisms in soil and water owing to their large capacity for mineralization of organic matter.

Psychrophilic bacteria
These bacteria have the ability of growing at low temperatures, i.e. 0 °C to 5 °C.

R

Rancidity
Oxidation of lipids.

Respiration
Aerobic energy-yielding metabolism of cells.

S

Shelf-life
The duration of that period between the packing of a product and its use for which the quality of the product remains acceptable to the product user.

Shelf-life technology
The methods for enhancing shelf-life.

Sous vide
Sous vide technique means preparing of the meal at low temperature (70 to 80 °C), vacuum packaging and quickly chilling down to +2 to +4 °C.

T

Thermophilic bacteria
Organisms that grow at elevated temperatures, i.e. above 55 °C.

W

Water activity
a_w. The ratio of the water vapour pressure of a material to the vapour pressure of pure water at the same temperatue.

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Sources of information.
The diagrams and illustrations in this book are based on our own data or on information found in the reference literature.

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“In future, consumers will demand food products of high quality that are natural, fresh and minimally processed.

Modified atmosphere packaging, MAP, has a role to play for better product quality with good food safety and shelf-life compared with today’s products.”

Ulf Rönner, Ph.D., Senior Scientist.
SIK, The Swedish Institute for Food Research.

“Correct use of MAP is very effective at inhibiting spoilage mechanisms affecting whole and prepared fresh produce, which continues to respire after harvesting.

MAP extends shelf-life by reducing respiration, ripening, softening and chlorophyll breakdown.”

Brian P.F. Day, M.Sc., Senior Research Officer.
Department of Product and Packaging Technology,
Campden Food and Drink Research Association, UK.

“MAP is an effective, economical and optimal method in improving the quality and shelf-life of most prepared foods.

MAP has a most remarkable retarding effect on yeast and mould growth and naturally on the sensory changes caused by these microbes.”

Raija Ahvenainen, Ph.D., Senior Scientist.
VTT, Food Research Laboratory, Finland.

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