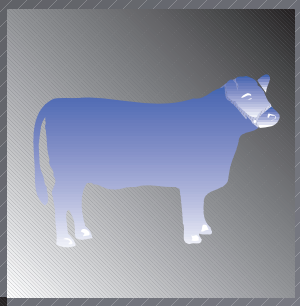
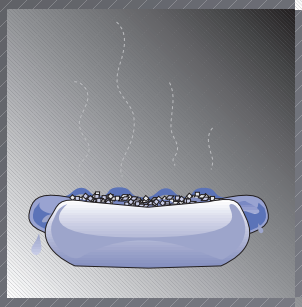
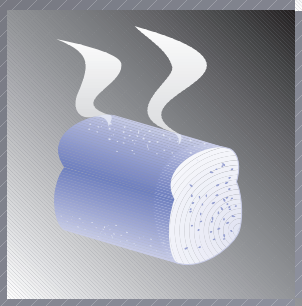
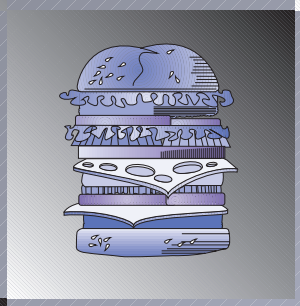
PRAXAIR







# Praxair Extendapak™

## Gases

## Applications Guide

## MAP Applications and Product Safety Assessment

Modified Atmosphere Packaging (MAP) represents only one aspect of what a food processor can practice to ensure that a high quality and safe food reaches the marketplace, and ultimately the consumer. Most importantly, MAP does not eliminate or reduce the processor's responsibility for good manufacturing practices. In fact, the opposite is true, MAP is only appropriate for plants producing the cleanest of products. No gas combination in the package will ever reverse a food's poor microbial condition. At its best MAP will only extend the keeping quality of a food.

## Please Note

Gases are only one part of the modified atmosphere packaging process. Information stated with respect to suggested gases for use with specific foods is based on data obtained from published results of similar processes. Since original quality, processing and packaging methods and materials, films and storage conditions all play an important role in achieving shelf life extension, ongoing quality control verification is essential.

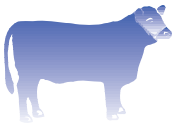
The information contained herein is offered for use by technically qualified customer personnel at their discretion and risk. All statements, information, suggestions and recommendations are based on information we believe to be reliable, but the accuracy or completeness thereof is not guaranteed and no warranty of any kind is made with respect thereto. Quality Control verification and monitoring in conjunction with any and all claims relating to atmospheric packaging is essential and is the responsibility of the Extendapak purchaser and/or user.

## Gas Safety Use Note

Pure gases and mixtures must be used only in strict adherence to the safety precautions as defined on the product labels and the information contained on the Material Safety Data Sheet (MSDS) supplied by Praxair. Packaging and processing areas must be designed with adequate ventilation to eliminate the potential for an oxygen deficient *or oxygen enriched* atmosphere that may result from use of Praxair Extendapak gases.

# TABLE OF CONTENTS





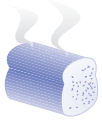



Table of Contents

The use of modified atmospheres to replace air in food packages is applicable to many types of food. Controlling food spoilage is complex. More than one gas may be appropriate for the same application. However, specific packaging conditions and shelf life extension requirements play a role in determining which one is most suitable to a given application.

The food type and form generally indicate the overall needs of the food product. For example, respiring fruits and vegetables need oxygen for continued cell functions. However, since oxygen also promotes deterioration by supporting microbial growth and chemical oxidation reactions, it is usually avoided for many non-respiring foods such as baked goods, and processed products. The product form e.g. fresh cut produce, homogenized milk, indicates the degree of physical changes that have been performed. These changes affect deterioration rates by altering the exposed product surface. Product form also dictates suitable package designs for the product when packaging atmospheres are used, and the gas volumes required per package.

Product characteristics such as pH, water activity, salt, and water content are important considerations since they affect the potential for microbial spoilage. At optimum levels these attributes present barriers or hurdles to the microorganisms ability to grow and degrade the product. While microbial spoilage is the major food safety concern, other forms of deterioration occur such as flavor loss, vitamin degradation, fat oxidation, or color change. Such changes when controlled to the extent possible with MAP of a given food or formulation play a key role in quality shelf life extension.

The use of preservatives in products helps to control microbial growth. In many cases, gases may reduce their use.

The chemistry of the food and to what extent it is processed will be related to the achieved shelf life and quality. Product characteristics relevant to gas packaging and shelf life extension include fat, salt, or sugar content, and the age or ripeness of the product before packaging.

**A list of frequently used abbreviations in this publication.**

| | | | |
|---|---|---|---|
| **EVA:** | Ethyl Vinyl Acetate | **PVC:** | Polyvinyl Chloride |
| **LDPE:** | Low Density Polyethylene | **EVOH:** | Ethylene Vinyl Alcohol |
| **PA:** | Polyacetate | **OPP:** | Oriented Polypropylene |
| **PE:** | Polyethylene | **PC:** | Polycarbonate |
| **PET:** | Polyethylene Terephthalate | **PP:** | Polypropylene |
| **PVA:** | Polyvinyl Alcohol | **PVDC:** | Polyvinylidene Chloride |

## Praxair Extendapak Gases

Praxair Extendapak gases are used by food processors and packagers to extend the shelf life of their products. These gases include pure nitrogen, carbon dioxide and oxygen or a mixture of these products and function to displace unwanted atmospheric gases when used in a Modified Atmosphere Packaging (MAP) process.

The numbering system for Praxair Extendapak gases (see Table 1) is exclusive to Praxair and does not match brand name numbering systems of competitive products.

*Continued on next page.*

**Table 1 – Praxair Extendapak Gases for Major Food Groups ***

| Product Group | Extendapak # | Storage Temperature |
|---|---|---|
| **Red Meats** | 14, 15, 16, 30, 32, 38 | 0-5 C (32-41 F) |
| **Poultry** | 2, 12, 13, 14, 15, 16 | 0-2 C (32-36 F) |
| **Fresh Fruits** | 1, 44, 47, 49, 50, 51, 57, 70 | 5-10 C (41-50 F) |
| **Processed Meats** | 2, 12, 14, 15, 16, 23, 24, 26, 28, 30, 31, 32, 33, 34 | 0-5 C (32-41 F) |
| **Dairy Products** | 2, 12, 14, 15, 16, 23, 24, 26, 28 | 1-3 C (34-37 F) |
| **Dry and Dehydrated Products** | 1, 12, 16, 28 | Ambient |
| **Prepared Foods** | 12, 14, 15, 16, 24, 26, 28 | 0-5 C (32-41 F) |
| **Bakery Products** | 1, 10, 12, 13, 14, 15, 16, 24, 25, 26, 27, 28 | Ambient |
| **Fresh Vegetables** | 1, 41, 42, 47, 48, 49, 50, 51, 70 | 0-5 C (32-41 F) |

** This is intended only as a general outline. For more information on specific products refer to the individual product section.*

## Packaging

A complex relationship exists between the product, its packaging material and the internal and external environments. Gas atmospheres are not static. They will change as the product changes, and as the package allows gas transmission to occur — only metal and glass containers prevent continuous exchange with the outside environment. The application of modified atmospheres usually involves a requirement for high barrier materials. However, fresh fruit and vegetables differ, as a very permeable material is required to allow a controlled exchange of gases.

Barrier materials are available as laminated plastic films. Film permeability generally allow a diffusion of oxygen and carbon dioxide gases outwards, and permeation of nitrogen inwards from the external environment. Carbon dioxide is usually lost most easily. The moisture vapor transmission rate (MVTR) indicates the film's tendency to let moisture vapor escape and determines the potential for gradual product dehydration and weight loss.

Modified atmospheres can be used on formfill-seal lines with a continuous gas flush to push air out of the package, or on thermo-forming packaging lines where a vacuum is pulled before addition of the gas mixture. The last method is more efficient for removal of oxygen for applications where this is desirable, such as in the packaging of prepared meats and foods. However, it is usually slower and more expensive.

## Storage

The storage extension of foods packaged in modified atmospheres is limited to the period when the internal environment maintains the desired composition. Shelf life studies of products should include regular monitoring of headspace gas composition.

For perishable products, modified atmosphere packaging is not a replacement for refrigeration but a complementary means of preservation. Cold temperatures slow the rates of chemical reactions and reduce the rate of bacteria growth. Carbon dioxide has an inhibitory effect on micro-organisms which is increased by it's solubility in the product at cold temperatures. Film permeability is reduced as temperature decreases. This is desirable where barriers are used, but an extra consideration when controlled permeability is required. Storage at refrigerated temperatures in conjunction with modified atmosphere packaging can mean significant storage cost reductions for food products normally kept frozen.

Exposure of the product to light promotes oxidative rancidity of fats and color fading. Praxair Extendapak gases can suppress this deterioration through the displacement of oxygen which is an important consideration for display purposes.

Storage temperatures must be constant and maintained during transport, especially where refrigeration is required. The advantages of carefully matched gas mixtures and packaging material can be defeated by temperature fluctuations and abuse.

Temperature changes at any stage may also alter the gas volume of the package. Conditions of slight vacuum or puffing may or may not be attractive and can cause stress on packaging material. Air transport involving significant changes of altitude can also strain package seals and even cause bursts. If these factors are found to critically affect the product during storage, gas injection volumes may have to be adjusted.

## Microbiological Issues in MAP

Foods provide an ideal environment for the growth of micro-organisms. The most common factors affecting microbial growth in foods are oxygen levels (aerobic or anaerobic), water activity, pH, and temperature. In general bacteria prefer aerobic environments, high water activity, neutral pH and ambient to warm temperatures. However, there are many exceptions including some very dangerous food-borne pathogens.

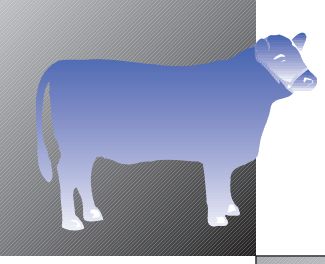
The major concern with MAP is in creating an anaerobic environment (without oxygen). Pathogens such as *Clostridium botulinum* (which causes Botulism) and *Clostridium perfringens* are anaerobic pathogens. Many other pathogens have the ability to grow in an environment with limited oxygen when necessary such as *Escherichia coli*, *Listeria monocytogenes*, *Salmonella* species, and *Staphylococcus aureus.*

Organisms that normally cause food spoilage cannot grow to compete with pathogens such as *C. botulinum* and *C. perfringens* in anaerobic environments. In normal environments, spoilage organisms grow faster and cause unpleasant changes to the food before some toxins are produced. *Clostridium botulinum* produces a neuro toxin that can be fatal when consumed.

This is why MAP without any oxygen can be dangerous and must be seriously considered. Other factors to consider in MAP include re-evaluating the product formulation and processing when the packaging and/or storage conditions change. This may change the microbial environment and must be considered.

## Other Considerations

Establishing a realistic shelf life expectation is important when evaluating the use of packaging atmospheres. In many instances, the degree of extension required will determine the choice of atmosphere. As well, sales volumes and distribution systems for the product should be consistent with the desired shelf life to maximize the benefits to be gained from the Praxair Extendapak application.





Consumers expect red meat to have a bright red color which requires oxygen to be present in the modified atmosphere. Oxygen free bulk packs of primal cuts, for institutional or commercial use, will "rebloom" when re-exposed to oxygen if they have been stored in certain oxygen-free atmospheres. Cuts that are targeted to immediate retail display are best in Praxair Extendapak #s 30, 32 or 38 as suggested below; when bloom is not necessary, mixtures #s 16, 15 and 14 are recommended.

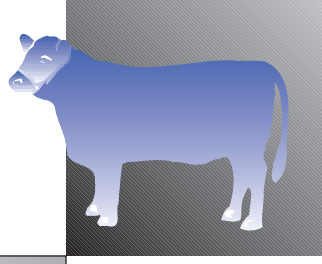
Due to the increased surface area, ground meats consume more oxygen and have higher initial microbial loads. It means that a shorter period of shelf life extension can be expected for ground meats. The size and thickness of cut, grade and fat coverage are important considerations when determining the packaging gas.

**Praxair Extendapak Gases for Red Meats**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Beef (retail)** | | | |
| Steaks, Roasts | 30, 32, 38 | 0-5 C (32-41 F) | 10-20 Days |
| Ground | 30, 32, 38 | 0-5 C (32-41 F) | Up to 10 Days |
| **Beef (institutional)** | | | |
| Chops, Roasts | 16, 15, 14 | 0-3 C (32-38 F) | 10-20 Days |
| Ground | 16, 15, 14 | 0-3 C (32-38 F) | Up to 10 Days |
| **Lamb** | | | |
| Chops, Roasts | 16, 15, 14 | 0-5 C (32-41 F) | 10-21 Days |
| Ground | 16, 15, 14 | 0-5 C (32-41 F) | Up to 10 Days |
| **Pork** | | | |
| Chops, Roasts | 16, 15, 14 | 0-5 C (32-41 F) | 10-20 Days |
| Ground | 16, 15, 14 | 0-5 C (32-41 F) | Up to 10 Days |
| **Veal** | | | |
| Chops, Roast | 16, 15, 14 | 0-2 C (32-36 F) | Up to 15 Days |
| Ground | 16, 15, 14 | 0-2 C (32-36 F) | Up to 5 Days |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*



## Packaging Suggestions

A high barrier material is required to contain the modified atmosphere. To support smaller portions, an over-wrapped tray container is recommended, but larger cuts may be bagged. Suggested barrier laminates include: PVC/PE (Polyvinyl Chloride/Polyethylene) or PET/PVDC/PC (Polyethylene Terephthalate/ Polyvinylidene Chloride/Polycarbonate) trays; PVDC (Polyvinylidene Chloride) on PE (Polyethylene/Polyester), PA/PE (Polyacetate/ Polyethylene) or PET/PE (Polyethylene Terephthalate/Polyethylene) overwraps; and PE/PA (Polyethylene/Polyacetate) or NYLON™/ SARAN™/PE bags.

A ribbed tray improves gas circulation to all surfaces of the meat to prevent discoloration. Also, an anti-fog treatment on the film prevents condensation from blocking visibility. Gas to product volume ratios of approximately 1:1 are suggested for portion packs. Absorbent pads may be desired under large cuts, but may not be required for steaks or chops because of the reduced weepage associated with modified atmospheres.

## Storage Specifications

The pH and water activity level of raw meat support many types of bacteria, including some pathogens, whose growth can be controlled by cold temperatures below 5 C (41 F). The temperature must be kept stable. Deviations to higher temperatures increase the rates of enzymatic and oxidative reactions, permeability characteristics of the laminates, and total gas volume of the package. Temperature should be monitored during transport and distribution. Exposure to light should be minimized as it catalyses rancidification of fats if oxygen is present.

## Other Considerations

When fresh meat is to be kept for extended periods, the initial microbial load of the product and packaging process is of utmost concern to the safety of the consumers. The eventual spoilage pattern for products packaged with modified atmospheres may produce off-odors and off-flavors that are not normally encountered in standard meat products.

The skin of fresh poultry shields muscle tissue from discoloration caused by bacterial activity, high carbon dioxide or dehydration. The skin also provides suitable pH and water activity conditions for promotion of bacterial spoilage. Poultry pieces with exposed flesh, especially the darker leg or thigh portions, may develop grayish discoloration if the carbon dioxide level is too high in the package.

Cooked poultry products should be sufficiently processed to minimize microbial and enzymatic activity. Slicing or dicing increases the post-processing microbial load. For breaded, fried or nugget-type products, the altered water content, water activity level and pH, plus salt, seasoning and fat levels can affect the potential spoilage patterns (i.e. microbial contamination from spices, oxidative, rancidity, flavor or moisture loss).

## Praxair Extendapak Gases for Poultry

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Chicken** | | | |
| (master pack) | 2 | 0-2 C (32-36 F) | Up to 21 Days |
| (retail) | 12, 13, 14, 15, 16 | 0-2 C (32-36 F) | Up to 21 Days |
| **Cornish Hens** | | | |
| (master pack) | 2 | 0-2 C (32-36 F) | Up to 21 Days |
| (retail) | 12, 13, 14, 15, 16 | 0-2 C (32-36 F) | Up to 21 Days |
| **Duck** | | | |
| (master pack) | 2 | 0-2 C (32-36 F) | Up to 21 Days |
| (retail) | 12, 13, 14, 15, 16 | 0-2 C (32-36 F) | Up to 21 Days |
| **Turkey** | | | |
| (master pack) | 2 | 0-2 C (32-36 F) | Up to 21 Days |
| (retail) | 12, 13, 14, 15, 16 | 0-2 C (32-36 F) | Up to 21 Days |
| **Breaded Chicken** (cooked) | 14, 15, 16 | 0-5 C (32-41 F) | Up to 17 Days |
| **Roast Chicken** | 12, 13, 14, 15, 16 | 0-5 C (32-41 F) | Up to 17 Days |
| **Roast Turkey** | | | |
| (whole) | 12, 13, 14, 15, 16 | 0-5 C (32-41 F) | Up to 17 Days |
| (sliced) | 12, 15, 16 | 0-5 C (32-41 F) | Up to 17 Days |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

Poultry

## Packaging Suggestions

A high barrier laminate is required for raw or cooked poultry to contain the modified atmosphere. Formed-fill-seal package trays are recommended for poultry pieces. Bags may be used for whole birds or for bulk quantities for institutional or commercial use. Suggested materials include laminated polystyrene foam trays covered with thick polyester or lacquered cellophane, or bags made of PE/PA. Antifog treatment is recommended for over wraps used on retail packages. After sealing, bulk bags can be cartoned for shipping. Absorbent pads may be used to soak up weepage.

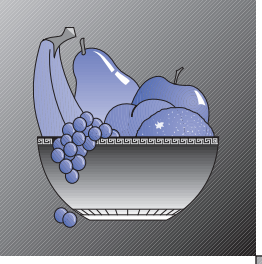
Gas to product volume ratios of approximately 1:1 are recommended for small packages, however, lower gas volumes can be used for bulk applications.

## Storage Specifications

Since bacterial growth is a concern, gas packaging does not replace the need for refrigerated storage. Low temperatures also control enzymes and fat oxidation, plus reduce film permeability and total gas volume. Temperature stability ensures that shelf life is limited by organoleptic deterioration such as off-odors or discoloration before pathogens can create a health safety risk, and must be monitored during transport and distribution.

## Other Considerations

Bacterial spoilage is the greatest concern in the storage of fresh poultry, especially with respect to pathogenic *Salmonella.* Hygiene is of utmost importance in all stages of processing if shelf life extension is to be achieved.





The respiration of fresh fruit makes them susceptible to lack of oxygen and excess of carbon dioxide in enclosed packages. Their high moisture and water activity levels lead to dehydration losses and attack from molds and bacteria. Praxair Extendapak gases can extend shelf life by reducing the rate of respiration, and inhibiting water loss and microbial growth.

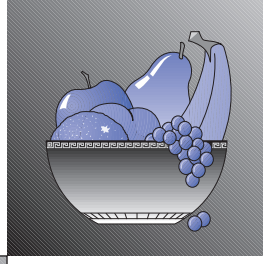
Sliced, peeled or diced raw fruit consumes more oxygen from the package, and is subject to enzyme activities such as browning. A preservative dip to prevent oxidative browning is usually necessary, especially for light colored fruits.

**Praxair Extendapak Gases for Fresh Fruit**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Apples** (whole) | 70 | 5-10 C (41-50 F) | Up to 6 Weeks |
| **Apricots** | 70 | 5-10 C (41-50 F) | Up to 5 Months |
| **Blueberries** | 47, 51 | 5 C (41 F) | Up to 2 Months |
| **Cherries** | 47, 51 | 5 C (41 F) | Up to 6 Weeks |
| **Grapes** | 1 | 5 C (41 F) | Insufficient Data |
| **Kiwi** (whole) | 51 | 5-10 C (41-50 F) | Up to 6 Months |
| **Honeydew** | 70 | 5-10 C (41-50 F) | Insufficient Data |
| **Nectarines** | 51 | 5 C (41 F) | Insufficient Data |
| **Orange Sections** | 70 | 5 C (41 F) | Insufficient Data |
| **Peaches** | 51, 49 | 5-10 C (41-50 F) | Up to 5 Months |
| **Pears** | 70 | 5-10 C (41-50 F) | Up to 5 Months |
| **Plums** | 51 | 5-10 C (41-50 F) | Insufficient Data |
| **Raspberries** | 49, 50, 51 | 5 C (41 F) | Insufficient Data |
| **Strawberries** (whole) | 57, 44 | 5 C (41 F) | 7-30 Days |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** All fruit can be flushed with 100% nitrogen if the package is flushed only and no vacuum is pulled.*



The pH is an important factor in protecting fruit juices and purees from microbial spoilage. Praxair Extendapak may reduce requirements for other processing such as pasteurization or the addition of preservatives like benzoates.

The age or ripeness and quality of the fruit when packaged is relevant information to the choice of atmosphere and shelf life.

### Packaging Suggestions

Formed-fill-seal package trays allow Extendapak application with good product protection and visibility. An oxygen permeable film should be used to permit oxygen to enter and accumulating carbon dioxide and ethylene to escape. Suggested films include LDPE (Low Density Polyethylene), especially with high EVA (Ethyl Vinyl Acetate) and PVC. The choice of Praxair Extendapak gas for fruit applications is largely dependent on the film permeability properties.

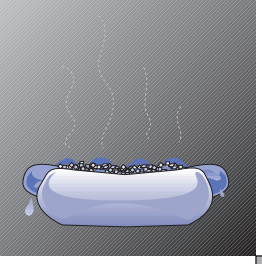
The headspace volume can be minimized to allow an equilibrium of gas exchange to be achieved quickly and provide the best storage atmosphere for the specific fruit. Antifog treatment of the film may be needed if the fruit moistens the film. Special gas absorbers are available to control carbon dioxide, ethylene and water vapor, if required.

### Storage Specifications

Cold temperatures promote shelf life extension by lowering respiration rates, but they also reduce film permeability. Some tropical and well-ripened fruits are susceptible to chilling injury. Ambient temperature storage of fruit is possible if a proper equilibrium atmosphere is achieved. However, this would require more research of the specific application.

### Other Considerations

Packaging of fruits with modified atmospheres allows for a wide variety of package sizes to be used. The retailer and consumer alike can benefit from the fruit not being overhandled by many people. Once removed from the modified atmosphere, the fruit ripening will parallel normal storage conditions.





Processed and cured meats generally require a blanketing atmosphere to guard color and fat components against oxygen and inhibit microorganisms.

Except for discoloration due to microbial spoilage, the color of cooked meats such as roast beef, is stabilized by the heat denatured globin pigment. Smoking or curing processes where nitrites are used also affect color, and inhibit microbial growth, with particular concern of the anaerobic *Clostridium botulinum* organism. In raw cured meats such as bacon and ham, the red myoglobin pigment is changed to nitrosylmyoglobin, but is easily oxidized to produce an unsightly brown color if oxygen is present. In cooked cured meats such as corned beef and frankfurters, nitrosylmyoglobin is heat denatured

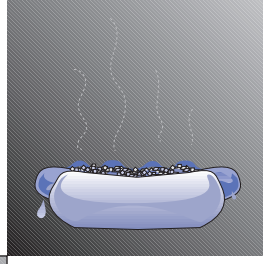
**Praxair Extendapak Gases for Processed Meats**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Bologna** | 14, 15, 16 | 0-5 C (32-41 F) | Up to 30 Days |
| **Corned Beef** | | | |
| cooked (whole) | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | Up to 30 Days |
| cooked (sliced) | 14, 15, 16 | 0-5 C (32-41 F) | Up to 30 Days |
| **Ham** | | | |
| cooked (whole) | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | Insufficient Data |
| cooked (sliced) | 14, 15, 16 | 0-5 C (32-41 F) | Up to 30 Days |
| **Pastrami** (sliced) | 14, 15, 16 | 0-5 C (32-41 F) | Up to 30 Days |
| **Roast Beef** | | | |
| (whole) | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | 17-30 Days |
| (sliced) | 14, 15, 16 | 0-5 C (32-41 F) | 17-30 Days |
| **Roast Pork** | | | |
| (whole) | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | 17-30 Days |
| (sliced) | 14, 15, 16 | 0-5 C (32-41 F) | 17-30 Days |
| **Salami** (whole) | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | Up to 30 Days |
| **Sausage** | | | |
| raw (color critical) | 34, 33, 32, 31, 30 | 0-2 C (32-36 F) | Up to 21 Days |
| raw (color not critical) | 14, 15, 16 | 0-2 C (32-36 F) | Up to 21 Days |
| cooked | 16, 12, 28, 26, 24, 23, 2 | 0-5 C (32-41 F) | Up to 17 Days |
| **Smoked Meat** | 16, 12, 28, 26, 24, 23, 2 | 0-2 C (32-36 F) | Insufficient Data |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

*Processed Meats*



when a temperature above 65 C (150 F) is reached. The denatured form is more stable to oxygen, but the potential for microbial spoilage remains if oxygen is present.

Since nitrite preservatives contribute desirable flavors and colors, they can not be completely eliminated from processed meats. However, in combination with modified atmosphere packaging, levels used can be significantly reduced. The health concerns over carcinogenic nitrosamines favor this move.

Slicing of processed meats can cause increased microbial cross-contamination loads, especially through handling by humans, and processing/ packaging equipment surfaces.

### Packaging Suggestions

Vacuum packaging is the standard for most retail processed meats. The packaging materials used are high barrier laminated plastics, and the same are required for Praxair Extendapak applications. Low MVTP is required to prevent dehydration losses. A possible combination for bacon is PVC/PE tray with Polyester/PVDC film and antifog treatment. To improve oxygen exclusion from the package, an initial vacuum step can be performed just before injection of the Extendapak gas.

Processed meats packaged with modified atmospheres have advantages over vacuum packs in appearance. The desired color can be maintained longer, pieces can be separated and kept intact by less restrictive packaging, and the problem of leakers through loss of vacuum or pin-holes is removed.

Protection against package punctures is important where meats with bones are concerned. For large, unsliced pieces, especially hams, modified atmosphere packaging eliminates the purge loss common with vacuum packaging which causes moisture to be drawn out of the product.

### Storage Specifications

Since modified atmosphere packaging reduces the requirement for nitrates below that traditionally required for safe microbial control, refrigeration of these products is required. In addition, the antimicrobial properties of carbon dioxide are enhanced when cooked or cured meats are refrigerated because of the increased carbon dioxide solubility in product and bacterial cells. Protection from light is desirable.




There are many forms of dairy products, including: fluids such as milk and concentrates, powders, cream emulsions such as butter or whipped toppings, semi-solids such as yogurt or soft cheeses and solid hard cheeses. The various physical characteristics are related to the water and fat content of the product, and to the special properties of the milk protein, casein, when it is denatured. Because carbon dioxide is quite soluble in water and fat especially when refrigerated, Praxair Extendapak gases and storage times must be chosen with consideration given to possible development of acidic or fizzy characteristics.

Raw milk is pasteurized to kill pathogens, to reduce other bacteria that cause off-flavors and souring, and to inactivate lipase activity which causes rancidity. For cultured dairy products, pasteurizing the raw milk eliminates native organisms that may interfere with the culture. Pasteurization time and temperature limits must be strictly followed to achieve a sufficient kill without causing cooked flavors or destroying vitamins that have a role in flavor stability as well as nutritional quality. MAP gases are useful for controlling the growth of bacteria in dairy products which result from post-pasteurization contamination.

**Praxair Extendapak Gases for Dairy Products**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Cottage Cheese** | 16, 12, 28 | 1-3 C (34-37 F) | 6-10 Weeks |
| **Cream Cheese** | 14, 15, 16 | 1-3 C (34-37 F) | Up to 21 Days |
| **Hard Cheeses** | 16, 12, 28, 26, 24, 23, 2 | 1-3 C (34-37 F) | Up to 4 Weeks |
| **Milk** | 1 | 1-3 C (34-37 F) | Insufficient Data |
| **Powdered Milk** | 1 | Ambient | Extended Period |
| **Processed Cheese** | 14, 15, 16 | 1-3 C (34-37 F) | 3-5 Weeks |
| **Ricotta Cheese** | 28, 12, 16 | 1-3 C (34-37 F) | 6-10 Weeks |
| **Shredded Cheese** | 15 | 1-3 C (34-37 F) | 18-21 Days |
| **Soft Cheese** | 14, 15, 16 | 1-3 C (34-37 F) | 18-21 Days |
| **Sour Cream** | 28, 12, 16 | 1-3 C (34-37 F) | Insufficient Data |
| **Yogurt** | 28, 12, 16 | 1-3 C (34-37 F) | Insufficient Data |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

*Dairy Products*


Praxair has developed *modified atmosphere processing* of dairy products, which in combination with MAP, can be even more effective than MAP alone. In this case, carbon dioxide is injected in-line at low levels, e.g. 400 ppm, below a sensory threshold. Candidate products must have a pumpable liquid phase at some point of the process. Such products include but are not limited to yogurt, cottage cheese, ice cream mix, and ricotta cheese.

The neutral pH of milk is ideal for the growth of most micro-organisms. Cultured dairy foods such as yogurt or sour cream quickly produce an acidic pH that inhibits most bacteria by the activity of lactic acid cultures. The pH will gradually increase again as the lactic acid bacteria die. The formed lactic acid breaks down into less or non-acidic products, and proteolysis progresses.

## Packaging Suggestions

Currently the use of modified atmospheres for fluid milk has primarily been applied to vat storage of raw milk before shipping to dairies. For yogurt, cottage cheese or sour cream products, the traditional polystyrene tubs are suitable for Extendapak application, provided a tight seal is achieved. Hard solid cheeses may be packaged in high barrier laminated films such a PP or Polyester on PVDC or PVA, using a PE sealant. The film should feature protection against oxygen entry and a low MVTR. A full headspace volume of the gas mixture to blanket the product is suggested.

## Storage Specifications

Dairy products are perishable and usually have large microbial populations since pasteurization is a minimal heat treatment for destruction of pathogens only. Gas packaging cannot replace the need for refrigerated storage of most products and refrigeration must be maintained during transport. Dried powders and sterilized products such as UHT or condensed milk which are aseptically packaged are exceptions.

Protection from oxygen and light exposure prevents oxidation of milk fat and development of rancid odors. Other types of deterioration are related to the heat treatment given to milk. Under pasteurization results in early souring and lipolysis, whereas more severe heating will induce crowning which progresses during storage.

For cultured products, molds and yeast will grow as the pH rises and the competitive lactic acid bacteria die. Praxair Extendapak gases inhibit this process.

## Other Considerations

Research studies and applications of modified atmosphere packaging with dairy products are limited compared to other food categories. However, the frequency of spoilage in the present distribution system leaves a great potential for extended shelf life of dairy products.





Dry products originate in general food type categories but become non-perishable after processing. Microbial spoilage is usually not a concern because the water activity of these items is too low to support any growth.

The form and particle size determine the amount of gas required and the degree of particle/atmosphere contact. Powdered products need protection against moisture to retain their free-flowing character. For very fragile products such as potato chips, the volume of gas is important to cushion against crushing, without giving excess headspace.

Most heating processes such as frying, roasting and spray drying will cause some breakdown of food components and start deteriorative reactions. Fat lipolysis and oxidation, vitamin, flavor and color losses, or development of undesirable flavors and colors are commonly initiated by heat.

Praxair Extendapak gases help to maintain the quality of dry and dehydrated products while extending the shelf life.

**Praxair Extendapak Gases for Dry and Dehydrated Products**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Coffee Beans** | 1 | Ambient | Several Months** |
| **Dehydrated Fruits** | 1 | Ambient | – |
| **Dry Soups** | 1 | Ambient | Several Months** |
| **Instant Coffee** | 1 | Ambient | Several Months** |
| **Nuts** | 1 | Ambient | 6-12 Months |
| **Potato Chips** | 1 | Ambient | Several Months** |
| **Prunes** | 12, 16, 28 | Ambient | – |
| **Sesame Seeds** | 1 | Ambient | 6-12 Months |
| **Sunflower Seeds** | 1 | Ambient | 6-12 Months |
| **Trail Mix** | 1 | Ambient | – |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

*** Shelf life will vary depending on packaging materials and storage conditions.*

## Packaging Suggestions

A wide variety of package designs are available for dry products, including bags, bag-in-box, paperboard canisters, metal cans and glass jars.

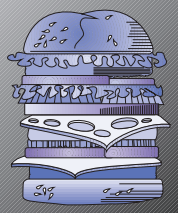
Except for metal or glass containers which are impervious, a barrier material is required either to coat the container or be the container itself. The barrier must prevent loss of volatile flavor and aroma for product freshness, and prevent entry of oxygen and moisture which cause oxidation and texture changes. Suggested barrier films are metalized PP or co-extruded PP/PVDC/PP.

When packaging in pouches, other important features include the material's durability on form-fill-seal machinery and throughout transportation, sealing strength, printability and in some situations product visibility and appearance. Fragile products may need extra protection with chipboard inserts.

## Storage Specifications

At ambient storage temperatures, deterioration by oxidative rancidity, staling, and flavor or aroma losses can occur at appreciable rates if the product is not protected from oxygen. Insect infestations are common especially in cereal-based products and dried fruits. Good quality control programs cannot always ensure a completely clean product. Modified atmospheres can kill insects and eggs and help prevent insect infestation during storage as well as cross contamination between stored products.

During storage, high fat products or powders may absorb carbon dioxide from certain Extendapak gases slightly reducing the total gas volume. If a sealed package is inflated near the tolerance of the packaging material, care must be taken, particularly if altitude changes are involved, to prevent package rupture.





Prepared foods are generally non-standardized items that can vary widely in composition and characteristics. Products made primarily from one type of food such as pasta, generally have more predictable and controllable deterioration patterns than do multi-component foods such as pizza. Interactions between components complicate the shelf life stability. It is important to consider each basic ingredient's storage limitations.

These products are generally solid foods but may include a liquid sauce or gravy, butter or mayonnaise on sandwiches or cooked salads, semi-solid fillings such as quiche or pudding, or chopped and shredded items in salads or as pizza toppings. Such conditions influence the ability of bacteria to spread, the susceptibility for oxidative reactions, flavor and odor loss, as well as package requirements.

Characteristics including pH, water activity, moisture and fat levels can be controlled in processed products and usually play an important role in the production process. Such factors help predict what types of organisms may grow and how a modified atmosphere will affect the product.

Cooking time/temperature combinations reduce bacterial loads, denature proteins, change flavors and textures and develop desired colors. It is the purpose of Praxair Extendapak gases to maintain the same fresh-cooked quality for an extended time.

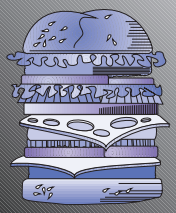
**Praxair Extendapak Gases for Prepared Foods**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Lasagna** | 14, 15, 16, 12 | 0-5 C (32-41 F) | Up to 3 Weeks |
| **Macaroni Salad** | 14, 15, 16, 12 | 0-5 C (32-41 F) | Insufficient Data |
| **Pasta** (fresh) | 14, 15, 16, 12 | 0-5 C (32-41 F) | 3 to 8 Weeks |
| **Pizza** | 12, 24, 28, 26, 16 | 0-5 C (32-41 F) | Up to 3 Weeks |
| **Potato Salad** | 14, 15, 16, 12 | 0-5 C (32-41 F) | Insufficient Data |
| **Quiche** | 14, 15, 16, 12 | 0-5 C (32-41 F) | Up to 3 Weeks |
| **Ravioli** | 14, 15, 16, 12 | 0-5 C (32-41 F) | Up to 3 Weeks |
| **Sandwiches** | 14, 15, 16, 12 | 5-8 C (41-46 F) | Up to 30 Days |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

*Prepared Foods*



## Packaging Suggestions

Packaging designs should be chosen to suit the product with consideration given to physical quality protection, sanitation, preservation and consumer appeal. There are a wide variety of products in this category and most require at least two packaging components: a moisture-proof container to provide support such as a foil plate or thermoformed plastic tray and a surrounding barrier film such as Polyester/PVDC/PE or Polyester/PVCC/Ionomer to contain the atmosphere inside the packaging. Visibility may be restricted if sauces tend to soil the container.

To reduce oxygen in the package to as low a level as possible, a vacuum step prior to gas flushing is recommended. Antifog treatment for films is recommended for high moisture products.

## Storage Specifications

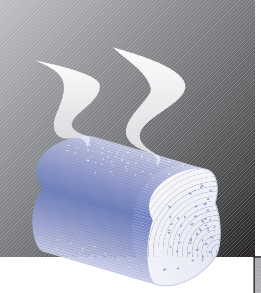
Prepared products deteriorate by microbial growth, oxidation of fats, loss of volatile flavors and colors, degradation of vitamins, dehydration and texture changes. Like all perishable products that require refrigeration, microbial spoilage is usually the most noticeable and therefore the reason for eventual rejection. However, when extended shelf life is made possible by MAP, the other forms of deterioration become more apparent.

Praxair Extendapak gases can delay the above deterioration reactions with the exception of texture or flavor changes which occur as a result of moisture or flavor migration within the product. Sandwich bread or pizza crusts may become soggy as moisture moves to them from the fillings, or toppings and cheeses on pizza can take up a spicy flavor from the sauce.

## Other Considerations

Prepared foods must be refrigerated for safety. Praxair Extendapak application to many prepared entree items reduces frozen storage requirements and retailers can take advantage of more appealing display techniques. Sanitary processing operations and thorough quality control and assurance programs will help achieve comparable shelf lives with modified atmosphere packaged products and offer the advantage of fresher, more convenient products.

The choice of a Praxair Extendapak gas depends on weighing the advantages of a longer shelf life against the effects of carbon dioxide absorption which may cause acidic flavors and package collapse. Higher levels of carbon dioxide are most effective for microbial inhibition (Extendapak #s 24 or 26), however, for sensory quality when balance of several combined flavors exists, a gas mixture lower in carbon dioxide may be required (Extendapak #s 14 or 15).





Modified atmosphere packaging can effectively inhibit mold growth which is a major concern with bakery products. By controlling mold, the water content and water activity of the product formulation can be increased to delay stale-hardening. By combating mold and staleness, it is possible to reduce the use of preservatives such as propionates.

A complete baking process will "heat kill" yeast in leavened products. Some products, such as fried doughnuts and boiled bagels, use alternate processes and special situations arise for un-cooked products such as rolls and pizza dough, where fermentation continues.

**Praxair Extendapak Gases for Bakery Products**

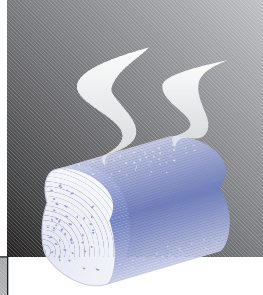
| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Bread** | 12, 16, 15, 13, 14 | Ambient | 1-6 Weeks |
| **Brown Serve Breads** | 24, 25, 26, 27, 28, 12, 16 | Ambient | Up to 3 Months |
| **Bread Crumbs** | 1 | Ambient | Several Months** |
| **Cakes** | 10, 12, 13, 14, 15, 16, 1 | Ambient | 3-9 Months |
| **Cookies** | 1 | Ambient | 6 Months |
| **Crumpets** | 12, 16, 15 | Ambient | 2-4 Weeks |
| **Doughnuts** | 12, 16, 15 | Ambient | Up to 25 Days |
| **English Muffins** | 12, 16, 15 | Ambient | Up to 6 Months |
| **Muffins** | 12, 16, 15 | Ambient | Up to 4 Weeks |
| **Pastry** | 12, 16, 15 | Ambient | Up to 45 Days |
| **Pizza Crusts** | 12, 16, 15 | Ambient | Up to 2 Months |
| **Rolls** | 12, 16, 15 | Ambient | Up to 3 Months |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*

*** Shelf life will vary depending on packaging materials and storage conditions.*

*Bakery Products*



## Packaging Suggestions

Total package volumes may change during storage. Carbon dioxide is initially absorbed into the product resulting in a reduced gas volume. Later, over extended storage carbon dioxide is produced by organisms causing an increase in the gas volume. These changes may affect the choice of packaging materials and design.

A barrier type laminate film with a low MVTR and a low carbon dioxide permeability is recommended. Suggested materials include Polyester/PE + NYLON/PE, PE + NYLON or PVDC coated Polyester/PE. Form-fill-seal lines are convenient for many varieties of products and package sizes. Paperboard cartons or thermoformed trays prevent crushing and contact between pieces.

## Storage Specifications

Praxair Extendapak gases can allow extended storage at ambient temperature for products that previously would have had to be frozen to achieve the same shelf life. The protective atmosphere suppresses most deteriorative reactions that would normally occur faster at ambient storage. Refrigeration is not suggested as this tends to favor staling.

Bakery products are generally short-lived because of deterioration due to mold, staleness, and flavor and aroma changes. Products with high fat content such as croissants and doughnuts are susceptible to fat oxidation if not protected by modified atmospheres. Shelf life may be limited by water distribution changes between components in products such as filled pastries or meat pies.

## Other Considerations

The choice of a modified atmosphere is a compromise between longer shelf life and the effects of carbon dioxide absorption by the product which may cause off-flavors and package collapse. This may also affect the choice of modified atmospheres that are used during cold versus warm seasons, since carbon dioxide becomes more soluble as temperature is reduced. Higher levels of carbon dioxide are most effective for mold inhibition (Extendapak #s 24, 25 or 26), but if excess carbon dioxide absorption reduces product acceptability, lower levels of carbon dioxide may be preferred (Extendapak #s 14, 15, 16 or 1).



Most vegetables are fully ripened at harvest, and storage is "deterioration in progress" (tomatoes are an exception). Vegetable tissues continue to respire, using oxygen and producing carbon dioxide within the modified package atmosphere. The purpose of the modified atmosphere is to reduce the rate of respiration without creating an environment below or above the product's oxygen and carbon dioxide tolerances respectively. If too little oxygen is present, anaerobic respiration will proceed, making a by-product such as ethanol that are toxic to the plant cells.

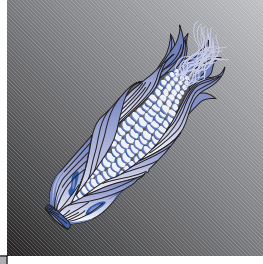
The normal rate of respiration depends on the type of vegetable. Legumes, seeds and asparagus respire rapidly; cabbage, broccoli and like products respire at a moderate rate while tubers and roots respire more slowly. The normal

**Praxair Extendapak Gases for Fresh Vegetables**

| Product | Extendapak # | Storage Temperature | Shelf Life Expectation* |
|---|---|---|---|
| **Asparagus** | 49, 50, 51 | 5 C (41 F) | Insufficient Data |
| **Beans** | 47, 51 | 5 C (41 F) | 2-3 Weeks |
| **Broccoli** | 47, 51 | 5 C (41 F) | Up to 11 Days |
| **Brussels Sprouts** | 51 | 1-5 C (34-41 F) | Up to 11 Days |
| **Cabbage** | 51 | 1 C (34 F) | Insufficient Data |
| **Carrots** | 51 | 5 C (41 F) | 2-3 Days |
| **Cauliflower** | 51 | 5 C (41 F) | Insufficient Data |
| **Corn** | 49 | 5 C (41 F) | Insufficient Data |
| **Cucumbers** | 49, 51 | 5 C (41 F) | Insufficient Data |
| **Leeks** | 48, 41 | 5 C (41 F) | Insufficient Data |
| **Lettuce** | 70 | 2-4 C (36-39 F) | 3-4 Weeks |
| **Onions** | 47, 51 | 5 C (41 F) | Insufficient Data |
| **Peppers** (bell) | 70 | 5 C (41 F) | Up to 3 Weeks |
| **Potatoes** | 50, 49 | Ambient | Insufficient Data |
| **Potatoes** (sweet) | 49 | Ambient | Insufficient Data |
| **Radishes** | 51 | 5 C (41 F) | Insufficient Data |
| **Spinach** | 70 | 2-4 C (36-39 F) | Insufficient Data |
| **Tomatoes** | 50, 42 | 10-20 C (50-68 F) | 2-3 Weeks |
| **Vegetable Salads** (mixed) | 70 | 2-4 C (36-39 F) | Insufficient Data |

*When more than one Extendapak number is referenced, they should be evaluated in the same sequence as listed, unless otherwise recommended.*

** Based on typical industry results.*



respiration rate can be increased by harvesting damage, shelling of peas, potato sprouting and cutting processes such as peeling, slicing or dicing The latter also allows activation of destructive enzymes that cause oxidative browning and loss of flavor, color and vitamins. Antioxidant dips or a blanching treatment may delay these reactions.

The respiration rate can reflect the possible shelf life of the product and is indicative of other changes that may occur.

### Packaging Suggestions

Vegetables packaged in Praxair Extendapak gases need a very permeable plastic film wrap that allows oxygen entry as the respiring cells demand it, and permits exit of carbon dioxide and other gaseous by-products. Depending on this, in addition to the initial gas composition and film permeability, an equilibrium to suit the product will be established between the internal and external atmospheres. Since the product will give off water by transpiration and the package must maintain relatively high internal humidity to prevent dehydration losses, packaging material with a low MVTR is recommended.

Suggested materials are plastic or paperboard trays wrapped with high EVA LDPE (Low Density Polyethylene), or PVC films. Metalized PE bags can be used for lettuce with the added advantage of protecting the product from ultraviolet light. The Extendapak gas selection is largely dependent on the permeability properties of the film. Minimum headspace in the package allows the desired equilibrium to become established sooner. Special gas absorbers may help if excess carbon dioxide or water are present.

### Storage Specifications

The high humidity, aerobic environment combined with low acid pH and any physical damage to the product that could allow entry to cells makes conditions ideal for growth of molds, yeast and bacteria. To reduce respiration rates and deter the growth of organisms that cause rot, slime and odors, cool temperatures are required. Tomatoes are more susceptible to chill injury and pitting that result in uneven ripening and rot. Vegetables such as potatoes, yams or squash, if stored in cold temperatures, will have reduced conversion of starch to sugars, and may require a period of warmer tempering post storage to ensure quality.

Prolonged exposure of vegetable products to light will cause vitamin and color deterioration. When the product is removed from the modified atmosphere it parallels normal storage conditions.

### Other Considerations

Praxair Extendapak gases packaging of vegetables allows a sanitary presentation of produce in a wide range of package sizes. However the application of modified atmospheres to fresh vegetable products is difficult to predict and not completely understood. There are significant advantages this technology can offer, such as prepared salads for institutional or retail use, out-of-season tomatoes that taste field-ripened or stored lettuce that does not have brown rust, but any application warrants specific product quality control monitoring and may require additional research and development.

## Gas Handling Solutions

Further enhancing our Praxair Extendapak gases offering is our complete line of gas handling, distribution and safety equipment:

- Regulators
- Control Panels
- Flow Control Devices
- Manifolds
- Accessories
- Purifiers
- Safety Equipment

## Food and Beverage Processing Solutions

Extended shelf life, fresher flavor, aroma and texture. That's what you can expect from Praxair Processing Solutions. We provide gases in a variety of cylinders, bulk delivery and on-site production options. Our specialty gases, liquid or gaseous nitrogen and carbon dioxide are used for:

- Cryogenic freezing and chilling operations
- Mixer and ingredient cooling
- MAP/CAP
- Beverage sparging, inerting and carbonation
- Specialized shelf-life extension
- Water treatment

Praxair has also developed other gas applications technologies such as:

- Ozone for chill bath and wash water sterilization
- Hydrogen generation for oil management
- Oxygen for aquaculture.

## Call Praxair Today

Explore all the benefits Praxair offers. Call 1-800-PRAXAIR today and see for yourself how we can help make a difference in your food packaging operation.

Praxair

## The Praxair Advantage

**Comprehensive, High Quality Product Line**
A full range of certified pure gases, mixtures, gas handling equipment and related services.

**Application-Based Solutions**
Sales, production and research capabilities and the ability to supply end use customers, OEMs and research institutes with a safe, accurate and precise product worldwide.

**Reliable Production and Distribution Network**
Seventeen specialty gases laboratories and production centers, more than 600 distribution locations in North America and Praxair's own delivery fleet – all serving you with the gases you need when you need them.

**Outstanding Technical Support**
A highly trained team of field sales representatives, technical service personnel and production chemists, in concert with dedicated market specialists who *quickly* provide the guidance and support our prospects and customers need to resolve regulatory, technical and safety application issues.

**Global Supplier**
Application-based research and development at five international technical centers, combined with specialty gases production and distribution in over 40 countries.

Praxair

**Praxair Specialty Gases & Equipment**

**United States**
39 Old Ridgebury Road
Danbury, CT 06877-5113
Tel: 1-800-PRAXAIR
(1-800-772-9427)
(716) 879-9985
Fax: 1-800-772-9985
(716) 879-2040
e-mail:info@praxair.com
Internet: www.praxair.com

**Canada**
1 City Centre Drive,
Suite 1200
Mississauga, Ontario
L5B 1M2
Canada
Tel: (905) 803-1600
Fax: (905) 803-1690

**Mexico**
Praxair Mexico SA de CV
Blvd. Manuel Avila Camacho 32
Col. Lomas de Chapultepec
11000 Mexico D.F.
Tel: 52 (5) 627-9500
52 (5) 899-3005
Fax: 52 (5) 627-9546
e-mail: prax_mex@praxair.com

Gases are only one part of the packing with atmospheres process. Information stated with respect to suggested gases for use with specific foods is based on data obtained from published results of similar processes. Since original quality, processing and packaging methods and materials, films and storage conditions all play an important role in achieving shelf life extension, ongoing quality control verification is essential.

The information contained herein is offered for use by technically qualified customer personnel at their discretion and risk. All statements, information, suggestions and recommendations are based on information we believe to be reliable, but the accuracy or completeness thereof is not guaranteed and no warranty of any kind is made with respect thereto. Quality Control verification and monitoring in conjunction with any and all claims relating to atmospheric packaging is essential and is the responsibility of the Extendapak purchaser and/or user.

**Special Note:** Gases and gas mixtures should be used only in packaging areas having adequate ventilation for operators, because gases and gas mixtures can cause rapid suffocation if inhaled.

PRAXAIR, the FLOWING AIRSTREAM design and Extendapak are trademarks or registered trademarks of Praxair Technology, Inc. in the United States and other countries.

Copyright © 1999, Praxair Technology, Inc.
All Rights Reserved.

P-8247 5M 1/99