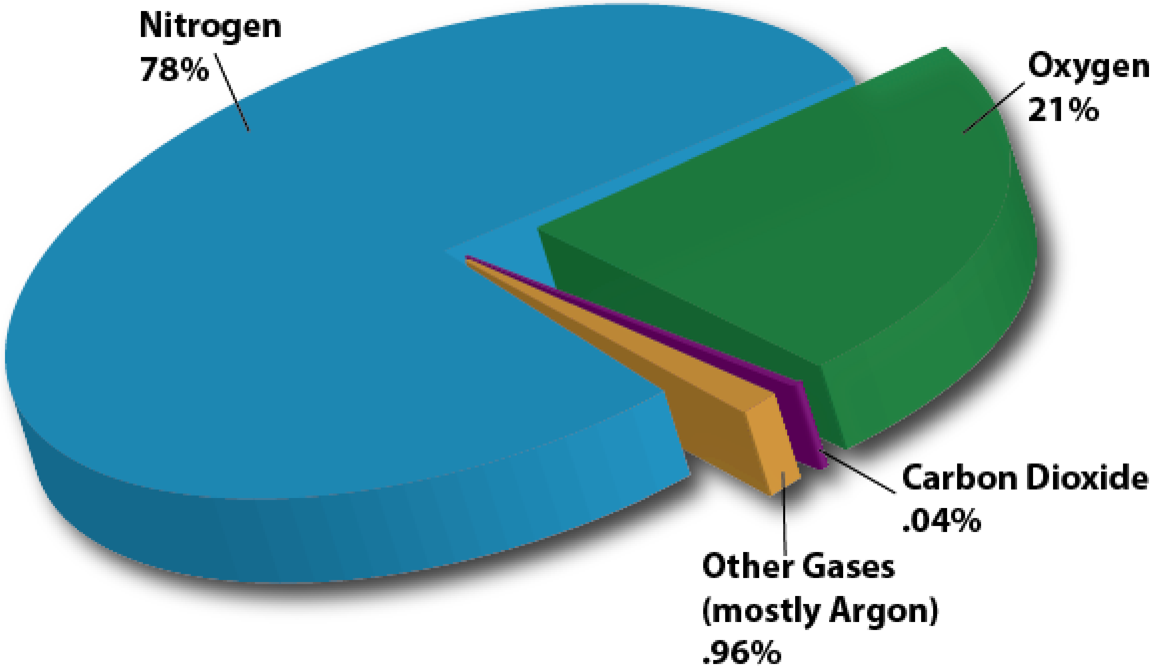
Modified-Atmosphere Packaging

Tajnuba Sharmin
Lecturer
Dept. of Nutrition & Food Engineering
Daffodil International University

What Do mean by Modified Atmosphere?

- Alteration of Atmospheric gas composition
- Atmospheric composition?



IF WE DON'T MODIFY THE ATMOSPHERE, WHAT WILL HAPPEN?

- The nutritional and organoleptic quality of foods will start to decline as a result of the………….
  - food's own metabolic activities (Respiration)
  - Moisture uptake/evaporation
  - microbial growth etc. oxygen
- The presence of is one of the major factors of food spoilage.
- Oxygen can cause oxidation reactions (damaging vitamins and causing growth of aerobic microorganisms)

Modified atmosphere

- MA involves the removal of air from the package and its replacement with a single gas or mixture of gases to enhance the shelf life of foods.
- Modified atmosphere (MA) is a preservation technique that may further minimize the physiological, chemical and microbial decomposition of foods by keeping them in an atmosphere that is different from the normal composition of air (78.08% nitrogen, 20.96% oxygen, 0.04% carbon dioxide, plus water vapor and traces of inert gases).
- This technology allows the storage of foods without use of any chemical additives by fewer processing treatments.

THE ADVANTAGES OF MAP

- increased shelf life
- reduction in retail waste
- improved presentation-clear view of product and all round visibility
- hygienic stackable pack, sealed and free from product drip and odor
- little or no need of chemical preservatives
- increased distribution area and reduced transport costs due to less frequent deliveries
- reduction in production and storage costs due to better utilization of labor, space and equipment.

The disadvantages of MAP

- capital cost of gas packaging machinery
- cost of gases and packaging materials
- cost of analytical equipment to ensure that correct gas mixtures are used

  cost of quality assurance systems to prevent distribution of leakers
- increase of pack volume which will adversely affect transport costs and retail display space
- benefits of MAP are lost once the pack is opened or leaks

MODIFIED ATMOSPHERE

- MAs without oxygen are used to
  - minimize oxidative deterioration reactions (such as brown discoloration of meat, rancidity of peanuts),
  - reduce microbial growth,
  - extend the shelf life of products,
  - improve the product image,
  - reduce the wastage of foods and
  - produce stable products

Gaseous atmospheres for Microbial growth

- Microorganisms differ in their requirement of gaseous atmospheres for growth as follows:
- Aerobic microorganisms require oxygen for growth, such as Pseudomonas, Psychrobacter, Shevanella, Acinetobacter/Moraxella, Micrococcus, some species of Bacillus, film yeasts, and molds. The growth inhibition of these microorganisms can be achieved by excluding oxygen from the MA.
- Microaerophilic microorganisms require low levels of oxygen for growth. Some may require increased levels of carbon dioxide for growth, such as Campylobacter and Lactobacillus.
- Facultative anaerobic microorganisms are able to grow in the presence or absence of oxygen, such as Escherichia coli, Staphylococcus aureus, Listeria monocytogenes, Brochothrix, Salmonella, Vibrio, Aeromonas, some species of Bacillus, lactobacilli, and fermentative yeasts.
- Anaerobic microorganisms are inhibited or killed by oxygen, such as Clostridium and Bifidobacterium.

Gases used for modification of atmosphere

- Carbon dioxide
- O2
- Nitrogen
- Carbon monoxide
- Argon
- Other gases

Carbon Dioxide

- Carbon dioxide has bacteriostatic and fungistatic properties and will retard the growth of mold and aerobic bacteria.
- It has little effect on the growth of yeast and does not retard the growth of all types of microorganisms.
- The growth of lactic acid bacteria is improved in the presence of carbon dioxide with low oxygen content.
- The inhibitory effect of carbon dioxide is increased at low temperatures because of its enhanced solubility in water, forming carbonic acid (H_2CO_3).
- The absorption of carbon dioxide in a pack depends on the water and fat content of the product.
- Excess carbon dioxide absorption can reduce the water-holding capacity of meats.
- Some dairy products can be tainted, and fruit and vegetables can be physiologically damaged, at high carbon dioxide levels.

Home work

- bacteriostatic and fungistatic???????????

OXYGEN

- In MA, oxygen levels are normally set as low as possible to inhibit the growth of aerobic spoilage microorganisms and to reduce the oxidative deterioration of foods.
- But oxygen is needed for fruit and vegetable respiration, color retention in red meats, and to avoid anaerobic conditions in packs.
- Oxygen is included in gas-flush mixtures in meat packaging to maintain the bright red appearance of oxymyoglobin.
- Oxygen is toxic to most microorganisms due to the formation of the superoxide radical.
- In the presence of oxygen, some microorganisms produce hydrogen peroxide that reacts with superoxide radicals, resulting in the formation of extremely reactive compounds, such as the hydroxyl radical.
- Different types of microorganisms are protected to various degrees against oxygen radicals by the enzymes such as superoxide dismutases, catalases, and peroxidases.
- They can remove hydrogen peroxide formed in the dismutation reaction.

Nitrogen

- Nitrogen is an effective inert gas, and has a low solubility in both water and fat.
- In MA, nitrogen is used primarily to displace oxygen in order to retard aerobic spoilage and oxidative deterioration.
- Nitrogen can also be used as a filler gas to prevent pack collapse.

CARBON MONOXIDE

- Carbon monoxide produces a stable, cherry-red color (carboxy myoglobin) in meat owing to it binding strongly to the muscle pigment deoxy myoglobin.
- Low concentrations of carbon monoxide (<0.5%) combined with anaerobic carbon dioxide atmospheres
  - improve meat color;
  - inhibit lipid oxidation,
  - bone discoloration, and browning of meat and meat products;
  - extend shelf life;
  - reduce growth of certain spoilage and pathogenic microorganisms; and
  - pose no toxic hazard to consumers.
- It is safe to use in food packaging.

Argon

- A wide range of foods are MA packed in argon-containing gas mixtures.
- Argon effectively inhibits enzyme activity, microbial growth, and degradative chemical reactions in foods.
- Argon is a chemically inert gas and it has a similar atomic size to oxygen, and higher density and solubility in water compared with nitrogen and oxygen.
- Argon is more effective than nitrogen at displacing oxygen from cellular sites to inhibit oxidative deterioration reactions.
- Argon demonstrates some properties that are beneficial, but it is more expensive than nitrogen.

OTHER GASES

- Other gases, such as
  - ozone,
  - nitrous oxide,
  - ethylene oxide,
  - helium, neon,
  - propylene oxide,
  - ethanol vapor, hydrogen,
  - sulfur dioxide, and chlorine,
  - can be used on a restricted commercial basis to extend the shelf life of a number of foods.

The commercial use of these gases is limited owing to safety concerns, regulatory constraints, negative effects on sensory quality, and economic factors.

Types of Modified-Atmosphere Techniques

- Modification of the atmosphere in a package involves a reduction of oxygen or an increase of the carbon dioxide/nitrogen concentrations, but in some cases an amount of carbon monoxide, ethylene, ethanol or other compounds in the atmosphere can also be used for shelf life extension.
- MA can be created passively by the respiration of the product inside the package (product MA packaging) or actively by introducing the desired gas mixture (modified atmosphere package, MAP).
- Other ways of obtaining MA are the use of gas generators and scrubbers to control levels of gases in the storage environment (controlled atmosphere packaging, CAP), evacuation of air from packages (hypobaric storage or vacuum packaging, VP), and addition of chemical systems to packs that absorb or generate gases or volatile compounds (active packaging, AP)
- Another application of the concept of changing the gas environment is the carbonation of drinking water and soft drinks.
- Carbonation increases both the shelf life and the safety of the product (Molin, 2000).
- The concept of high carbon dioxide pressure (5–15 MPa) is used to inactivate microorganisms in liquid foods.

CHOOSING PARTICULAR SYSTEM?

The choice of a particular packaging atmosphere depends on many considerations:

- such as effect on microorganisms,
- retaining food stability,
- prevention of oxidative deterioration,
- inhibition of ripening, and
- protecting packaging of noncarbonated beverages from collapse.

CAP

- In CAP, the foods are placed into a room or container with a gas or mixture of gases after removal of air from the headspace by vacuum, and the levels of the gases are continuously monitored and adjusted as required throughout storage.
- This method is used for bulk storage or transport of smaller or larger quantities of foods.
- Modification of the controlled atmosphere is an expensive technique and is used for long-term storage of foods to maintain their freshness and quality.
- CAP is used for transportation of foods, particularly fruit and vegetables, in atmospheres containing reduced oxygen (2–5%) and increased carbon dioxide (8–10%) in airtight chilled storage rooms, and shipment of chilled carcasses packed in aluminum foil laminate bags with an atmosphere of 100% carbon dioxide.
- This storage prevents the respiration and adverse changes to the sensory and textural properties of foods, and inhibits the growth of certain spoilage microorganisms (such as aerobic bacteria and molds).
- Growth inhibition is evident both in the extension of the lag phase and the reduction of maximal biomass formation.

MAP

- In MAP, the gas composition within the package is not monitored or adjusted for changes during storage as CAP.
- One gas or a mixture of gases is flushed into the package before closing depending on the oxygen sensitivity, metabolic activity and stability of the products.
- The air in the package is removed by vacuum before gas flushing.
- Products sensitive to oxygen or products with a low level of respiratory activity are packed with a gas mixture composed of low oxygen and moderately high carbon dioxide.
- After closing the package, respiration of the product will decrease oxygen and increase carbon dioxide in the package.
- The composition of the gas atmosphere changes during storage as a result of product and microbial respiration, dissolution of carbon dioxide into the aqueous phase, and gas diffusion through the foods and the package materials.

MAP

- Gas diffusion through foods is affected by temperature, food mass and volume, respiration rate of food, cell-membrane permeability, gas diffusion path, maturity stage of the product, gas gradient across the film, and water-vapor gradient.
- Most plastic films do not have the proper oxygen/carbon dioxide permeability for specific foods.
- The gas permeability of the film depends on the concentration of gases; structure, pore size, thickness and surface area of film; temperature; and relative humidity.
- MAP controls or reduces the growth of undesirable microorganisms (pathogenic or spoilage) in food, and retards enzymatic and respiratory activities of foods.
- The growth of aerobes is prevented in packed products while anaerobic and facultative anaerobic bacteria can grow unless other additional techniques are used to control their growth.
- MAP is used to increase the shelf life of many refrigerated foods, such as fresh pasta, bakery products, cooked poultry products, cooked egg products, fresh and cooked sea foods, sandwiches, raw meats, and fruit and vegetables.

RESPIRATION

- Respiration of a food depends on its
  - physiological stage,
  - temperature,
  - oxygen and carbon dioxide partial pressures,
  - relative humidity, and ethylene concentration.

VP

- Whereas MAP and CAP mostly operate at ambient pressure (101 kPa), storage of foods at reduced atmospheric pressures is possible with VP.
- In VP, the air is removed from the headspace of the package by vacuum and the altered initial atmosphere is not controlled during storage.
- The initial gas composition is normal air but with oxygen present at about one-third of the normal amount due to its partial pressure (at an air pressure of 1–40 kPa).
- The lower oxygen content stabilizes the product quality by slowing down the metabolism of the product and the growth of spoilage microorganisms.
- VP strongly retards enzymatic browning of the cut food surfaces, such of as vegetables, fruit, and salad mixes.

VP

- The atmosphere which develops during storage is mainly the result of biological activity.
- VP is predominantly used for meat and related products.
- Another VP process is the sous-vide method.
  - Sous-vide is a form of cooking in which food is placed into airtight plastic bags, vacuum sealed, immersed in hot water, and allowed to cook by heating for a period of time at a relatively low cooking temperature (usually around 60C).
- The final minimally processed product may have a better flavor, color, texture, and aroma with minimal loss of juices while at the same time greatly improving food safety.
- The cooking temperatures are not to high enough to kill all microorganisms and spores therefore foods packed with sous-vide must be stored at low temperature.
- Clostridium botulinum can grow in food in the absence of oxygen and produce the deadly botulinum toxin, so sous-vide cooking must be performed under carefully controlled conditions and chilling requirements to avoid botulism.
- Sous-vide is a safe and effective method of packaging for minimally processed food, and mostly used in restaurants to control the organoleptic properties of a product.
- In sous-vide, hermitic vacuum sealing of the plastic bags, heat treatment, and the oxygen barrier inactivate and slow the growth of most microorganisms, thus delaying spoilage.

AP

- AP techniques can be defined as a packaging of the product together with an "active" material (chemical in absorbers/releasers) to prolong shelf life, enhance safety and sensory properties, and maintain the quality of the product.
- The atmosphere in packages can be controlled by the use of a gas or volatile compound-absorbing material or carbon dioxide-releasing material.
- The material in the package continuously modifies the gas environment by removing gases or adding gases to the package headspace.
- The active materials are either combined with the packaging material or placed in the package.
- The amount of active compound added depends on the production rates of metabolites (carbon dioxide, ethylene), concentrations of gases to be reached, length of storage, and type of food, among others.

AP

- Incorporation of chemicals into packaging materials, increasing shelf life of products, eliminating the risk of accidental rupture of the sachets, and inadvertent consumption of their content.
- AP is used in packs for popcorn, fries, pizzas, pies, baked goods, etc.
- Time-temperature indicators (TTIs) can be used on packages to display loss of shelf life and temperature-abuse conditions.
- Possible future developments in AP include self-venting microwave packs in which a vent opens at a temperature and closes on cooling.
- AP systems include oxygen absorbers, carbon dioxide generators, preservative releasers (e.g. ethanol production), aroma releasers, moisture absorbers, odor and off-flavor or ethylene removers, TTIs, edible coatings, and the others.

EFFECTS OF MODIFIED GAS ATMOSPHERES ON MICROORGANISMS AND FOODS