Controlled Atmosphere

The best way to preserve quality and extend shelf life is by cooling, and another method used to extend shelf life is the modification of the atmosphere surrounding the product. Most products tend to keep longer in atmospheres that are high in carbon dioxide and low in oxygen. Atmosphere modification is usually used as a complement for cooling. Controlled Atmosphere Storage (CAS) and Modified atmospheric packaging (MAP) are two hot topics for food researchers to maintain food quality and freshness.

Controlled Atmosphere Storage (CAS) The technique of modification of the atmosphere surrounding perishable products is referred to as CAS.

In CAS, the atmosphere is created artificially and the gas composition is continuously monitored and adjusted to maintain the optimum gas concentration. There are different types of controlled atmosphere storage depending mainly on the method or degree of control of the gases.

Mainly two type of control atmosphere storage systems

- Static controlled atmosphere storage
- Flushed controlled atmosphere storage

Requirements for Ideal CAS

A. CA Storage Room

A gas tight room is an obvious prerequisite for achieving a good controlled atmosphere storage system. Thus it is necessary to make room walls gas -tight. In order to ensure that the walls are gas tight to CA storage they are lined with sheets of galvanized steel.

B. Temperature Control

CA storage is only successful when applied at low temperatures. Ammonia or chlorofluorocarbons are common refrigerants.

C. Humidity Control

Most fruits, vegetables and meats, which are kept in CA storage, require a high relative humidity, generally the closer to saturation the better, so long as moisture does not condense on the foods. The amount of heat absorbed by the cooling coils of the refrigeration unit is related to the temperature of the refrigerant they contain and the surface area of the coils. If the refrigerant temperature is low compared to the store air temperature then water will condense on the evaporator. This removal of moisture from the store air, reduces its relative humidity, which results in the stored food losing moisture by evaporation-transpiration. In order to reduce food desiccation the refrigerant temperature should be kept close to the store air temperature.

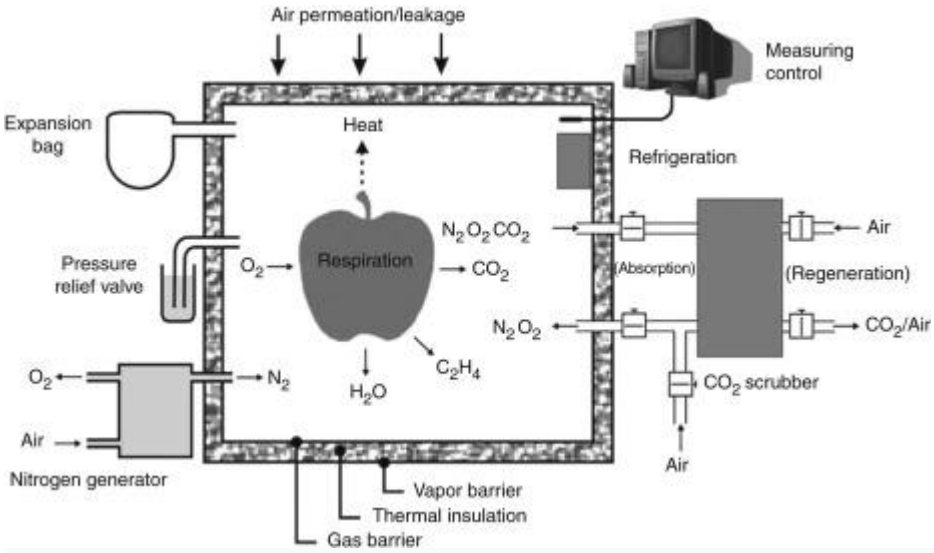
D. Gas Control

The atmosphere in a modern CA store is constantly analyzed for CO2 and O2 levels using an Infrared gas analyzer to measure the gas content in the store constantly. There are also ethylene analyzers that continuously measure ethylene concentration in the store. In storage rooms where low ethylene is essential, checks can be made that the ventilation and ethylene removal systems are operating correctly.

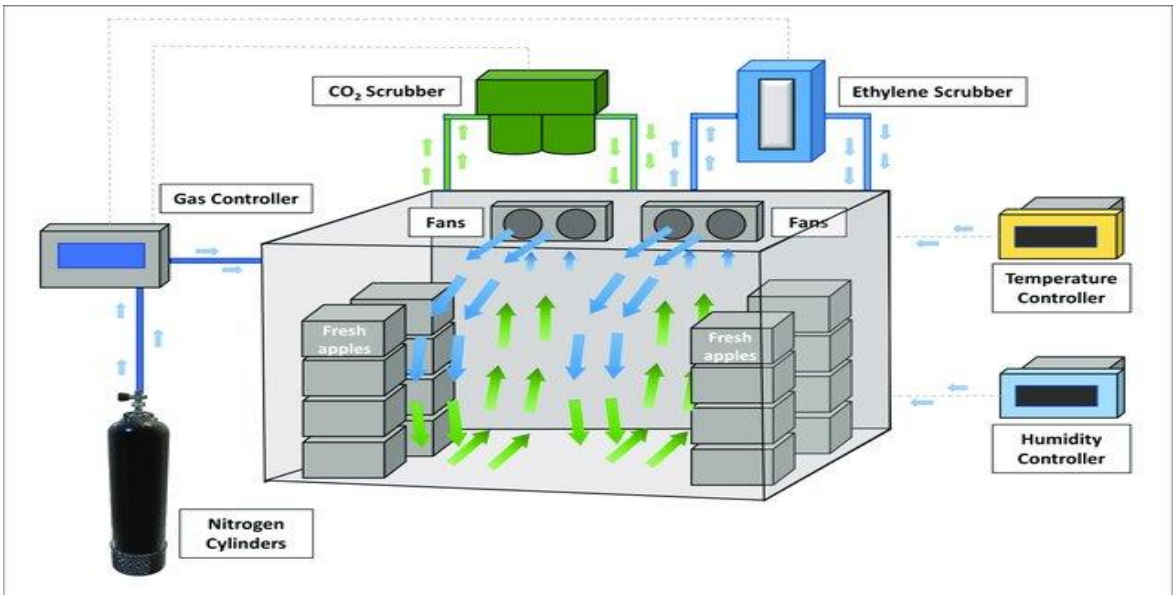
E. Scrubbers

Scrubbers are used in controlled atmosphere storage to absorb the extra amount gases present inside the packaging material .The composition of the gas mixture inside the storage rooms undergoes continuous change as a function of the metabolic activity of the stored product and scrubbers are necessary to absorb excess CO2. Scrubbers are generally classified according to the absorbent material: Ca(OH)2, NaOH, H2O, zeolites, activated charcoals. They are also classified according to the mode of absorption (i.e. chemical or physical), or to the mode of air passage through the absorbing agent. Scrubbers using activated charcoal are currently the most popular. Gas removal with this type of equipment is based on the fixing of CO2 in a particular way, and releasing it again on contact with atmospheric air, even at room temperature

The gas concentration ranges encountered in CA storages are 1 to 10% O_2, 0 to 30% CO_2, and the balance is nitrogen (N_2). Air consists of approximately 78% N_2, 21% O_2, 0.03% CO_2, and traces of several other gases that have no physiological significance.



Samad B. and Mohammad M. 2016 Advances in controlled atmosphere storage of fruits and vegetables. Eco-Friendly Technology for Postharvest Produce Quality**. P39-76**https://doi.org/10.1016/B978-0-12-804313-4.00002-5



Fresh apples are stored in a controlled atmosphere (CA) cold storage room (adopted from http://www.agroripe.com/controlled-atmosphere-storage

Beneficial effects of CAS

Using CAS has a wide range of benefits such as the following:

1. A considerable decrease in respiration rate of fruits and vegetable
2. A reduction in the effect of ethylene on metabolism due to the interaction of O_2 with ethylene.
3. An extension in storage life, which can even be doubled, in as much as the overripening is delayed.
4. The preservation of an excellent firmness of meat, due to effect of CO_2 concentration on the enzymes acting on cellular membranes.
5. A high turgidity is achieved, such that fruits become more juicy and crispy.
6. A smaller loss of acidity, sugars and vitamin C, so that the nutritional and sensory quality is higher.
7. A limited degradation of chlorophyll, with a consequent higher stability of colour.

Dry commodities

Grains, legumes and oilseed are stored in a controlled atmosphere primarily to control insect pests. Most insects cannot survive indefinitely without oxygen or in conditions of raised (<30%) carbon dioxide. Such controlled atmosphere treatments of grains may take several weeks at lower temperatures (<15 °C). A typical schedule for complete disinfestation of dry grain (<13% moisture content) with carbon dioxide at approximately 25 °C is a concentration above 35%(v/v) carbon dioxide in air for at least 15 days.

- adding pure carbon dioxide or nitrogen, or the low oxygen exhausts of hydrocarbon combustion.
- using the natural effects of respiration (by grain, molds or insects) to reduce oxygen and increase carbon dioxide (Hermetic storage).

MODIFIED ATMOSPHERE PACKAGING (MAP) ¬ Modified Atmosphere Packaging (MAP) involves the modification of the head space gas in a package in order to prolong the shelf life of the product it contains.

Types of MAP

1. Active modification

The atmosphere is modified by pulling a slight vacuum and replacing the packaging atmosphere within the desired gas mixture.

Active MAP Use of active scaveng ers or emitters to control O2 and CO2,moisture and ethylene.

Active modification

Displace or remove gases in package

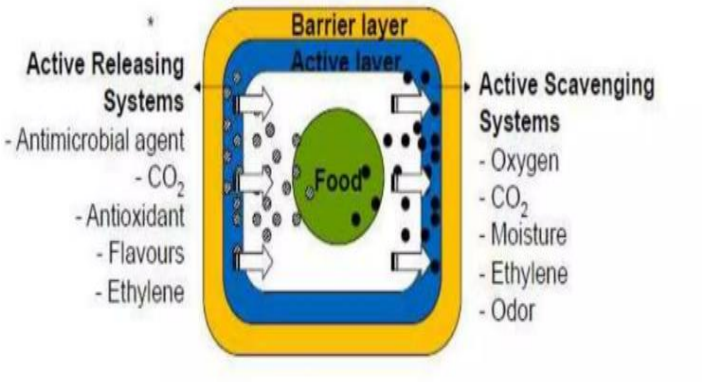
Replace with mix of desired gases and seal

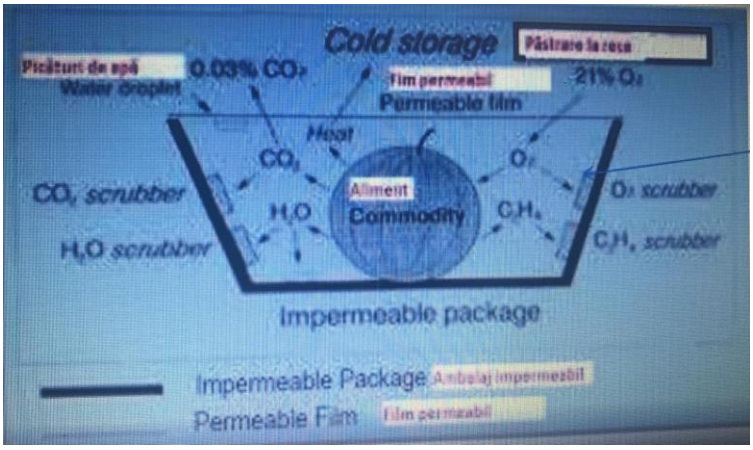
Better shelf life is achieved with Active Modification

¬ The greatest use of MAP is for fresh-cut products (to maintain 2-5% O2 and 8-12% CO2).

¬ It is possible to improve gas control in MAP by adding absorbers of ethylene, carbon dioxide and oxygen.

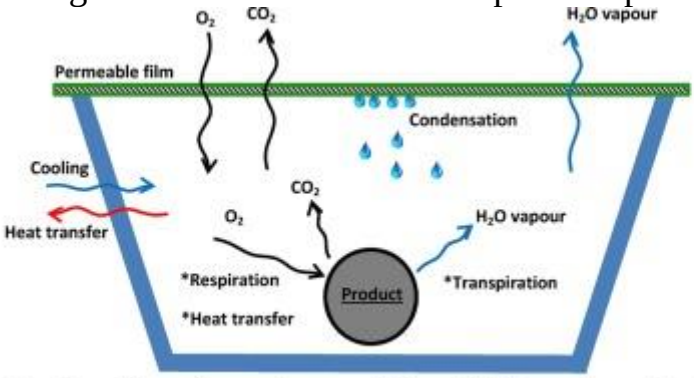
- O2 absorber:- Iron powder is used commercially as the active ingredient. Ex. FeO, Fe O , Fe $O_{2\ 3\ 3\ 4}$
- CO2 absorber:- Lime(freshly hydrated high calcium lime ,activated charcoal,$_2$ magnesium oxide)
- Ethylene absorber:- Potassium permanganate, builder clay powder, hydrocarbons, silicones





2. Passive modification

Modification is achieved by respiration of commodity within the package and depends on the characteristics of the commodity and the packaging film.
Passive MAP It is achieved by respiration of fruits and vegetables and gas transmission rates of the packaging film.
In passive modification, the respiring product is placed in a polymeric package and sealed hermetically. Only the respiration of the product and the gas permeability of the film influence the change in gaseous composition of the environment surrounding the product.
Passive modification
Product packaged with selected film
Desired atmosphere develops naturally over time
Takes longer to achieve desired atmosphere in package



Overview of the continuous phenomena (*) in modified atmosphere packaged fresh product.

Plastics packaging for MAP applications is most commonly found in the form of flexible films for bags, pouches, pillow packs and top webs or as rigid and semi-rigid structures for base

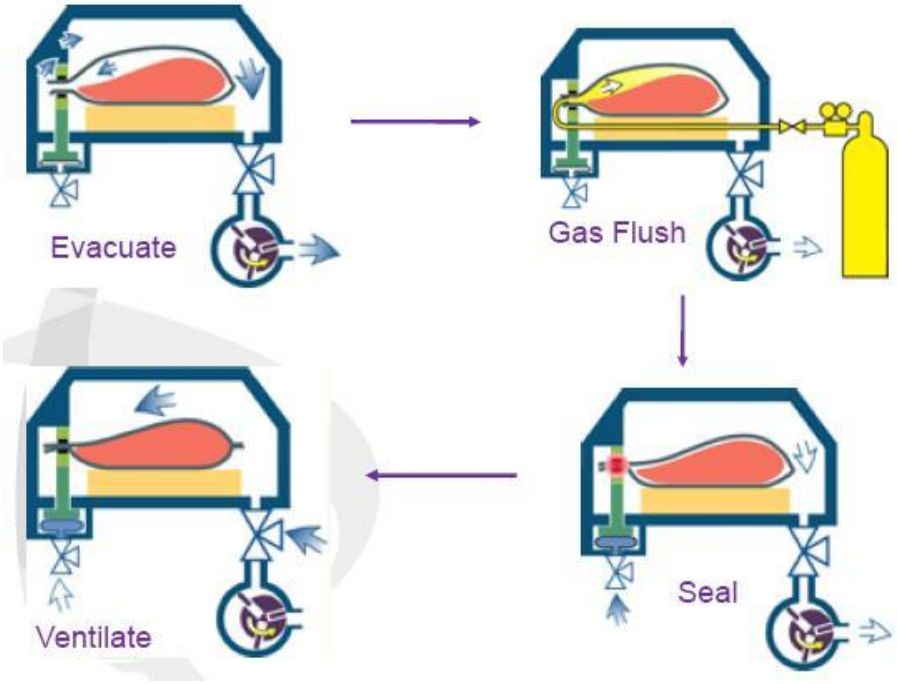
trays, dishes, cups and tubs. Commonly used plastic flexible laminates are produced from polyethylene (PE), polypropylene (PP), polyamide (nylons), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polyvinylidene chloride (PVdC) and ethylene vinyl alcohol (EVOH).

3. Gas Flushing

Gas flushing of modified gases composition during packaging

Gas flushing is a process in which various types of inert gas (most commonly nitrogen) or other gases are injected inside, sucked out, and re-injected repetitively to remove oxygen from food packaging. Gas flushing is the most common type of modified atmosphere packaging. Gas flushing is done to improve the shelf life of the product contained within.

is the practice of causing a change in the atmosphere in a package to help preserve the food contained within (IE: poultry, beef, pork, fish). The ultimate end-goal of this type of food packaging is to increase the shelf life of your food products



4. Vacuum

Remove internal gases of packages.

the three process steps in a chamber packaging machine: 1. Evacuation, 2. Sealing, 3. Aeration. Source: Busch Vacuum Solutions.