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Maintaining harvest fresh apples

Controlled Atmosphere storage requires accurate carbon dioxide measurements

Controlled atmosphere (CA) storage is a widely used technique for long-term storage of freshly picked fruits and vegetables. Historically, CA storage has been the primary method for the long-term storage of apples. Through a biological process called respiration, apples take in oxygen and generate carbon dioxide, water, and heat.

Controlled Atmosphere storage is an entirely natural process that reduces the effects of respiration to a minimum by controlling the environmental conditions surrounding the stored fruit. CA storage makes it possible to buy crisp, juicy apples year round. Many cultivars of apples can be preserved for a remarkable 9 – 12 months in CA storage, as opposed to only 2 – 3 months if using refrigerated storage.

Optimal conditions important

In order to effectively preserve apples the storage atmosphere must have a controlled amount of humidity, oxygen (O_2), carbon dioxide (CO_2) and temperature. The essence of CA storage is the range for O_2 and CO_2 concentrations, which both must be kept between 0.5 to 2.5%. The precise optimum concentrations vary for different varieties of apples (i.e. Golden Delicious apples may need different conditions than Jonagold apples, etc).

The relative humidity is kept in the range between 90 to 95%. High relative humidity slows down water loss and enhances storage life of the produce, but humidity too close to saturation encourages bacterial growth. Temperature in the storage container is maintained

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Storage Control Systems Inc's CO_2 scrubber called the Series II Smart Scrubber.

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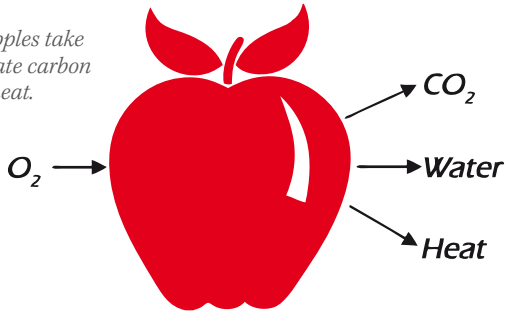

around 1°C, the lowest possible temperature before damage to tissue occurs.

Carefully designed process

The typical process for CA storage begins by filling a storage chamber with apples. Some chambers are large enough to contain up to 400 tons of apples. The refrigeration apparatus is then activated to achieve the target temperature of 1°C. During cooling, the windows or other chamber openings are left open to prevent a possible collapse due to pressure changes.

When the desired storage temperature is reached, the room is sealed with an airtight CA door. Once sealed, a nitrogen generator is started to purge the O_2 concentration in the chamber from 21% (found in normal air) to approximately 3%. Once this level is reached the fruit will continue to reduce the O_2 concentration through the respiration process. If the O_2 concentration were to ever fall to zero the apples would suffer unwanted and irreversible fermentation reactions in the fruit. If O_2 levels drop below the safe concentration, outside air is added to the chamber to raise O_2 concentration to the intended level.

In addition to generating CO_2, the apples also generate ethylene gas which accelerates ripening. Increased levels of CO_2 will halt the ethylene production and therefore slow the ripening process of apples dramatically. However, if the CO_2 concentration is too high it may terminate the life of the apple by destroying appearance, flavor, and nutritional value. In order to maintain the CO_2 at the desired level, the excess CO_2 must be removed from the air in the chamber.

Gas analyzers are used to monitor and control the addition and removal of O_2 and the reduction of CO_2 through the course of the storage period. Because of their responsibility to control the desired gas concentrations in the chambers, these analyzers are critical to the operation of the entire system.

From bags of lime to more sophisticated methods

Years ago, chamber operators used hydrated lime to control the CO_2 in the fruit store. Bags of lime were loaded on pallets and placed into the store which absorbed all the CO_2 that was emitted from the apples, eventually leaving the store with no CO_2. Lime (calcium oxide, CaO) absorbs CO_2 and in turn reacts to form calcium carbonate (limestone, $CaCO_3$). Once all the lime was converted to calcium carbonate, the operator was forced to manually vent or flush the room with nitrogen to control the CO_2 level.

Nitrogen generators require large, high-power air compressors that can be costly to run with continuous usage. A carbon dioxide scrubber is a more efficient and affordable tool for removing and controlling CO_2 inside a fruit store. CO_2 scrubbers not only remove CO_2, but also remove some volatile organic carbons (VOCs) and ethylene, allowing optimal storage of fruit.

Seriously smart CO_2 scrubbers

Storage Control Systems, Inc. is a company that specializes in gas analyzers, nitrogen generators and CO_2 scrubbers for CA storage systems. Having been in the business for over 25 years, they are one of the longest established CA companies in the world.

SCS supplies a unique CO_2 scrubber called the Series II Smart Scrubber. This scrubber consists of two cylindrical beds containing activated carbon. Activated carbon is a porous adsorbent material, meaning that the carbon dioxide molecules are attracted to and adhere to the surface of the carbon media. The activated carbon gradually becomes saturated, so it is necessary to periodically purge the beds with fresh air to remove the CO_2. The unit is programmed to adsorb on one bed, while purging with fresh air on the other to allow for continuous scrubbing. The Series II Smart Scrubber is also programmed with a "DeOx" cycle to minimize oxygen feedback to the CA room.

The Series II Scrubber uses a programmable logic controller (PLC) with a color touchscreen interface to carry out its control and sequencing functions. The PLC operator interface allows simple programming of CO_2 concentrations, resulting in highly effective fresh fruit storage regimes.

The Vaisala CARBOCAP® Carbon Dioxide Module GMM221 is used to monitor the CO_2 output from the beds, which controls the switching of the process from scrubbing to regenerating or vice versa at the most efficient point. Also, a snapshot of the CO_2 coming from the room is taken at the beginning of the cycle using the GMM221. This information is logged into the PLC, which uses the readings to set the optimal scrub and regeneration set points.

The Vaisala carbon dioxide sensor is highly stable, very reliable, does not require routine calibration and is able to read gas concentration levels over several months to an accuracy of <0.5%. This is critically important for successful long-term fruit storage and requires minimal maintenance by the operator. ■