Carrier TRANSICOLD

CONTROLLED ATMOSPHERE HANDBOOK

What's Shipped Fresh, Arrives Fresh

A Guide to Shipping Perishables in Refrigerated Containers with Controlled Atmosphere Technology

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FORWARD

Controlled Atmosphere (CA), used as a supplement to proper temperature management, can contribute significantly in extending postharvest and transit life, and maintaining quality and condition of many perishable products during transport.

CA involves relative humidity, temperature, reduction of oxygen (O_2) and / or elevation of carbon dioxide (CO_2) to achieve an atmospheric composition around the product that is different from regular air. The proper selection of O_2 and CO_2 levels and consequent benefits and risks are dependent upon the type of product, variety, maturity, physiological age, growing region, season, temperature, quarantine requirements by importing countries, and trip length.

The optimum transport conditions recommended in this handbook are based on the best available information for the specific commodity. Because optimum atmospheres may vary depending on the many factors mentioned, the recommended conditions are given in ranges. Recommendations include cautions and other appropriate conditions. Adjust if experience suggests.

This handbook is published by Carrier Transicold to aid the many people – growers, shippers, forwarders, logistic personnel, shipping lines, receivers, importers, distributors – who may benefit from the application of CA during the transport of fresh produce.

What is Controlled Atmosphere?

CA is the reduction of O_2 and / or elevation of CO_2 concentrations to achieve an atmospheric composition around the product that is different from that of regular air (78.08% N_2, 20.85% O_2, 0.041% CO_2). CA involves active management and control of both gases O_2 and CO_2 to optimum setting levels during the entire journey to destination markets.

Active controlled atmosphere systems such as Carrier's EverFRESH® system provides true control of O_2. It actively separates Nitrogen (N_2) from air, injecting it into the container, and displacing O_2 to setting levels. The stream of N_2 being injected will have a purity of 95 to 97% where the other 3 to 5% will mostly be O_2 and a few inert gases which means that low O_2 between about 3 to 5% is injected frequently during transit providing an even better O_2 pulldown and optimization. This active CA system does not depend on product respiration to pulldown O_2 and does not depend much on container leak rate to maintain setting O_2 levels because it maintains a positive pressure inside the container as the stream of high purity N_2 and very low O_2 is injected.

In active CA the increase of CO_2 to setting levels still depends on product respiration. Control of excess CO_2 is regulated by displacement with the high N_2 / very low O_2 mix being introduced, as needed.

In terms of setting CO_2 levels, the respiration rate of the commodity, which can be categorized into high, moderate, or low respiring, will determine if the commodity can produce enough CO_2 or if it needs initial and / or in transit injection of external CO_2 to maintain adequate levels during the entire journey. Carrier's EverFRESH active CA system can inject CO_2 initially and offers the option for injecting CO_2 in transit when needed, for even more accurate control.

What is Container Modified Atmosphere?

As with CA, Modified Atmosphere (MA) also involves the reduction of O_2 and / or elevation of CO_2 concentrations to achieve an atmospheric composition around the product that is different from that of regular air.

Container MA systems are not active systems, they are *passive* systems. The MA is established inside a reefer container through product respiration, closing the vents completely, plugging the drains, and sealing the unit at the door's internal frame with a plastic curtain. Excess CO_2 can be removed by scrubbing or by filtration and when O_2 is needed it is done through fresh air intake from outside ambient air.

Container MA is very dependent on container air tightness to prevent O_2 from ambient leaking in which would compromise O_2 pulldown to proper O_2 setpoint values.

Benefits of CA

CA and MA works by slowing down respiration and metabolic activity thereby delaying undesirable changes in the commodity. These two actions can bring about several benefits to the commodity itself, and to its commercialization.

Direct potential benefits on the commodity:

1. Slow down and retard ripening
2. Retard decay and spoilage and reduce its incidence and severity
3. Slow down senescence and deterioration of visual appearance
4. Maintain firmness, structure, and texture
5. Retard undesirable color changes
6. Reduce sensitivity to ethylene and its action
7. Mitigate chilling injury symptoms, allowing shipping with lower temperatures on certain fruits and vegetables
8. Alleviate certain physiological disorders most of which cause discolorations
9. Reduce moisture loss and consequently quality loss (e.g. wrinkling) and loss of mass
10. Retard loss of sensory quality attributes such as flavor and aroma
11. Reduce loss of nutritional and compositional quality
12. Improve ripening uniformity at destination
13. *Allows for mature and more ripe fruit to be transported
14. Strict CA conditions during transport extend shelf life after transport

Potential commercial benefits:

1. Allow products to reach new and more distant markets
2. Allow greater selection of fresh produce to consumers around the globe
3. Protects quality and condition when routes are extended because of additional port stops
4. Less expensive option compared to air freight
5. Maintains more uniform and consistent quality on arrivals to destination markets
6. Lose less weight and capital

* The potential benefit depends on several variables and needs to be taken with great caution as postharvest and transit life potential could be reduced.

Risks and Limitations of CA

The risks and hazards that can occur when transporting commodities CA or MA will happen if recommendations for optimal and safe O_2 and CO_2 levels are not followed, and commodities are exposed to lower than safe O_2 and / or higher than safe CO_2 that will cause damage. Not following optimum and minimum safe temperature recommendations will also affect CA and MA performance ultimately reducing the beneficial aspects on the commodity.

It is important to understand the tolerance of every commodity to the low O_2 and high CO_2 levels that are to be used during transport. Shippers need to be aware that:

1. The limit of tolerance to low O_2 is higher as transport temperature and / or duration increases because O_2 requirements for aerobic respiration of the product increase with higher temperatures

2. Tolerance limits to elevated CO_2 decrease with a reduction in O_2 level and, similarly, the tolerance limits to reduced O_2 decrease with the increase in CO_2 level

CA and MA can be very effective supplements to proper handling practices and proper temperature management, but they are not an insurance against poor initial product quality and condition, poor handling practices, inadequate pre-cooling and cooling, improper packaging, breakage in the cold chain, or exposing the commodity to suboptimal temperatures for periods of time.

CA / MA Requirements and Recommendations

The requirements and recommendations given herein refer to Container CA / MA and do not include suggestions for Modified Atmosphere Packaging (MAP).

Proper temperature management is the most important variable for best transit life potential* of any fresh commodity, and CA is the best supplement to proper temperature management for maximum transit life extension.

Under certain circumstances and for some commodities, transport at slightly higher temperatures than minimum safe can still add enough transit life potential* providing quality is optimal and commodity was pre-cooled properly. In these cases it is important to consider very carefully the trip length and the time from harvest to delivery, to port of destination to make the judgement if a slightly higher temperature than minimum safe setting is possible and will still provide sufficient transit life potential*.

To re-iterate, adequate management of these two variables would not be meaningful if the product being shipped is not at its maximum quality and condition potential, when shipped.

Best postharvest handling practices must be followed at packing houses, to loading into a refrigerated container and delivering to shipping lines, to ensure that the commodities are at their best possible quality and condition.

The key parameters to pay attention to in packing house operations include harvesting at the proper maturity and age, sanitation, removal of decayed product, handling with care, cooling the product as soon as possible after harvest to remove the field heat that has accumulated on the product, maintaining the product at the recommended minimum safe temperature, proper packing, expediting the process from harvest, to loading correctly into the refrigerated container for transport.

Precooling is crucial to maximizing postharvest life and maintaining quality and condition. Commodities should be precooled as soon as possible after harvest to remove field heat and to slow down metabolic activity. It is imperative that precooling cools down the product as quickly as possible and brings the temperature down to the minimum safe temperature for each commodity.

Refrigerated containers are not generally designed to cool down the product and to bring down pulp temperature effectively, because they do not have the refrigeration nor the air circulation capacity required. Refrigerated containers are designed to maintain the temperatures of already cooled products. Therefore, if products such as bananas, some citrus, and some tropical fruits are not normally precooled and are loaded warm, it will take several days to cool it down to setting values. During this temperature pulldown period to setting values CA / MA can start protecting the product once the recommended O_2 / CO_2 levels are established, but will not maximize benefits until both temperature and O_2 / CO_2 reach recommended setting values.

In order to obtain the maximum transit life potential*, the best handling practice when processing fruits and vegetables through a packing house is to harvest, process, precool, and load the container within the same day, and maintain the cold chain until loaded at the port onboard the vessel.

Mixing warm and cold products into the same container is bad practice. Carryover from one day to the next (not completing loading of the container on the same day) can result in loading warm and cold product the following day, which compromises product condition, firmness, and transit life potential* (unless both cargo loads being mixed, are managed with strict temperature control and are loaded at the exact same temperature the following day).

Loading the refrigerated container is also key to ensuring that the cargo is properly stowed and no warm air nor ethylene from the outside are introduced inadvertently during the operation. Stowing a tight load and ensuring proper cooling air circulation around and through the cargo will optimize cooling and maximize the benefits of CA or MA.

When shipping with CA, the product must be packed in plastic bags, liners, or clam shells, that need to be perforated. Sealed bags or MA packaging cannot be used together with CA / MA as the product will very likely asphyxiate under a double CA / MA. Plastic bags with minimum amount of ventilation allows for proper levels of O_2 and CO_2 to be established and maintained, without the risk of asphyxiation of the product and this can be beneficial in reducing water loss and dehydration in transit. Sealed pallets without proper perforation can increase moisture loss.

Product in any type of plastic bag or liner needs to be handled under very strict temperature control and management during transport because any fluctuations in temperatures will result in condensation on the plastics' inner surface and consequently on the product, which will favor decay.

Fruit waxing is the process of removing the natural wax of, for instance apples and citrus, followed by adding a coating of a biological or petroleum derived wax. The primary reasons for waxing are to prevent water loss and improve appearance. Waxing will, however, hinder gas exchange, and is therefore less or not suitable for CA applications. The key parameters to pay attention to in packing house operations include harvesting at the proper maturity and age, sanitation, removal of decayed product, handling with care, cooling the product as soon as possible after harvest to remove the field heat that has accumulated on the product, maintaining the product at the recommended minimum safe temperature, proper packing, expediting the process from harvest to loading correctly into the refrigerated container for transport.

Certain commodities can be mixed together in the same container provided they have the same requirements and are fully compatible with regards to temperature settings, O_2/ CO_2 settings, RH settings, neither commodity is sensitive to ethylene nor produce ethylene, and they will not transfer undesirable aromas among each other.

Regardless of which CA or MA system is used, the atmosphere inside a reefer container under CA can vary according to several variables including type of product, variety, commodity maturity and ripeness stage, amount of product, load mix, temperature of the product, packaging, loading and stowage patterns, void volume, leak rate of the container, and time in transit. Growers and shippers need to consider all these variables when they prepare their product for shipment under CA / MA and when they select the levels of O_2/ CO_2 to be used in transit.

For refrigerated containers to successfully reach and maintain optimum O_2/ CO_2 levels under CA / MA conditions, they need to be prepared and be CA-ready. There is a check list of requirements for a given refrigerated container to be eligible for atmospheric modification which include: adequate structure and integrity, good air supply front, venting plats can close air tight, floor drains can be securely plugged, seals and gaskets are undamaged, existing relief valves can be closed and sealed, a plastic curtain can be installed at the door and sized and seal properly, tracks for the plastic curtain are undamaged, and the container meets the positive pressure requirements.

Some countries demand quarantine treatments on several fruits to allow them to enter their territory. Those quarantine treatments whether heat or cold have a damaging effect on these fruits and CA or MA can help maintain better quality and condition in transit, to some extent. In a many of these cases, the lowest value of the recommended O_2% and the highest value of the recommended CO_2% may be more effective.

CA and MA may provide a slight residual effect on fresh commodities after arrival to destination markets and transferring the product to regular air, which could be translated into slightly better shelf life (maintenance of desirable color and firmness, and delayed decay). Generally, the lower the concentration of O_2 and the higher the concentration of CO_2 (within the tolerance limits of the commodity), and the longer the exposure to CA / MA conditions, the more noticeable those residual effects might be. In some cases CA / MA may not extend shelf life per se but it may still confer certain benefits such as mitigate chilling injury or maintain firmness of some fruits.

The use of CA on nuts and dried commodities (for insect control and quality maintenance, including prevention of rancidity) is increasing, as it provides an excellent substitute for chemical fumigants (such as Phosphine).

Operators and personnel involved in handling containers using CA / MA need to be instructed that CA / MA produce an atmosphere that can be deadly to humans and that breathing an oxygen-depleted atmosphere, even for a few seconds, induces rapid unconsciousness and may result in death. Adequate warning and safety systems must be in place and the safety requirements should extend to those unloading cargoes. Proper ventilation prior to entering containers and training of workers are essential.

Ethylene Removal

Ethylene is the simplest vegetable hormone and is produced by all plants, fruit, vegetables, and flowers. Ethylene is used to artificially ripen climacteric fruits at destination markets, after shipping, to achieve a uniform commercial quality.

The so-called climacteric is the final physiological process that marks the beginning of fruit ripening and senescence. The climacteric burst is associated with increased ethylene production and a rise in respiration rate. Apples, bananas, blueberries, melons, apricots, and tomatoes, among others, are climacteric fruits; citrus, grapes, and strawberries are not climacteric. CA conditions will postpone the climacteric by greatly reducing the production of ethylene and the commodity's sensitivity to it. It can be interpreted as a 'point of no return'. Ethylene is undesirable in transit around fresh produce cargo in reefer containers as it can trigger many negative responses such as ripening, decay, loss of firmness, color changes, sprouting, and physiological disorders.

The source of ethylene inside refrigerated containers can either be ethylene being produced by the commodity being shipped or external contamination upon loading the cargo into the container. Whatever the source of ethylene is, it is imperative to prevent ethylene around fresh produce in transit.

Fresh commodities can be categorized based on the amount of ethylene they produce. Although it is more obvious to take preventive actions to avoid ethylene from being produced inside the container by high and moderate ethylene producers, it is just as important to consider that even those commodities that produce little or very little ethylene could produce significant amounts of it if they are wounded or have any type of physical injury. Careful handling of all commodities and very strict selection process before packing are crucial to limit the risk of ethylene being produced in transit.

In order to avoid external ethylene from being introduced inadvertently into containers while loading them it is important to comply with the following practices:

1. When a refrigerated closed dock can be used for loading: make sure the container is tightly attached to the bay / doors of the dock, use only electrical operated fork lifts, do not use those operated by gas, diesel or gasoline

2. When no refrigerated closed docks are available and the cargo is loaded in open air (as is the case in banana, some citrus, and many tropical, operations): do not run the refrigeration unit of the container while loading as the evaporator will pull warm air and ethylene that might be around (sources of ethylene can be combustion engines, any type of smoke, decaying organic material, fluorescent ballasts)

It is important to be aware that perishables that are sensitive to ethylene and are exposed to it prior to loading and shipping during temporary storage, could start ripening or start decaying while in transit, which would result in lesser transit life potential.

Therefore, these commodities should not be held or stored in conditions that can favor exposure to ethylene. Such facilities where perishables can be held temporarily before shipment such as stage rooms, cold rooms, or warehouses need to be separate for ethylene producers and ethylene sensitive commodities. Additionally, cooling air from rooms with ethylene producers should not cause cross contamination with rooms with ethylene sensitive commodities through ventilation and exhausters.


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Optimum Transport Recommendations

The proposed conditioning for the different commodities is based on scientific results and publications. In most cases a condition range is given. The reason for this is that optimal conditions can depend on a number of pre-harvest and post-harvest factors, such as: cultivation location, picking date, climate and maturity stage. In short, fruit has a history before being transported that can determine optimal conditions during transport. In case of doubt, please contact Carrier Transicold.

Apple – Braeburn

Optimum Temperature: 1.0°C
Optimum CA levels: O_2: 1.5-2.0%, CO_2: 0.5%
Weeks in Air: 3-4
Weeks in CA: 8-10
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can reduce core flush, core browning, scald, and maintain firmness and acidity.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
High CO_2 can result in brown heart symptoms. Conditioning in air at 0°C for 2 weeks prior to CA storage can reduce the expression of the disorder.

Apple – Cortland

Optimum Temperature: 3.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 1.5-3.0%
Weeks in Air: 2-3
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening and maintains firmness.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Chilling sensitive <2°C. Cortland apples are susceptible to senescent breakdown and high CO_2 injury. They require a scald inhibitor.

Apple – Empire

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: <1.0%
Weeks in Air: 2-3
Weeks in CA: 5-10
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening and maintains firmness and acidity.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
O_2 <1.5% can cause flesh browning. Empire apples from New York may undergo internal breakdown if stored more than 5 months at 0°C. Empire apples from different regions may vary in their sensitivity to temperature and CO_2. A scald inhibitor is not required.

Apple – Fuji

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 1.0%
Weeks in Air: 14-16
Weeks in CA: 44-48
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 retards ripening, maintains firmness, and prevents scald.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Fuji apples are particularly prone to water core and scald. Fujis are sensitive to CO_2 and late season fruit may develop internal injury at levels >2-3%.

Apple – Gala

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0%
Weeks in Air: 8-12
Weeks in CA: 20-24
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 retards ripening, maintains firmness, and prevents scald.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
At O_2 levels <1.5% ribbon scald may develop. Gala apples from some geographic areas experience less breakdown with high CO_2 > 3-5%, but apples from other areas develop CO_2 injury at concentrations > 2%.

Apple – Golden Delicious

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0-3.0%
Weeks in Air: 12-16
Weeks in CA: 32-40
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, acidity, skin color, and reduces core flush.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Low O_2 <1% can result in off-flavors. High CO_2 >5% can result in CO_2 injury. Golden Delicious apples are susceptible to scald, shrivel and ribbon scald. Golden Delicious apples grown in different regions vary in their tolerance to CO_2.

Apple – Granny Smith

Optimum Temperature: 1.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 1.0%
Weeks in Air: 12-16
Weeks in CA: 40-44
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, acidity, and skin color. Reduces incidence of scald and core flush.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
O_2 <1% for more than 10 days can result in off-flavors, ribbon scald and core browning. High CO_2 >1% if O_2 <1.5% or >3% if O_2 >2% can result in severe core flush.

Apple – Idared

Optimum Temperature: 1.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0-3.0%
Weeks in Air: 3-4
Weeks in CA: 28-36
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, acidity, skin color, and reduces core flush.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
European Idared apples are chilling sensitive <3°C. North American Idareds may be kept at 0°C. Idareds are susceptible to core flush. They may develop Jonathan Spot in hot summers.

Apple – Jonagold

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 1.3-2.0%, CO_2: 2.0-3.0%
Weeks in Air: 2-3
Weeks in CA: 20-28
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, acidity and taste.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
O_2 <1% may result in off-flavors . CO_2 >5% may result in flesh browning.

Apple – Jonathan

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 1.5-3.0%, CO_2: 2.0-3.0%
Weeks in Air: 1-4
Weeks in CA: 8-28
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, acidity and taste. May reduce incidence of Jonathan Spot and ribbon spot.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
O_2 <1% may result in off-flavors and core browning. CO_2 >5% may result in flesh browning. CO_2 of 3-5% is recommended if O_2 is >2%. The higher CO_2 can reduce Jonathan spot but can also increase core flush. European Jonathan apples are chilling sensitive and should be held at 3°C.

Apple – McIntosh

Optimum Temperature: 3.0°C
Optimum CA levels: O_2: 1.5%, CO_2: 2.0%
Weeks in Air: 8-12
Weeks in CA: 20-28
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness, and acidity.

Treatment Before Shipping:
Conditioning with low O_2 (1-1.5%) followed by higher O_2 (2-3%) lessens risk of O_2/CO_2 injury.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
McIntosh apples from some countries are particularly prone to scald. Too low O_2 can result in corky browning, skin discoloration, flesh browning and off-flavors. High CO_2 >5% continuously or >15% for short periods can cause core flush and CO_2 injury. McIntosh apples are sensitive to low temperatures and can develop core flush if kept too cold. They may also develop ribbon scald in low O_2.

Apple – Mutsu

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 1.5%, CO_2: 2.0-3.0%
Weeks in Air: 3-4
Weeks in CA: 24-32
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening and maintains firmness.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Mutsu apples can develop flesh browning and off flavors at $CO_2 > 5\%$ and $O_2 < 2\%$.

Apple – Red Delicious

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0%
Weeks in Air: 12-16
Weeks in CA: 44-48
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening and maintains firmness and acidity. Helps reduce scald.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Red Delicious apples have been reported in Australia to become very sensitive to CO_2 >1% when in low O_2 <1%. This may result in off-flavors. CO_2 >3% may cause internal browning. Red Delicious apples are susceptible to scald, flesh browning, and watercore.

Apple – Spartan

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 2.0-3.0%
Weeks in Air: 3-4
Mpnths in CA: 24-32
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening, maintains firmness and acidity.

Special Treatments Before Shipping:
Spartan apples are prone to breakdown if calcium level is <4mg/100g fresh weight. Adequate calcium content is imperative.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Spartan apples will develop off-flavors in O_2 <1.5%. They may develop core flush and CO_2 injury in CO_2 >3%. Susceptible to skin shrivel.

Apple – Stayman

Optimum Temperature: 1.0-2.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 2.0%
Weeks in Air: 2-3
Weeks in CA: 20-28
Relative Humidity: 90-95%

Benefits of CA:
Retards ripening and maintains firmness and acidity.

Ethylene:
Apples produce moderate amounts of ethylene and are sensitive to it. Ethylene may accelerate loss of firmness, senescence, and may increases susceptibility to scald. Avoiding ethylene in transit can help extend transit life.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Apples may absorb aromas from onions, garlic, and potato.

Cautions:
Spartan apples can develop off-flavors in O_2 <1.5%. They may develop core flush and CO_2 injury in CO_2 >5%. Scald inhibitor is essential. Susceptible to skin shrivel.

Apricot

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 2.0-3.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening. Elevated CO_2 can delay softening.

Special Treatments Before Shipping:
Exposure to 20% CO_2 for 2 days can delay decay incidence during subsequent transit/ storage in CA or air.

Varietal Differences:
There appear to be varietal differences in tolerance to CA. Some Japanese varieties appear to be chilling sensitive at 5°C, though not at 0°C (internal breakdown or browning).

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 <1% can cause off-flavors. CO_2 >5% can cause flesh browning and loss of flavor.

Green Asparagus

Optimum Temperature: 0.0-2.0°C
Optimum CA levels: O_2: 10.0-15.0%, CO_2: 10.0-15.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 is not beneficial for asparagus. Elevated CO_2 can help maintain tenderness and green color, and retard development of soft rot. 10% O_2 + 10% CO_2 is beneficial for long distance shipments.

Special Treatments Before Shipping:
Hydrocooling is the best pre-cooling method for asparagus. Asparagus should be kept vertical so that the spears do not bend as they continue to elongate after harvest. Brief exposures to 20% CO_2 can reduce soft rot at the butt end. Spears tolerate insecticidal treatments with 60% CO_2 for 4 days at 0°C.

Ethylene:
Asparagus produces very little ethylene but is sensitive to it. Avoiding ethylene in transit will help prevent toughening of spears and help extend transit life potential.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 10% can cause discoloration of the spear. CO_2 >10% at 3-6°C and >15% at 0-3°C can increase elongation of the spears, weight gain, and sensitivity to chilling and pitting. Asparagus is sensitive to chilling at <2-3°C for longer than 4 weeks.

Avocado

Optimum Temperature: 5.0-8.0 °C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 4.0-10.0%
Weeks in Air: 2-4
Weeks in CA: 4-6
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 and elevated CO_2 can delay ripening, softening and decay. Elevated CO_2 can reduce the symptoms of chilling injury and may allow shipping at lower temperatures.

Maturity Index:
Percent (%) Dry Matter (DM) is highly correlated with oil content and is used as maturity index criteria at harvest. For Hass avocado which amounts for most the of global export volumes, minimum % DM is 20.8% although it fluctuates between 18-30% depending on production area/country so index needs to be adjusted. The higher the DM the lower the transit life potential* and therefore CA levels need to be adjusted accordingly.

Ethylene:
Avocadoes produce moderate to large amounts of ethylene and are quite sensitive to it. Ethylene accelerates ripening and softening, and increases sensitivity to chilling. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
Cultivars of avocado differ in their chilling sensitivity and in low O_2 and high CO_2 tolerance. Hass, Fuerte, and Booth 7 are chilling sensitive <7°C. However, they may be held in CA at temperatures as low as 5°C. Fuchs, Pollock cultivars are very sensitive to chilling <12°C. Lula, Booth 1, Booth 8, Taylor cultivars are sensitive to chilling <5°C.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities. Pineapples may absorb aromas from avocados.

Cautions:
O_2 <1% and/or. CO_2 > 10% can cause off-flavors and flesh (O_2) or skin (CO_2) browning.

Banana

Optimum Temperature: 13.3-14.5°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-6.0%
Weeks in Air: 2-4
Weeks in CA: 4-6
Relative Humidity: 85-95%

Benefits of CA:
Low O_2 and/or elevated CO_2 can delay ripening, retard decay, maintain firmness, and reduce peel split.

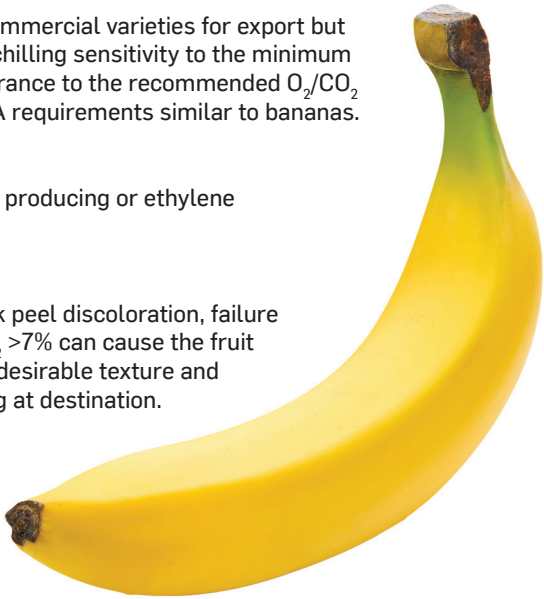
Ethylene:
Bananas produce low amounts of ethylene but are quite sensitive to it. Ethylene accelerates ripening, color changes, softening, and decay. Avoiding ethylene in transit will help prevent premature ripening and can extend transit life potential*.

Special Treatments Before Shipping:
Only effective control against anthracnose is adequate sanitation in the field and the packing plant, and careful handling during harvest, hauling to packing plant, and processing to avoid wounding to the peel. Fungicide application to the crown will delay development of crown mold.

Varietal Differences:
There are no more than a handful commercial varieties for export but there might be slight differences in chilling sensitivity to the minimum safe temperature of 13.3°C, and tolerance to the recommended O_2/CO_2 indicated settings. Plantains have CA requirements similar to bananas.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 <1.5% can cause dull brown/black peel discoloration, failure to ripen properly and off-flavors. CO_2 >7% can cause the fruit to soften while still green, confer undesirable texture and flavor, and prevent adequate ripening at destination.



Bean, Snap

Optimum Temperature: 5.0-7.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 4.0-7.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 95-98%

Benefits of CA:
Low O_2 and elevated CO_2 reduce color loss and discoloration due to physical injury.

Ethylene:
Beans produce very little ethylene but are sensitive to it. Ethylene enhances yellowing and browning. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
The discoloration of broken beans awaiting processing can be reduced by holding them in 20-30% CO_2 and 8-10% O_2 for 24 hours.

Varietal Differences:
Bean cultivars may differ significantly in their sensitivity to chilling. Some cultivars may be held in CA at temperatures as low as 5°C. Others will experience chilling injury <7.2°C.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 <2% or CO_2 >7% can cause off-flavors. Sensitive to chilling <5-7°C. Symptoms may appear only after transfer to warmer room temperatures. Russeting is aggravated by free moisture.

Bell Pepper

Optimum Temperature: 7.0-10.0°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 2.0-5.0%
Weeks in Air: 2-4
Weeks in CA: 3-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 retards ripening. Elevated CO_2 may help retain green color and delay decay.

Ethylene:
Peppers produces very little ethylene but are moderately sensitive to it. Ethylene can enhance decay. Avoiding ethylene in transit will help prevent premature senescence and help extend transit life potential*.

Special Treatments Before Shipping:
Most bell peppers are waxed and this prevents abrasion injury as well as moisture loss.

Mixed Loads:
Should not be shipped with ethylene producing commodities. Pineapples absorb pepper odors so the two should not be shipped together.

Cautions:
O_2 <2% can cause tissue breakdown and off-odors. CO_2 >5% can result in calyx discoloration, internal browning, and increased softening. Peppers are sensitive to chilling <7°C.

Blackberry

Optimum Temperature: -0.5-0.5°C
Optimum CA levels: O_2: 5.0-8.0%, CO_2: 10.0-18.0%
Weeks in Air: <1
Weeks in CA: 1-2
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can delay softening. High CO_2 can prevent or delay decay (botrytis mold). CA will reduce respiration and consequently water loss and dehydration.

Ethylene:
Blackberries are not sensitive to ethylene. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Blackberries can be shipped with other commodities in mixed loads with same temperature and CA requirements.

Cautions:
Blackberries are very susceptible to water loss and dehydration which accelerates decay and softening. O_2 <2% or CO_2 >25% can cause off flavors.

Blueberry

Optimum Temperature: -0.5-0.5°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 12.0-20.0%
Weeks in Air: 1-3
Weeks in CA: 8-10
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 retard ripening. High CO_2 can maintain firmness, and prevent or delay decay (botrytis mold). CA reduces respiration and consequently water loss and dehydration.

Ethylene:
Blueberries are not very sensitive to ethylene. However, avoiding ethylene in transit may help retard decay and can help extend transit life potential*.

Special Treatments Before Shipping:
Handling of blueberries should be minimized to prevent damage to the bloom (waxy blush) which maintains healthy fruit and helps reduce dehydration.

Varietal Differences:
Different varieties can have different tolerances to high CO_2 levels, which can affect flavor and taste.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements. Sensitive varieties should not be shipped with ethylene producing commodities.

Cautions:
Blueberries are very susceptible to water loss and dehydration which accelerates decay and softening. O_2 <1.5% can cause off-flavors. CO_2 >25% can cause skin browning and off-flavors.

Broccoli Florets

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 6.0-7.0%
Weeks in Air: 1-2
Weeks in CA: 2-5
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 and elevated CO_2 can delay yellowing of flower buds and suppress the growth of decay- causing fungi. CA may also help preserve vitamins C and A.

Ethylene:
Broccoli produce very little ethylene but is sensitive to it. Ethylene enhances yellowing and browning of the buds. Avoiding ethylene in transit can help prevent this and extend transit life potential*.

Mixed Loads:
Broccoli should not be shipped with ethylene producing commodities.

Cautions:
CO_2 >15% or O_2 <1% can cause persistent off odors.

Brussels Sprouts

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 1.0-5.0%, CO_2: 5.0-7.0%
Weeks in Air: 3-5
Weeks in CA: 4-6
Relative Humidity: 95-98%

Benefits of CA:
Low O_2 and elevated CO_2 may help reduce yellowing and retard decay.

Ethylene:
Brussels sprouts produce low to moderate amounts of ethylene and are sensitive to ethylene. Avoiding ethylene in transit will help prevent yellowing and extend transit life potential*.

Mixed Loads:
Brussels sprouts should not be shipped with ethylene producing commodities.

Cautions:
O_2 <1% or CO_2 >10% can cause internal discoloration and off-odors.

Cabbage

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 3.0-7.0%
Weeks in Air: 3-6
Weeks in CA: 5-8
Relative Humidity: 95-98%

Benefits of CA:
Low O_2 reduces loss of green color. Elevated CO_2 reduces decay and sprouting.

Ethylene:
Cabbage produces very little ethylene but is sensitive to it. Avoiding eternal ethylene in transit will help prevent leaf abscission, loss of green color, and extend transit life potential*.

Varietal Differences:
Red and Savoy cabbage require similar conditions. However, response to CA varies by cultivar and exposure duration. Firmness and chlorophyll of Chinese cabbage are retained at 1% O_2 and 1% CO_2.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 <2% can cause off-flavors and increased sensitivity to freezing. CO_2 >10% can cause off odors, and discoloration of inner leaves and apex.

Cactus Pear (Prickly Pear)

Optimum Temperature: 5.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0-5.0%
Weeks in Air: 2-5
Weeks in CA: 4-7
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 can delay ripening , decay, and maintain visual quality.

Ethylene:
Prickly pears produce very little ethylene and are not sensitive to it. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
O_2 <1% or CO_2 >10% can cause off-flavors and discoloration.

Cantaloupe

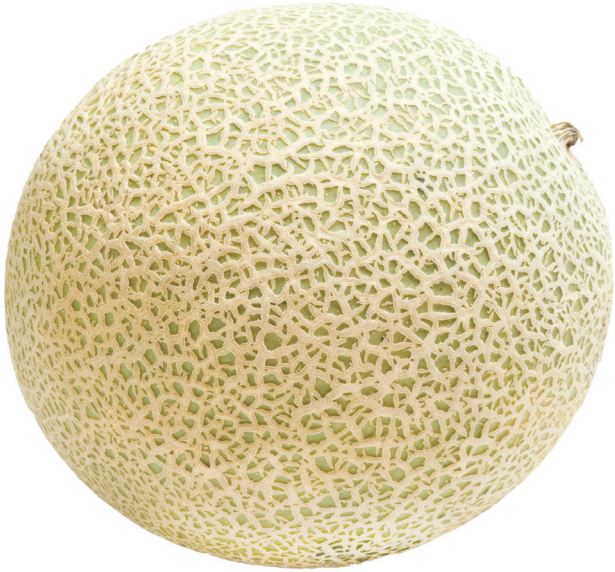
Optimum Temperature: 2.0-3.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 10.0-15.0%
Weeks in Air: 2-3
Weeks in CA: 4-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 retards ripening. Elevated CO_2 reduces decay, sugar loss, and slows ripening.

Ethylene:
Cantaloupes produce ethylene and are moderately sensitive to it. Ethylene will accelerate ripening and depletion of sugars affecting taste and flavor quality. Avoiding ethylene in transit will help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O2 <1% or CO_2 >20% can cause impaired ripening, off-flavors and off-odors. CO_2 >10% can cause a carbonated taste, but the off flavor dissipates during subsequent air storage. Cantaloupes are slightly sensitive to chilling under 2.5°C, depending on maturity at harvest.



Cauliflower

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 3.0-4.0%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 may aid in maintaining white curd and green leaves as well as reduce weight loss and curd spotting. Cauliflower does not benefit from high CO_2.

Ethylene:
Cauliflower produces very little ethylene but is sensitive to it. Ethylene may cause yellowing of the leaves. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 <2% or CO_2 >5% can cause persistent off-flavors and off-odors after cooking.

Celery

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-4.0%, CO_2: 3.0-5.0%
Weeks in Air: 4-7
Weeks in CA: 5-9
Relative Humidity: 95-98%

Benefits of CA:
Low O_2 delays senescence and discoloration of damaged tissue. Elevated CO_2 delays decay development, and discoloration due to physical injury.

Ethylene:
Celery produces very little ethylene but is sensitive to it. Ethylene may cause yellowing of leaves. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Celery is extremely sensitive to water loss and dehydration and wilting is a major cause of quality loss. Very high RH is essential. And bagging celery with lightly perforated plastic will benefit this commodity.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions: O_2 <1% or CO_2 >10% can cause persistent off-flavors and off-odors as well as internal brown discoloration.

Cherimoya

Optimum Temperature: 12.0-13.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-10.0%
Weeks in Air: 2-4
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can retard ripening, maintain firmness, and delay discoloration.

Ethylene:
Cherimoyas produce substantial amounts of ethylene, and are sensitive to it. Ethylene accelerates ripening color changes and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 <1% and CO_2 >10-12% may cause off-flavors. Chilling injury can occur <9-10°C depending on maturity.

Cherry, Sweet

Optimum Temperature: 0.0-2.0°C
Optimum CA levels: O_2: 3.0-8.0%, CO_2: 10.0-14.0%
Weeks in Air: 3-4
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can maintain firmness. Elevated CO_2 can delay decay, maintain juiciness and turgidity, and maintain a fresh appearance.

Ethylene:
Sweet cherries produce very little ethylene and are not sensitive to it. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
O_2 <1% can cause skin pitting and off-flavors. CO_2 >30% can cause skin browning and off-flavors.

Corn, Sweet

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-10.0%, CO_2: 5.0-15.0%
Weeks in Air: 1-2
Weeks in CA: 3-4
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 reduces loss of sugars. Elevated CO_2 reduces growth of mold on husks and reduces loss of sugar from kernels and loss of chlorophyll from husks

Ethylene:
Sweet corn produces very little ethylene and is not sensitive to it. Ethylene removal in transit is not generally necessary*.

Special Treatments Before Shipping:
Sugar to starch conversion occurs rapidly after harvest and this process is significantly reduced by cooling to near 0°C as soon and quickly as possible (hydrocooling preferred).

Varietal Differences:
The newer super sweet varieties (reduced starch forming enzyme) lose sugar more slowly than traditional varieties and may benefit only little from CA on this parameter.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements. Corn will absorb odors from green onions.

Cautions:
O_2 <2% or CO_2 >15% may cause off flavors and odors.

Cucumber

Optimum Temperature: 10.0-12.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 3.0-7.0%
Weeks in Air: 1-2
Weeks in CA: 3-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 delays senescence and chlorophyll loss. Elevated CO_2 is not too beneficial to cucumbers, it may retard yellowing.

Ethylene:
Cucumbers produce very little ethylene but are sensitive to it. Avoiding ethylene in transit will help prevent yellowing and extend transit life potential*.

Special Treatments Before Shipping:
Cucumbers for the fresh market are usually waxed or wrapped in shrink-film to prevent moisture loss and shriveling.

Mixed Loads:
Should not be shipped ethylene with producing commodities.

Cautions:
Cucumbers are sensitive to chilling <10°C. O_2 <1% can cause off-odors, tissue breakdown, and increased sensitivity to chilling injury. CO_2 >9-10% can increase softening rate and cause surface discoloration and pitting.

Dragon Fruit (Pitahaya)

Optimum Temperature: 8.0-10.0°C
Optimum CA levels: O_2: 3.0-4.0%, CO_2: 5.0-7.0%
Weeks in Air: 2-4
Weeks in CA: 3-6
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 and high CO_2 can delay ripening and peel discoloration.

Ethylene:
Dragon fruits produce very little ethylene and are not sensitive to it. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
Can develop chilling symptoms < 7-8°C. O_2 < 2% can result in failure to ripen and gray discoloration. High CO_2 > 5% can cause discoloration. Peel is highly sensitive to abrasion and compression injury.

Durian

Optimum Temperature: 12.0-14.0°C
Optimum CA levels: O_2: 4.0-5.0%, CO_2: 5.0-15.0%
Weeks in Air: 1-5
Weeks in CA: 4-7
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 can delay ripening and senescence. CA can reduce production of sulfurous odor.

Ethylene:
Durians can produce large amounts of ethylene depending on maturity stage, and are sensitive to it. Ethylene accelerates ripening and spoilage. Avoiding ethylene in transit can retard this and help extend transit life potential*.

Mixed Loads:
Durian produce a sulfurous odor as they ripen that will be absorbed by other commodities. Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 < 2% can result in failure to ripen and gray discoloration of the pulp. High CO_2 > 20% can cause discoloration and affect ripening.

Fig

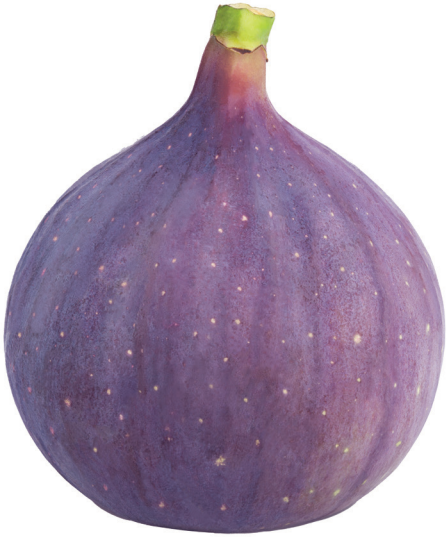
Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 12.0-17.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 and elevated CO_2 help maintain firmness and reduce decay.

Ethylene:
Figs produce moderate amounts of ethylene and are moderately sensitive to it. Ethylene may accelerate ripening. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Can be shipped in mixed loads as long as the other commodities are compatible in temperature and/or CA levels, and produce none or very little ethylene.

Cautions:
O_2 < 2% or CO_2 > 15% can cause off-flavors.



Flower - Carnation

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 1.5-3.0%, CO_2: 2.0-10.0%
Weeks in Air: 2-6
Weeks in CA: 6-12
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 retards deterioration. Elevated CO_2 reduces sensitivity to ethylene

Ethylene:
Carnations are among the most ethylene- sensitive commodities. Ethylene levels as low as 30-60 parts per billion can cause in-rolling of carnation petals (called 'sleepiness') and shorten the postharvest life of the flowers. Carnations should never be kept in proximity to ethylene-producing commodities. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Carnations suitable for long- distance transportation are best harvested at the tight-bud stage. Carnations are often pulsed with silver thiosulfate to reduce ethylene sensitivity and damage.

Varietal Differences:
There are important differences among carnation varieties in their ethylene sensitivity, response to controlled atmospheres (beneficial, neutral - no beneficial, or injurious), and postharvest life. Shipping conditions should be guided by experience with the variety. Shipment of loads of mixed carnation flower varieties, which would be the most common practice, should be guided by experience with each type of flower.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Low O_2 may cause leaf discoloration. Studies of the use of CA with carnations have yielded mixed results depending on conditions and variety tested. Unless CA for a given variety has been evaluated and shown to be beneficial, CA is not recommended.

Flower - Chrysanthemum

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 1.5-2.0%, CO_2: 0.0-2.0%
Weeks in Air: 2-4
Weeks in CA: 2-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 delays loss in chlorophyll and maintains greener leaves

Ethylene:
Chrysanthemums produce little ethylene but are moderately sensitive to it. Ethylene can cause acceleration of bud opening and leaf abscission. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Pulsing or loading stems with a preservative solution for 16 hours before shipping is beneficial in extending longevity after shipment. Preservatives containing 5% sucrose and some biocides have been shown to be effective for pulsing.

Varietal Differences:
There are important differences among chrysanthemum varieties in their ethylene sensitivity, response to controlled atmospheres (beneficial, neutral - no beneficial, or injurious), and postharvest life. Shipping conditions should be guided by experience with the variety. Therefore, shipment of loads of mixed chrysanthemum flower varieties, which would be the most common practice, should be guided by experience with each type of flower.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Low O_2 may cause petal browning. For some varieties, there may be no benefit from CA. For some varieties, deterioration after storage may be faster for CA-stored flowers than for those stored in air.

Flower - Gladiolus

Optimum Temperature: 0.0-3.0°C
Optimum CA levels: O_2: 1.0-3.0%, CO_2: 0.0-5.0%
Weeks in Air: 1-3
Weeks in CA: 1-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay deterioration.

Ethylene:
Gladiolus produce little ethylene. Exposure to ethylene does not affect opened florets but can reduce flower life causing abortion of unopened buds. Avoiding ethylene in transit can help extend transit life potential *

Special Treatments Before Shipping:
Spikes should always be packed and shipped vertically to prevent bending. Gladiolus benefit from a pulse treatment with 20% sucrose plus a biocide to suppress bacterial growth.

Varietal Differences:
There are important differences among gladioli varieties in their ethylene sensitivity (unopened buds), response to controlled atmospheres (beneficial, neutral - no beneficial, or injurious), and postharvest life. Shipping conditions should be guided by experience with the variety. Therefore, shipment of loads of mixed gladioli flower varieties, which would be the most common practice, should be guided by experience with each type of flower.

Mixed Loads:
Gladiolus may be shipped with other commodities if florets are opened as long as there is compatibility in temperature and/ CA requirements.

Cautions:
O_2 < 1% or CO_2 > 5% may cause leaf discoloration.

Flower - Rose

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 1.5-3.0%, CO_2: 5.0-10.0%
Weeks in Air: 1-2
Weeks in CA: 1-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can slow bud opening, retard decay and extend flower life.

Ethylene:
Some Rose cultivars are sensitive to ethylene which can cause acceleration or inhibition of bud opening and leaf abscission. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
On removal from container and/or truck at destination markets, roses should be recut and conditioned in preservative solution at 4-6°C for at least 3 hours.

Varietal Differences:
There are important differences among rose varieties in their ethylene sensitivity, response to controlled atmospheres (beneficial, neutral - no beneficial, or injurious) and postharvest life. Shipping conditions should be guided by experience with the variety. Therefore, shipment of loads of mixed rose flower varieties, which would be the most common practice, should be guided by experience with each type of flower.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Low O_2 may cause leaf discoloration. High CO_2 may cause petals to turn a blueish color.

Garlic

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 5.0-10.0%
Weeks in Air: 16-24
Weeks in CA: 16-24
Relative Humidity: 60-70%

Benefits of CA:
Low O_2 may extend storage life. Elevated CO_2 may help reduce sprouting and root growth.

Ethylene:
Garlic produces very little ethylene and is relatively insensitive to it. Ethylene removal in transit is not generally necessary*.

Special Treatments Before Shipping:
Garlic should be well cured before transportation. Garlic is sometimes treated with maleic hydrazide before harvest to prevent sprouting and extend the postharvest life.

Mixed Loads:
Garlic can be shipped in mixed loads except with products that tend to absorb odors, particularly apples, pears and celery. Garlic may be shipped with onions.

Cautions:
It is imperative that the relative humidity be kept low to avoid sprouting and root growth of garlic as well as the growth of molds.

Grape

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 10.0-15.0%
Weeks in Air: 4-16 (with SO_2)
Weeks in CA: 4-18
Relative Humidity: 85-95%

Benefits of CA:
Low O_2 delays senescence. Elevated CO_2 reduces decay. CA could substitute for the use of SO_2. 25-45% CO_2 can be used up to 2 weeks for insect control.

Ethylene:
Grapes produce little ethylene and are not very sensitive to it. However, ethylene can enhance senescence and browning of stems (variety dependent). Avoiding ethylene in transit can help extend transit life potential *

Special Treatments Before Shipping:
Grapes are often treated with SO_2 to prevent botrytis, either in fumigation chambers and/or slow release pads during transit.

Varietal Differences:
Keeping quality and response to CA is dependent upon variety. With some varieties CA can keep fruit and rachis quality. With other varieties CA can keep fruit quality but causes rachis to turn brown. Benefits of CA need to be assessed for each specific variety.

Mixed Loads:
If grapes have SO_2 packets, they should not be mixed with other produce as SO_2 can damage many kinds of produce. Otherwise grapes can be shipped in mixed loads with same temperature, CA, and ethylene sensitivity requirements. Grapes can absorb odors from leeks, garlic and onions.

Cautions:
O_2 < 1% can cause off-flavors. CO_2 > 5-10%, depending on variety, can cause browning of berries and stems. SO_2 is associated with health hazards SO_2 and may not be approved in some exporting countries. SO_2 is a very strong oxidant and causes corrosion in the aluminum inside marine reefer containers. SO_2 in transit is incompatible with CA so they should not be used together.

Grapefruit

Optimum Temperature: 10.0-14.0°C
Optimum CA levels: O_2: 3.0-10.0%, CO_2: 5.0-10.0%
Weeks in Air: 4-6
Weeks in CA: 6-8
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can delay senescence and maintain firmness. Elevated CO_2 can reduce stem-end breakdown and can reduce pitting and other symptoms of chilling injury at 7-12°C. Fungistatic protection by CO_2 is only attained if CO_2 is maintained above 10 to 15%, a level which damages grapefruits.

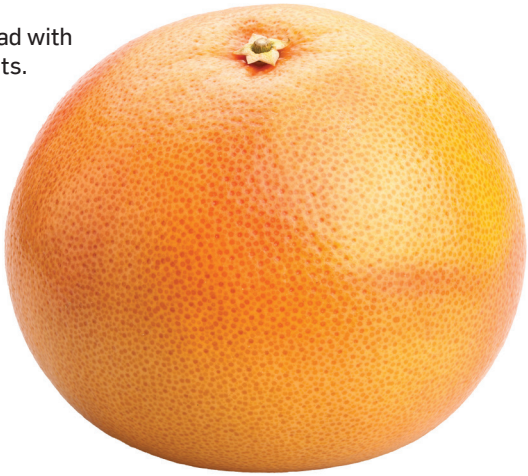
Ethylene:
Grapefruits produce little ethylene and are only slightly sensitive to it. Ethylene removal in transit is not generally necessary*.

Special Treatments Before Shipping:
Ethylene is sometimes used to de-green grapefruits. De-greening can favor decay in transit. Grapefruit is sensitive to chilling injury < 8-10°C. Conditioning in air or air +10-15% CO_2 for 5-7 days at 15-20°C may reduce chilling injury during transport at lower temperatures for quarantine cold treatment.

Varietal Differences:
Sensitivity to chilling temperatures, response to CA, and transit life potential are dependent on variety and growing region.

Mixed Loads:
Grapefruits can be shipped in mixed load with same temperature and CA requirements.

Cautions:
O_2 < 3% can cause off-flavors. CO_2 > 10% may cause off-flavors and areas of scald-like damage on the rind. Are chilling sensitive < 10-12°C.



Guava

Optimum Temperature: 5.0-10.0°C
Optimum CA levels: O_2: 5.0-8.0%, CO_2: 3.0-5.0%
Weeks in Air: 2-3
Weeks in CA: 3-4
Relative Humidity: 90-95%

Benefits of CA:
2-5% O_2 may delay ripening. High CO_2 may delay softening and reduce chilling injury.

Ethylene:
Guava produces ethylene and is sensitive to it. Ethylene can accelerate ripening of immature fruit, and can induce a 'rubbery" texture. Avoiding ethylene in transit can help extend transit life potential *

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
Guava is sensitive to chilling < 5°C.

Honeydew

Optimum Temperature: 7.0-10.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-10.0%
Weeks in Air: 3-4
Weeks in CA: 4-6
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 and high CO_2 can delay ripening and decay.

Ethylene:
Honeydews produce very little ethylene, but are sensitive to it. Ethylene can induce ripening and accelerate depletion of sugars affecting taste and flavor quality. Avoiding ethylene in transit can help prevent this, and extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities

Cautions:
Honeydew melons are sensitive to chilling under 7°C. O_2 <1% and/or CO_2 >20% can cause impaired ripening, off-flavors and off-odors. CO_2 >10% can cause a carbonated taste but the off flavor dissipates during subsequent holding in air.

Kiwifruit

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 3.0-5.0%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening. Elevated CO_2 can maintain firmness.

Ethylene:
Kiwifruit produces little ethylene but is extremely sensitive to it. As little as 20-50ppb will cause premature ripening. Ethylene concentrations should be maintained < 20 parts per billion to prevent flesh softening and incidence of white core inclusions avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Kiwifruit should never be stored with or near, nor be shipped with, ethylene producing commodities.

Cautions:
O_2 < 1% can cause off-flavors. CO_2 > 7% may cause internal flesh breakdown.

Lemon

Optimum Temperature: 10.0-13.0°C
Optimum CA levels: O_2: 6.0-8.0%, CO_2: 4.0-8.0%
Weeks in Air: 4-10
Weeks in CA: 6-12
Relative Humidity: 85-95%

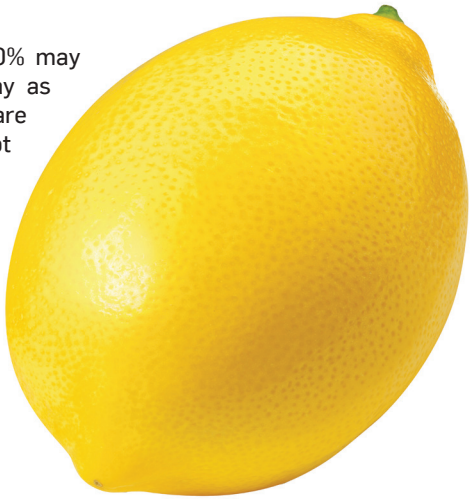
Benefits of CA:
Low O_2 can delay senescence. Elevated CO_2 may delay loss of green color. Fungistatic protection by CO_2 is only attained if CO_2 is maintained above 10 to 15%, a level which damages lemons.

Ethylene:
Lemons produce very little ethylene but are sensitive to it. Ethylene induces lose of green color unmasking yellow pigments, and favors susceptibility to decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Most lemons are picked dark green and require conditioning after harvest to develop color, juice content and flavor. This is normally achieved by storage at 13-15.5°C and 85-90% relative humidity with sufficient ventilation to allow escape of ethylene and reduce fungal growth.

Mixed Loads:
Lemons should not be shipped with ethylene-producing commodities. Lemons absorb odors from some strongly scented vegetables.

Cautions:
O_2 <5% can cause off-flavors. CO_2 >10% may cause increased susceptibility to decay as well as decreased acidity. Lemons are chilling sensitive and should not be kept <10-12°C. Lemons need to be harvested when they are not very turgid, and be handled with great care after harvest to avoid rupturing of the oil cells on the peel which would cause staining (Oleocellosis), that greatly affect quality and appeal.



Lettuce – Crisphead (Iceberg)

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: <1.0-2.5%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 can delay senescence and reduce physiological disorders such as pink rib. Elevated CO_2 >2% can induce brown stain on the midribs of leaves.

Benefits of Ethylene Removal:
Crisphead lettuce produces very little ethylene but is sensitive to it. Ethylene will cause development of russet spotting (small brown spots concentrated along the midrib). Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
Sensitivity of head lettuce to ethylene and to elevated CO_2 is highly cultivar dependent.

Mixed Loads:
Lettuce should not be shipped with ethylene producing commodities.

Cautions:
O_2 <1% can cause tissue breakdown inside the head. CO_2 >2% may cause brown stain. Brown stain injury is greater at the low transport temperatures.

Lettuce - Romaine

Optimum Temperature: 0.0-1.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: < 2.0-3.0%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 can delay senescence and reduce physiological disorders such as pink rib. Elevated CO_2 > 2-4% can induce brown stain on the midribs of leaves.

Ethylene:
Romaine lettuce produces very little ethylene but is sensitive to it. Ethylene will cause development of brown discolored spots on midribs. These are generally larger and less defined than those found with ethylene induced Russet spotting on Crisphead lettuce. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
Sensitivity of Romaine lettuce to ethylene and to elevated CO_2 is highly cultivar dependent.

Mixed Loads:
Lettuce should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 1% can cause tissue breakdown inside the leaves. CO_2 > 2-4% may cause brown stain. Brown stain injury is greater at the low transport temperatures.

Lime

Optimum Temperature: 9.0-12.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 4.0-10.0%
Weeks in Air: 3-6
Weeks in CA: 4-8
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can delay senescence. Elevated CO_2 may delay loss of green color. Fungistatic protection by CO_2 is only attained if CO_2 is maintained above 10 to 15%, a level which damages limes.

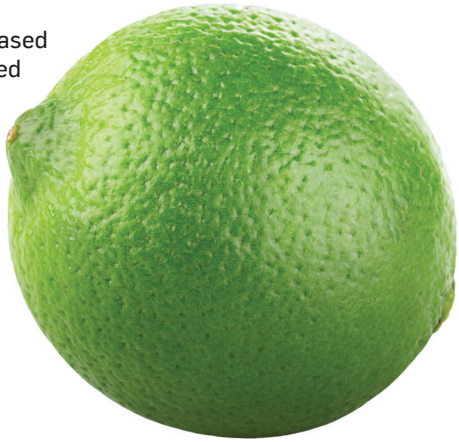
Ethylene:
Limes produce very little ethylene but are sensitive to it. Ethylene causes limes to lose their green color and unmask their yellow pigments, and favors decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Limes are often waxed prior to shipping to retard water loss.

Varietal Differences:
Key limes and Mexican limes typically keep somewhat better than Tahiti limes. Key limes at market are usually yellow.

Mixed Loads:
Should not be shipped with ethylene-producing commodities. Limes absorb odors from strongly scented vegetables.

Cautions:
O_2 < 5% can cause scald-like injury and decreased juice content. CO_2 > 10% may cause increased susceptibility to decay. Limes are sensitive to chilling and should not be transported < 9-10°C. Limes need to be harvested when they are not very turgid, and be handled with great care after harvest to avoid rupturing of the oil cells on the peel which would cause staining (Oleocellosis), that greatly affect quality and appeal.



Longan

Optimum Temperature: 4.0-7.0°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 5.0-15.0%
Weeks in Air: 2-3
Weeks in CA: 3-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 may delay skin browning, maintain firmness, and delay decay. CA could substitute for the use of SO_2.

Ethylene:
Longans produce very little ethylene but are sensitive to it. Ethylene may favor decay and skin browning. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Longans are fumigated with SO_2 in some countries to prevent skin browning and control postharvest disease.

Mixed Loads:
Longans should not be shipped with ethylene producing commodities.

Cautions:
Longans are chilling sensitive < 5°C. SO_2 is associated with health hazards, and may not be approved in some exporting countries. SO_2 is a very strong oxidant and can cause corrosion to the aluminum inside marine containers.

Lychee

Optimum Temperature: 2.0-6.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 3.0-5.0%
Weeks in Air: 2-5
Weeks in CA: 4-8
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can reduce, ripening and skin browning. Elevated CO_2 can slow down decay, and the rate of loss of ascorbic acid and acidity. CA could substitute for the use of SO_2.

Ethylene:
Lychees produce very little ethylene, but it can accelerate deterioration (aryl breakdown and increased decay). Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Lychees are fumigated with SO_2 in some countries to maintain peel color and prevent browning, and decay.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Lychees are very sensitive to moisture loss which can cause cracking of the peel (variety dependent). $O_2 < 1\%$ can cause off-flavors. $CO_2 > 15\%$ can cause off-flavors and a dull gray appearance of the pulp. SO_2 is associated with health hazards, and may not be approved in some exporting countries. SO_2 is a very strong oxidant and can cause corrosion to the aluminum inside marine containers.

Mandarin - Tangerine

Optimum Temperature: 5.0-8.0°C
Optimum CA levels: O_2: 5.0-8.0%, CO_2: 2.0-5.0%
Weeks in Air: 3-5
Weeks in CA: 4-7
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 can delay senescence and color changes. Fungistatic protection by CO_2 is only attained if CO_2 is maintained above 10 to 15%, a level which damages mandarins.

Ethylene:
Mandarins produce very little ethylene but is sensitive to it. Ethylene causes de-greening and can cause decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
De-greening with ethylene at 28-29 C 95% RH for 12 hr – 3 days. Conditioning at 10-15°C for 1 week before quarantine cold treatment to increase resistance to chilling injury.

Mixed Loads:
Mandarins should not be shipped with ethylene-producing commodities.

Cautions:
Mandarins are sensitive to chilling < 5°C. Mandarins need to be harvested when they are not very turgid, and be handled with great care after harvest to avoid rupturing of the oil cells on the peel which would cause staining (Oleocellosis), that greatly affect quality and appeal.

Mango

Optimum Temperature: 10.0-13.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-10.0%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 85-95%

Benefits of CA:
Low O_2 can delay ripening. Elevated CO_2 can maintain firmness. Low O_2 and high CO_2 can delay decay. However, anthracnosis which comes from the field is not effectively prevented by the use of CA as CO_2 levels would have to be higher than 10-15% which would damage fruit and cause undesirable flavors.

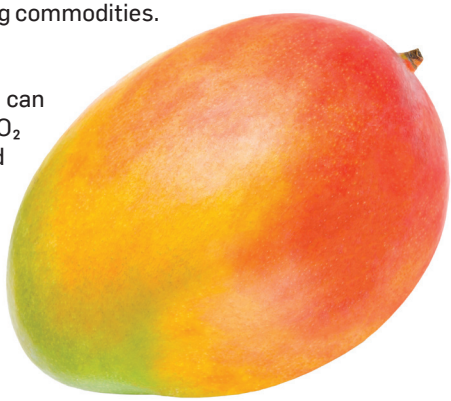
Ethylene:
Mangoes produce ethylene and are sensitive to it. Ethylene favors ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Heat treatments may be used to reduce anthracnose. Heat treatment is used for quarantine insect control for certain importing countries. Heat treatment weakens the fruit and makes it more susceptible to premature ripening and decay. CA can help retard these effects.

Varietal Differences:
Varieties differ in their sensitivity to chilling injury. Less ripe fruit are more sensitive to chilling injury than more ripe fruit. Most varieties, when unripe, will be injured if held < 10°C. Many varieties grown in Southeast Asia are sensitive to lower than 5% O_2.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 2% (< 5% for SE Asia-grown varieties) can cause off-flavors and skin discoloration. CO_2 > 10% can cause softening, off-flavors and grayish flesh color.



Mangosteen

Optimum Temperature: 12.0-13.0°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 5.0-10.0%
Weeks in Air: 2-4
Weeks in CA: 3-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 can retard ripening, color changes and can help maintain firmness and internal quality.

Ethylene:
Mangosteen produces ethylene and are sensitive to it. Ethylene can trigger ripening and color changes. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Need to be handled with great care as damage can cause translucent pulp, softening, and bitter taste.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
Mangosteen is sensitive to chilling < 10-12°C, which increases susceptibility to decay.

Mushroom

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 3.0-20.0%, CO_2: 5.0-15.0%
Weeks in Air: 1-2
Weeks in CA: 3-5
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 3-5% and 10 CO_2 % can be beneficial. CA can reduce growth of microorganisms. Elevated CO2 can reduce cap opening and browning of the stipe and gills.

Ethylene:
Mushrooms produce little ethylene and are not very sensitive to it, but ethylene could still cause browning of the caps. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
There are many kinds and types of mushrooms, and many will respond differently to CA conditions.

Mixed Loads:
Should not be shipped with ethylene producing commodities. Mushrooms absorb odors from green onions.

Cautions:
Because spores of Clostridium botulinum (the cause of botulism poisoning) can sometimes be found on mushrooms, and because botulism toxin only develops under low O_2, mushrooms are generally not held under low O_2. When mushrooms are packaged in plastic film, the film needs to be perforated or quite permeable to O_2 to ensure adequate ingress of O_2. O_2 < 1% can also cause off-odors and off-flavors as well as stimulate cap opening and stipe elongation. CO_2 > 20% can cause surface pitting and browning.

Nectarine

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 3.0-5.0%
Weeks in Air: 3-4
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and retains firmness. Elevated CO_2 may reduce internal breakdown in some cultivars. Some varieties of nectarines can be shipped in 6% O_2 and 17% CO_2 if they are kept near 0°C.

Ethylene:
Nectarines produce ethylene and are sensitive to it. Ethylene enhances ripening, favors decay and softening. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
There is significant variability among nectarine cultivars in their propensity to develop internal breakdown, in their shelf lives, and in their abilities to benefit from controlled atmospheres. Experience with individual varieties is necessary to develop optimal handling procedures.

Mixed Loads:
Nectarines should not be shipped with ethylene producing nor ethylene-sensitive commodities.

Cautions:
O_2 < 1% can cause off-flavors, skin browning and failure to ripen. CO_2 > 10% may cause flesh browning and loss of flavor. Nectarines are more likely to develop internal breakdown at temperatures between 4-10°C.

Okra

Optimum Temperature: 7.0-10.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 4.0-10.0%
Weeks in Air: 1-2
Weeks in CA: 2-3
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 has limited benefit. Elevated CO_2 can delay decay, and maintain tenderness, high mucilage, and green color.

Ethylene:
Okra produces very little ethylene but it is sensitive to it. Ethylene can cause loss of green color and enhance decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Okra should not be shipped with ethylene producing commodities.

Cautions:
Okra is sensitive to chilling < 7°C. Okra bruises easily and the bruises blacken within hours. Care in handling should be exercised to reduce mechanical damage.

Olive

Optimum Temperature: 5.0-10.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 1.0%
Weeks in Air: 4-6
Weeks in CA: 6-8
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay senescence and retards softening. Elevated CO_2 can maintain firmness.

Ethylene:
Olives produce little ethylene but are sensitive to it. Ethylene can affect green color and firmness. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
'Mission' variety is less sensitive to chilling injury than 'Manzanillo,' which is less sensitive to chilling than 'Ascolano' and 'Sevillano' olives.

Mixed Loads:
Olives Should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 1.5-2% can cause off-flavors. CO_2 > 5% may increase severity of chilling if held < 7°C.

Onion

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 4.0-10.0%
Weeks in Air: 5-7
Weeks in CA: 24-40
Relative Humidity: 65-85%

Benefits of CA:
Low O_2 may be of little benefit in retarding senescence. Elevated CO_2 may help reduce sprouting and root growth. Most of he onions that respond well to CA are high value sweet onions (Vidalia, Maui, Walla Walla).

Ethylene:
Dry onions produce very little ethylene and are relatively insensitive to it. Ethylene removal in transit is not generally necessary*.

Special Treatments Before Shipping:
Onions should be well cured before transportation. Onions are considered cured when the neck is tight and the outer scales are dry and will rustle. Sprout growth indicates too high a storage-pre-transport temperature and poorly cured bulbs.

Varietal Differences:
There are varietal differences in the response to and benefits of CA, as well in their transit life potential*.

Mixed Loads:
Onions should not be transported with commodities that tend to absorb odors, particularly apples, pears, grapes, mushrooms, and celery. Garlic may be transported with onions.

Cautions:
It is imperative that the relative humidity be kept low to avoid sprouting and root growth of onions as well as the growth of molds.

Onion - Green

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-4.0%, CO_2: 1.0-5.0%
Weeks in Air: 3-4
Weeks in CA: 5-8
Relative Humidity: 95-98%

Benefits of CA:
Low O_2 can reduce decay and extend quality condition and freshness. Elevated CO_2 may help reduce sprouting and root growth.

Ethylene:
Green onions produce very little ethylene and are not sensitive to it. Ethylene removal in transit is not generally necessary*.

Special Treatments Before Shipping:
Need to be cooled promptly after harvest to 0°C to prevent curvature and bending of young shoots.

Mixed Loads:
Green onions produce odors that may be absorbed by many commodities such as apples, pears, grapes, mushrooms, and celery.

Orange

Optimum Temperature: 2.0-8.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 1.0-5.0%
Weeks in Air: 4-10
Weeks in CA: 6-12
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can delay senescence and maintain firmness. Elevated CO_2 may reduce chilling injury symptoms. Fungistatic protection by CO_2 is only attained if CO_2 is maintained above 10 to 15%, a level which damages oranges.

Ethylene:
Oranges produce very little ethylene but are sensitive to it. Ethylene can favor stem-end decay and loss of desirable orange flavor. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
De-greening with ethylene may be necessary for some oranges before shipping. However, de-greening can increase susceptibility to decay.

Mixed Loads:
Oranges should not be shipped with ethylene producing commodities. Oranges produce odors than can be absorbed by commodities such as apples, pears, grapes, celery, and mushrooms.

Cautions:
O2 < 5% or CO2 > 5% can cause off-flavors.

Papaya

Optimum Temperature: 7.0-13.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-8.0%
Weeks in Air: 1-3
Weeks in CA: 2-5
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can maintain firmness and delay decay.

Ethylene:
Papayas produce ethylene and are sensitive to it. Ethylene can favor ripening, softening, and decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Heat treatments, either vapor heat or hot water treatment may be used to reduce anthracnose or for quarantine insect control. Heat treatment weakens the fruit and makes it more susceptible to premature ripening and decay. Waxing may be used to prevent moisture loss.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 < 2% can cause off-flavors and failure to ripen. CO_2 > 10% can cause off flavors and may aggravate chilling injury.

Passion Fruit

Optimum Temperature: 7.0-10.0°C
Optimum CA levels: O_2: 4.0-5.0%, CO_2: 10.0-15.0%
Weeks in Air: 3-4
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can delay ripening and decay, and maintain firmness. CA can help maintain acidity and Vitamin C content.

Ethylene:
Passion fruit produces very high levels of ethylene and are sensitive to it. Ethylene can favor ripening, softening, and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
Sensitive to chilling injury < 5-7°C.

Pea - Snap, Snow, Sugar

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 3.0-6.0%
Weeks in Air: 1-2
Weeks in CA: 2-3
Relative Humidity: 90-98%

Benefits of CA:
Low O_2 reduces respiration and maintains sugars. Elevated CO_2 can maintain green color and retard development of soft rot.

Ethylene:
Peas produce little ethylene but are sensitive to it. Ethylene causes loss of green color. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Peas lose their sugars very fast after harvest if not cooled rapidly and held near 0°C.

Peach

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 3.0-5.0%
Weeks in Air: 2-4
Weeks in CA: 4-6
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 delays ripening and softening. Elevated CO_2 helps maintain firmness, and prevent internal breakdown in certain cultivars. Some varieties of peaches can be shipped in 6% O_2 and 17% CO_2 at 0°C.

Ethylene:
Peaches produce ethylene and are sensitive to it. Ethylene can favor ripening, softening, internal breakdown, and decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Hot water dips at 52°C for 2.5 minutes can be effective for the control of brown rot and Rhizopus decay, but weakens the fruit and makes it more susceptible to softening and ripening.

Varietal Differences:
There is significant variability among peach cultivars in their propensity to develop internal breakdown, shelf life potential , and in their ability to benefit from controlled atmospheres. Experience with individual varieties is necessary to develop optimal procedures and settings.

Mixed Loads:
Should not be shipped with ethylene producing or ethylene sensitive commodities.

Cautions:
O_2 < 1% can cause off-flavors, peel browning, and failure to ripen. CO_2 > 5% may cause flesh browning in some varieties. Peaches are more likely to develop internal breakdown at temperatures between 4-10°C.

Pear - Bartlett

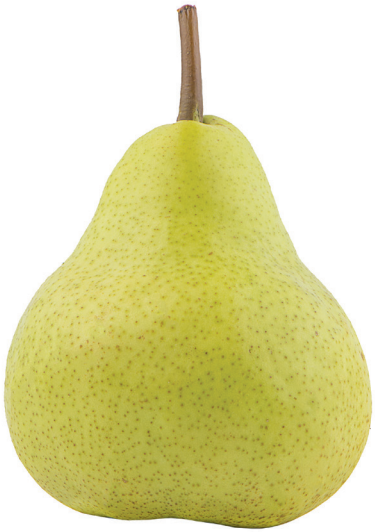
Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: < 1.0%
Weeks in Air: 8-12
Weeks in CA: 12-24
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help delay ripening, maintain firmness, and reduce incidence of brown core.

Ethylene:
Bartlett pears produce moderate amounts of ethylene, but are quite sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1% may cause brown core and off-flavors. High CO_2 > 2% can cause core flush, surface pitting, core cracking and flesh discoloration, especially on late season fruit.



Pear - Bosc

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0-2.5%, CO_2: 1.0%
Weeks in Air: 2-4
Weeks in CA: 12-28
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help maintain firmness and reduce incidence of brown core.

Ethylene:
Bosc pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1 may cause off-flavors. Low O_2 < 1% and/or high CO_2 > 0.5-1.0% can cause core flush, surface pitting, core cracking and flesh discoloration.

Pear - Comice

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 3.0%, CO_2: 1.0%
Weeks in Air: 8-12
Weeks in CA: 12-28
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help maintain firmness and reduce incidence of brown core.

Ethylene:
Comice pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1% may cause off-flavors. Comice pears may develop brown core and pulp discoloration if under < 1% O_2 and/or > 1 % CO_2. Overmature fruit is susceptible to internal breakdown and browning.

Pear - Conference

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.5-3.0%, CO_2: 1.0%
Weeks in Air: 8-12
Weeks in CA: 12-28
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help maintain firmness and reduce incidence of brown core.

Ethylene:
Conference pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1% may cause off-flavors. Low O_2 < 1% and/or high CO_2 > 0.5-1.0% can cause brown core, core flush, core cracking and flesh discoloration. Late season fruit is more susceptible. CA conditions should only be applied 4 weeks after harvest. Then pull down at once to 6% and continue going down slowly to 3% over a period of 3 weeks. CO_2 must be kept low all the time to avoid internal browning and cavities. A note however on Southern European Conference hardly needs adaptation, and requires lower oxygen.

Pear - d'Anjou

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0-2.5%, CO_2: 1.0%
Weeks in Air: 12-24
Weeks in CA: 16-32
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help maintain firmness, green color, acidity, and reduce incidence of brown core and scald.

Ethylene:
d'Anjou pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
In Australia, an initial low O_2 conditioning <0.5% for 10 days before shipping can reduce the incidence of scald.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1% and/or CO_2 > 1% may cause off-flavors, brown core, black peel spot, or cavitation.

Pear - Nashi

Optimum Temperature: 0.5-1.0°C
Optimum CA levels: O_2: 0.5-3.0%, CO_2: 0.0-3.0%
Weeks in Air: 4-6
Weeks in CA: 20-28
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can help maintain firmness and peel color.

Ethylene:
Nashi* pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities. Nashi pears may absorb odors from onions, garlic and potatoes.

Cautions:
Low O_2 <1% may cause brown core and off-flavors. High CO_2 >2% can cause core flush, surface pitting, core cracking and flesh discoloration.

*Pear- Nashi, can be in different forms

Pear – Packham's Triumph

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0-3.0%, CO_2: 1.0-3.0%
Weeks in Air: 2-4
Weeks in CA: 3-7
Relative Humidity: 90-95%

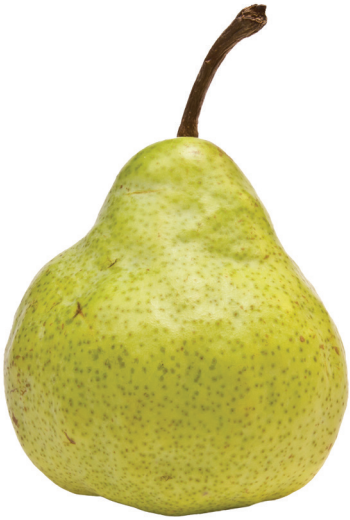
Benefits of CA:
Low O_2 can delay ripening and softening. Elevated CO_2 can help maintain firmness and reduce incidence of brown core and scald.

Ethylene:
Packhams produce low to moderate amounts of ethylene, and are moderately sensitive to it. Ethylene can enhance ripening and decay. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
In Australia, an initial low O_2 conditioning <0.5% for 10 days before shipping can reduce the incidence of scald.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
Low O_2 < 1% and/or CO_2 > 1% may cause off-flavors, brown core, black peel spot, or cavitation.



Pear - Ya Li

Optimum Temperature: 0.5°C
Optimum CA levels: O_2: >4.0%, CO_2: 0.0-3.0%
Weeks in Air: 4-6
Weeks in CA: 20-28
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can help maintain firmness and peel color.

Ethylene:
Ya Li* pears produce low to moderate amounts of ethylene, and are moderately sensitive to it. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities. Ya Li pears may absorb odors from onions, garlic and potatoes.

Cautions:
Low O_2 < 1% may cause brown core and off-flavors. High CO_2 > 2% can cause core flush, surface pitting, core cracking and flesh discoloration.

*Pear- Ya Li, can be in different forms

Persimmon

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-8.0%
Weeks in Air: 6-10
Weeks in CA: 8-14
Relative Humidity: 85-95%

Benefits of CA:
Low O_2 can delay ripening. Elevated CO2 can help maintain firmness, and reduce chilling injury symptoms on “Fuyu fruit”.

Ethylene:
Persimmons produce low amounts of ethylene, but are quite sensitive to it. Ethylene accelerates softening and ripening. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Hachiya-type persimmons are naturally astringent. Their astringency can be removed by treating the fruit with 60-90% CO_2 for 24 hours at 17-20°C >4% CO_2 in transit can help reduce astringency. High levels of ethylene can also remove stringency but reduces firmness.

Varietal Differences:
Fuyu and Hachiya persimmons may be treated differently because of the astringency of the Hachiya-type fruits.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
O_2 < 3% can cause off-flavors and failure to ripen. CO_2 > 10% may cause off flavors and brown discoloration of flesh.

Pineapple

Optimum Temperature: 7.0-8.0°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: < 2.0%
Weeks in Air: 2-4
Weeks in CA: 4-6
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can delay senescence and reduce flesh translucency. (water-soaked flesh) Elevated CO_2 delays de-greening of crown.

Ethylene:
Pineapples fruits produce very little ethylene and are not sensitive to it, but the leaves on their crown are sensitive. Ethylene can enhance decay in leaves, especially in folded and cut surfaces. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Pineapples fruits need to be waxed to maintain good peel appearance and prevent the leaves on the eyes to dry out giving a non-fresh appearance, and reduce chilling symptoms (there are a number of available waxes). The wax also provides an MA effect which can help reduce internal browning and translucency. These waxes can cause browning of the leaves of the crown.

Mixed Loads:
Pineapples can be shipped in mixed load with same temperature and CA requirements. Pineapples readily absorb off-odors from avocados and green peppers.

Cautions:
Pineapples are very sensitive to chilling < 7.5°C (water-soaked, translucency, fermentation-like discolorations). O_2 <2% can cause off-flavors. The older traditional commercial variety “Smooth cayenne” (Champaka) could be shipped under high CO_2 up to 8- 10% without negative effects. However the newer sweet variety MD2 type is very sensitive to CO_2 >2% which can cause off flavors, flesh translucency, and fermentation.

Plum

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 2.0%, CO_2: 2.0-5.0%
Weeks in Air: 3-6
Weeks in CA: 6-8
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening. Elevated CO_2 can help maintain firmness, and ground color, and reduce internal breakdown.

Ethylene:
Plums produce moderate amounts of ethylene and are sensitive to it. Ethylene favors ripening, softening, and internal breakdown. Avoiding ethylene in transit can help extend transit life potential*.

Varietal Differences:
Many cultivars of plum are currently marketed. They vary in their responses to CA, their expected shelf lives, their sensitivity to chilling injury and their rates of potential premature ripening during transportation.

Mixed Loads:
Should not be shipped with ethylene producing nor ethylene sensitive commodities.

Cautions:
O_2 < 1% can cause off-flavors and failure to ripen. CO_2 > 2% can cause flesh browning in some cultivars.

Pomegranate

Optimum Temperature: 2.0-6.0°C
Optimum CA levels: O_2: 2.0-5.0%, CO_2: 6.0-15.0%
Weeks in Air: 2-6
Weeks in CA: 24-40
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and high CO_2 can reduce chilling symptoms, reduce scald, retard decay, and extend postharvest life for months.

Ethylene:
Pomegranates produce very little ethylene and are not sensitive to it. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Pomegranates can be shipped in mixed load with same temperature and CA requirements.

Cautions:
Minimize physical injury to the calix to avoid gray mold.

Rambutan

Optimum Temperature: 10.0-12.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 7.0-12.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can retard senescence. Elevated CO_2 can slow down red color loss, maintain firmness, and reduce incidence of chilling injury.

Ethylene:
Rambutans produce very little ethylene and are relatively insensitive to it. Ethylene removal in transit is generally not necessary.

Mixed Loads:
Can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
Rambutan are sensitive to moisture loss and high humidity is essential in minimizing water loss and preventing skin darkening. Low O_2 < 1% can increase decay incidence. CO_2 > 15% may cause damage.

Raspberry

Optimum Temperature: -0.5-0.0°C
Optimum CA levels: O_2: 5.0-8.0%, CO_2: 10.0-18.0%
Weeks in Air: <1
Weeks in CA: 1-2
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can reduce decay, maintain color, and maintain firmness.

Ethylene:
Raspberries produce very little ethylene and are relatively insensitive to it. Ethylene removal in transit is not generally necessary*.

Mixed Loads:
Raspberries can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
O_2 < 2% can cause off-flavors. CO_2 > 22-25% may cause flesh browning and off flavors.

Sapote (Black, Mamey)

Optimum Temperature: 12.0-13.0°C
Optimum CA levels: O_2: 5.0%, CO_2: 5.0-10.0%
Weeks in Air: 2-4
Weeks in CA: 4-5
Relative Humidity: 90-95%

Benefits of CA:
High CO_2 can delay ripening and deterioration and prevent ethylene effects.

Ethylene:
Sapotes produces low levels of ethylene but are moderately sensitive to it. Ethylene can hasten ripening and deterioration. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 4% can cause off flavors. CO_2 > 10% can damage appearance and taste. Can develop chilling injury below 5°C if more than 10 days.

Starfruit (Carambola)

Optimum Temperature: 7.0-10.0°C
Optimum CA levels: O_2: 2.0-4.0%, CO_2: 5.0-8.0%
Weeks in Air: 2-3
Weeks in CA: 3-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 and elevated CO_2 can retard ripening and deterioration

Ethylene:
Starfruit produces very little ethylene but are sensitive to it. Ethylene can increase loss of acidity which is desirable but it accelerates deterioration. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
Sensitive to chilling injury < 5-6°C. Very sensitive to abrasion injury and water loss.

Strawberry

Optimum Temperature: 0.0°C
Optimum CA levels: O_2: 5.0-10.0%, CO_2: 15.0-20.0%
Weeks in Air: 1-2
Weeks in CA: 2-4
Relative Humidity: 90-95%

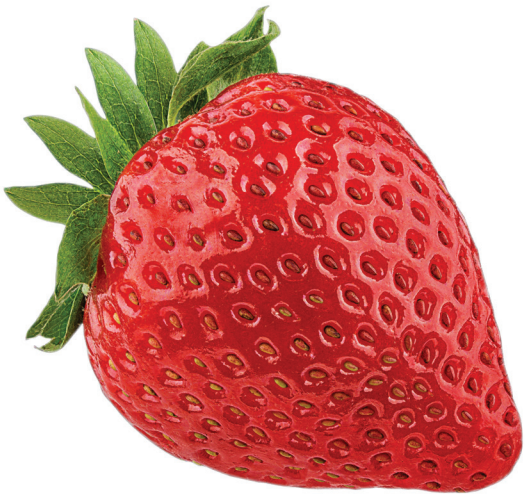
Benefits of CA:
Low O_2 has little benefit. Elevated CO_2 can help maintain firmness and retard decay

Ethylene:
Strawberries produce little ethylene and are not very sensitive to it. Ethylene may or may not slightly enhance deterioration. Avoiding ethylene in transit may or may not help extend transit life potential*.

Varietal Differences:
Different varieties may have variable tolerance to CO_2 > 15-20%.

Mixed Loads:
Strawberries can be shipped in mixed loads with same temperature and CA requirements.

Cautions:
O_2 < 2% can cause off-flavors. CO_2 > 25% may cause flesh browning and off-flavors.



Sweetsop (Sugar/Custard Apple)

Optimum Temperature: 12.0-15.0°C
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 5.0-10.0%
Weeks in Air: 2-3
Weeks in CA: 4-5
Relative Humidity: 85-90%

Benefits of CA:
Low O_2 can reduce ripening. Elevated CO_2 can delay ripening and deterioration.

Ethylene:
Sweetsop produces low levels of ethylene but can be sensitive to it. Ethylene may accelerate ripening and deterioration. Avoiding ethylene in transit can help extend transit life potential*.

Mixed Loads:
Should not be shipped with ethylene producing commodities.

Cautions:
O_2 < 1% can result in failure to ripen. High CO_2 > 15% can confer a flat taste and cause uneven ripening. Very sensitive to chilling injury < 13°C.

Tomato

Optimum Temperature: 7.0-14.0°C (Ripe) 12.0-20.0°C (Green)
Optimum CA levels: O_2: 3.0-5.0%, CO_2: 2.0-3.0%
Weeks in Air: 1-4
Weeks in CA: 3-5
Relative Humidity: 90-95%

Benefits of CA:
Low O_2 can delay ripening, color changes, and development of mold on surface and stem scar. Elevated CO_2 can retard ripening and decay.

Ethylene:
Tomatoes produce moderate amounts ethylene and are sensitive to it. Avoiding ethylene in transit can help extend transit life potential*.

Special Treatments Before Shipping:
Tomatoes are harvested at the mature green, or breaker stage. If shipped mature green ethylene needs to be avoided in transit. If shipped at the breaker or more advanced stage ethylene removal in transit is of no consequence. Tomatoes might be shipped at differential temperatures to improve visual and eating quality at arrival to destination markets (lower end of recommended temperature first and increase to higher end of temperature the last 5-7 days in transit).

Varietal Differences:
Tomato varieties vary greatly in their firmness, propensity to decay, flavor, and postharvest life. Experience with particular varieties, and differing growing regions is essential to accurately predict the postharvest life of tomatoes.

Mixed Loads:
Should not be shipped with ethylene producing or sensitive commodities.

Cautions:
O_2 <2% can cause discoloration, uneven ripening and off flavor. CO_2 >3% for mature green tomatoes, or >5% for turning tomatoes, may cause internal browning , softening and uneven ripening. Tomatoes are chilling sensitive (maturity, variety). Mature green tomatoes should be kept at 12-14°C. Turning fruit at 8-12°C.

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