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Automatic Fresh Air Management for Fruit & Vegetables

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Thermo King has developed a new product called AFAM+ ("Automatic Fresh Air Management"). Our expert commentary presents plausible applications and uses for this new technology.

AFAM+ is an automated fresh air exchange system for refrigerated containers that will open the fresh air exchange to a specific setting in ft3/min or m3/hr through the refrigeration unit's controller. The setting can be delayed for any specific period of time to remove field heat from the harvested product more quickly, adding quality to the product out turn, and then open to a pre-determined setting. All actions are recorded in the data logger on the unit, ensuring that proper settings were made, and that openings actually did happen at the appropriate time. The unit further will adjust the door opening to compensate for variances in evaporator fan speed caused by controller action, or to adjust for different power supplies. AFAM+ adds intelligence to the Automatic Fresh Air Management system. AFAM+ has carbon dioxide and oxygen sensors that monitor the levels of each gas in the cargo area. The fresh air exchange remains closed until either a set high threshold of carbon dioxide has been achieved, or a low oxygen setting is met. The door then opens to ventilate the cargo area until the gas levels return to pre-selected concentrations. The fresh air then closes again and continues to monitor gases until some action is called for. The carbon dioxide ceiling and oxygen floor are set points in the controller, established for each cargo as it is loaded. (Source - Steve Bryant, Thermo King, 2001).

Commercial Applications. AFAM+ is ideally suited to protect all fruit, vegetables and horticultural items ("commodities") from injurious levels of oxygen and carbon dioxide that may develop within the cargo space of refrigerated containers.
Moreover, AFAM+ can potentially be used as a means of deriving desirable atmospheric modifications in properly sealed refrigerated containers by taking advantage of the oxygen consumed and carbon dioxide produced by the commodities as by-products of respiration. It is, however, necessary to use only refrigerated containers that are capable of maintaining nearly airtight conditions in order for this technology to work effectively as a means of modifying the atmosphere.

Commodities that derive their primary benefit from high carbon dioxide with less oxygen benefit are ideal candidates for AFAM+. Examples of these commodities include Asparagus, Blackberry, Blueberry, Raspberry, Strawberry, Broccoli, Cantaloupe, Cherry, Durian, Fig, Freesia, Lily, Mango, Mushroom, Okra, Anjou Pear (short term), Chili Pepper, Tulip bulb, Grape, Nectarine and Peach (Source - Dr J. K. Brecht).

Likewise, sensitive commodities that can be damaged by elevated carbon dioxide are equally good candidates for AFAM+. Examples of these commodities include various cultivars of apples (Boskoop, Braeburn, Cox, Cortland, Elstar, Empire, Fuji, Gala, Gloster, Granny Smith, Idared, Red Delicious, Spartan), Asian pear, Bosc pear, Plum, Iceberg lettuce, Cucumber, Eggplant, Bulbs, Mimosa, and Potted plants (Source - Dr J. K. Brecht).

Some high-value commodities can derive benefit from costly controlled atmosphere ("CA") systems but shippers and receivers often cannot justify the added cost of CA for the preponderance of the rest of the fruit and vegetables that are moved in international trade.

Additionally, many international transportation companies have been unable to cost justify the acquisition of specialized CA containers because of the significant capital cost and the small volume of fruit and

vegetables that derive a cost effective benefit from using CA. Now, a low cost AFAM+ unit could be the right "economic choice" for these carriers.

Interestingly, some commodities that derive benefits from both low oxygen and high carbon dioxide (i.e., CA systems) are also potentiality good candidates for the less costly AFAM+. For high respiring commodities like durian and asparagus, a desirable modified atmosphere ("MA") environment can potentially be established in properly sealed refrigerated containers by using AFAM+, assuming the respiratory quotient ("RQ") is about equal to 1. Some of these commodities are discussed below.

In the following discussions, it must be understood that mention of optimum oxygen and carbon dioxide levels and the responses to modified levels of those gases are general rules, which do not apply at temperatures other than the optimum for a particular commodity, and which may also differ for different maturities or ripeness stages, varieties, growing regions, and growing conditions (i.e., seasons.). For example, mature-green and tree-ripe fruits generally have very different optimum oxygen and carbon dioxide levels. Also, as a rule, fruits and vegetables are more likely to be injured by rather than benefit from a given low oxygen level at higher than optimum temperatures, and are more likely to be injured by a given high carbon dioxide level at lower than optimum temperatures. It is highly advisable to consult with knowledgeable sources before attempting to use modified oxygen or carbon dioxide levels for conditions or commodities for which the shipper does not have previous commercial experience with this technology.

AFAM+ Applications, Considerations & Commodity Requirements

1) Apples

Injury level: Varieties differ in sensitivity to carbon dioxide over long term (> 1 month) storage with injury potentially occurring from core flush upon exposure to 5% carbon dioxide at 0°C. Symptoms include core and/or flesh browning. A carbon dioxide level of 2% would be safe for all varieties during shipping.

Benefit: Helps retain firmness, green color, and acidity.

AFAM+: Apples do not need CA for normal transit times. Therefore, they are very well suited for AFAM+. AFAM+ can protect apples from low oxygen and elevated carbon dioxide injuries

2) Asparagus

Injury level: Asparagus can tolerate 10-14% carbon dioxide for several weeks at 3°C. There is little or no benefit from oxygen. In fact, oxygen levels less than 10% can cause discoloration

Benefit: Very high (10-14%) carbon dioxide treatment delays decay development and keep the spears green and tender. .

AFAM+: Asparagus is very well suited for AFAM+ application when shipped in a properly sealed refrigerated container. If we assume a RQ of 1, then the oxygen and carbon dioxide levels can be modified to about 10% oxygen and 10% carbon dioxide, which is ideal. AFAM+ can protect asparagus from low oxygen and elevated carbon dioxide injuries.

3) Avocados

Injury level: Fuerte and Hass varieties can tolerate 25-30% carbon dioxide for 2-3 days and 15% carbon dioxide for 2 weeks at 7°C.

Benefit: A short (2-3 days) very high (25-30%) carbon dioxide treatment delays subsequent decay development. Lower carbon dioxide treatments also help retain firmness and reduce chilling injury at 5°C.

AFAM+: CA is necessary to successfully ship avocados for over 2 weeks transit time. AFAM+ would not be able to replace CA for that application. AFAM+ can protect avocados from low oxygen and elevated carbon dioxide injuries.

4) Banana

Injury level: Bananas can be injured by <2% oxygen or more than 5% carbon dioxide at 13-15°C. Lower oxygen levels can cause off-flavors, peel discoloration, and inhibit ripening. Higher carbon dioxide levels can result in fruit with green skin and soft flesh. Ethylene exposure is also very detrimental, causing premature ripening.

Benefit: Low oxygen and high carbon dioxide help to inhibit banana ripening mainly by interfering with ethylene synthesis and action. Elevated carbon dioxide also increases banana resistance to chilling injury (under peel discoloration).

AFAM+: AFAM+ can be a good supplement to ethylene scrubbing by maintaining elevated carbon dioxide levels and also by reducing temperature pulldown time, which helps prevent initiation of ethylene production. AFAM+ can also protect bananas from low oxygen and elevated carbon dioxide injuries and decrease the chances of chilling injury ("under peel discoloration") occurring.

5) Broccoli

Injury level: Broccoli can tolerate up to 15% carbon dioxide and about 1% oxygen at 0-2°C. Lower levels of oxygen can cause off-flavors.

Benefit: Broccoli benefits from low oxygen and elevated carbon dioxide. Elevated carbon dioxide should reduce decay and slow the onset of bud opening.

AFAM+: Broccoli is well suited for AFAM+ applications when shipped in a properly sealed refrigerated container because elevated carbon dioxide reduces yellowing of the flower buds and decay. A carbon dioxide setting of 10% should work for broccoli. Oxygen is generally set at 1 to 3% for CA systems. However, the oxygen set point for AFAM+ should be set to protect the broccoli from excessively high levels of carbon dioxide. Assuming an RQ of 1, an oxygen setting of 11% is suggested.

6) Garlic

Injury level: Garlic can tolerate up to 10% carbon dioxide and 2-3% oxygen at 0-2°C.

Benefit: Garlic benefits from low oxygen and elevated carbon dioxide. Elevated carbon dioxide should reduce sprouting, decay and root growth. Low oxygen may extend postharvest life.

AFAM+: Garlic is well suited for AFAM+ applications when shipped in a properly sealed refrigerated container because elevated carbon dioxide reduces sprouting, root growth and possibly decay. In the absence of local research findings, a carbon dioxide setting of 5% should work for garlic. Oxygen is generally set at 1 to 3% for CA systems involving long-term storage. However, the oxygen set point for AFAM+ should be set to protect the garlic from excessively high levels of carbon dioxide. Assuming an RQ of 1, an oxygen setting of 11% is suggested.

7) Grapes

Injury level: Exposure to > 15% carbon dioxide for more than 2 weeks at 0°C can cause browning of grape pedicels.

Benefit: Use of 10-15% carbon dioxide at 0°C can be an alternative to sulphur dioxide ("S02") fumigation or S02-release packets for effective decay control.

AFAM+: Table grapes do not need CA for normal transit times if S02-release packets are used. Therefore, grapes are very well suited for AFAM+. AFAM+ can protect grapes from low oxygen and elevated carbon dioxide injuries.

8) Kiwis

Injury level: Kiwis can develop flesh breakdown if exposed to > 7% carbon dioxide for more than 1 month at 0°C. Low oxygen levels less than 1% can cause off-flavors.

Benefit: Greater than 3% carbon dioxide helps retain firmness and reduces decay.

AFAM+: Ethylene scrubbing is more critical than oxygen or carbon dioxide levels for kiwis within a typical transit timeframe. That is, CA is not necessary and AFAM+ would be beneficial. AFAM+ can protect kiwis from low oxygen and elevated carbon dioxide injuries.

9) Mangoes

Injury level: Carbon dioxide in excess of 10% at 12-13°C can cause quality problems like off flavors, discoloration and softening of mature-green mangoes. Mango cultivars vary in their response to temperature, oxygen and carbon dioxide, and riper fruit benefit more from higher carbon dioxide levels. Consequently, postharvest recommendations should be solicited from local extension workers or Universities for the cultivars of interest.

Benefit: Mangoes benefit from low oxygen and elevated carbon dioxide. Elevated carbon dioxide maintains firmness whereas low oxygen delays ripening.

AFAM+: AFAM+ can protect mangoes from injurious levels of oxygen and carbon dioxide. For mangoes, the decision to use CA or AFAM+ could boil down to a simple cost-benefit decision. Can I cost justify paying $1800 per load for CA (assuming that CA is even available) when AFAM+ at a much lesser cost may be more than adequate? In the case of mangoes, low 02 (CA required) will delay mango ripening whereas elevated C02 (5%) will maintain the firmness (AFAM+ will suffice). An added benefit of AFAM+ for mangoes is that undesirably high levels of carbon dioxide (greater than 10%) can be avoided.

10) Onions

Injury level: Onions can tolerate up to 10% carbon dioxide and 2-3% oxygen at 0-2°C.

Benefit: Onions benefit from low oxygen and elevated carbon dioxide. Elevated carbon dioxide should reduce sprouting, decay and root growth. Low oxygen may extend postharvest life

AFAM+: Onions are well suited for AFAM+ applications when shipped in a properly sealed refrigerated container because elevated carbon dioxide reduces sprouting, root growth and possibly decay. In the absence of local research findings, a carbon dioxide setting of 5% should work for onions. Oxygen is generally set at 1 to 3% for CA systems involving long-term storage. However, the oxygen set point for AFAM+ should be set to protect the onions from excessively high levels of carbon dioxide. Assuming an RQ of 1, an oxygen setting of 11% is suggested

11) Papaya

Injury level: Papayas can be damaged by oxygen less than 2% and carbon dioxide greater than 10% at 10-15°C (lower temperatures are used for riper fruit).

Benefit: Papayas benefit from desirable levels of oxygen and carbon dioxide. Desirable levels of carbon dioxide maintain firmness whereas desirable levels oxygen delay softening, ripening and degreening.

AFAM+: AFAM+ can protect papayas from low oxygen and elevated carbon dioxide injuries. The decision to use CA or AFAM+ could boil down to a simple cost-benefit decision. Can I cost justify paying $1800 per load for CA (assuming that CA is even available) when AFAM+ at a much lesser cost may be more than adequate? In the case of mangoes, low oxygen (CA required) will delay mango ripening whereas elevated carbon dioxide (5%) will maintain the firmness (AFAM+ will suffice). An added benefit of AFAM+ for mangoes is that undesirably high levels of carbon dioxide (greater than 10%) can be avoided. carbon dioxide in excess of 10% can cause quality problems like off flavors, discoloration and softening.

12) Peach/Nectarine (stone fruit).

Injury level: Peaches and nectarines can be injured by < 2% oxygen and can develop flesh browning and either off-flavor or loss of flavor if exposed to > 10% carbon dioxide for more than 3 weeks at 0°C.

Benefit: Elevated carbon dioxide at 0°C helps retain firmness and reduces internal breakdown (chilling injury) in some varieties.

AFAM+: CA is useful for shipping peaches/nectarines with transit times of 2 weeks or more because of its effect in reducing internal breakdown in susceptible varieties. AFAM+ would not replace CA for those sensitive varieties, but would benefit those varieties that can be shipped successfully in normal air. AFAM+ can protect peaches/nectarines from low oxygen and elevated carbon dioxide injuries.

13) Pears

Injury level: Pears generally show injury from > 3% carbon dioxide if exposure exceeds 1 month at 0°C. Symptoms can include brown core, core flush, core cracking, cavitation of flesh, flesh browning, and surface cracking, depending on the variety.

Benefit: Use of 1-3% carbon dioxide helps retain firmness, green color, and acidity.

AFAM+: Pears do not need CA for normal transit times. Therefore, they are very well suited for AFAM+. AFAM+ can protect pears from low oxygen and elevated carbon dioxide injuries.

14) Plums

Injury level: Flesh browning can occur if plums are exposed to > 5% carbon dioxide for more than 1 month at 0°C.

Benefit: Proper levels of carbon dioxide helps retain plum firmness at 0°C.

AFAM+: Same comments as for peaches/nectarines. AFAM+ can protect plums from low oxygen and elevated carbon dioxide injuries.