PRECONDITIONING GUIDELINES FOR KIWIFRUIT SHIPPERS

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This protocol will deal specifically with preconditioning at shipping point. Kiwifruit ripening is triggered by an ethylene treatment but ripening changes are slowed down by decreasing the fruit temperature. As the fruit warms up at the warehouse/retailer stores, ripening will continue.

Harvest - Kiwifruit should be picked according to soluble solids content (SSC). In accordance with the California Kiwifruit Marketing Order, kiwifruit must be picked to correspond with the actual minimum maturity index of at least a 6.5% soluble solids content (SSC) when inspected at the shipping point. To assure fruit quality and consumer acceptance, we recommend picking kiwifruit when it reaches a minimum of 7.0% SSC measured in the field or approximately 14% SSC after forced ripening. Research clearly states that higher sugars at harvest increases the consumer acceptance, storage and shelf-life of kiwifruit. Make sure to check the refractometer and standardize it against distilled water (0%) and/or 20% sucrose solution.

To precondition well mature kiwifruit, 100 ppm ethylene exposure per 12 hours is recommended. A short ethylene exposure of 6 hours is enough to precondition well mature kiwifruit which have been in storage for one week. This preconditioning treatment is only necessary on kiwifruit that have been in cold storage for less than 4-5 weeks.

Preconditioning for Long Distance Shipping (2-3 weeks) - Place cold kiwifruit in any type of container with polyliners at 32^{o}F in a 40-48ft. truck or ripening room with a temperature setting control. The types of kiwifruit containers such as tray packs, volume fill packages, or tri-wall containers with box polyliners does not interfere with the preconditioning treatment. We recommend the use of polyliners to protect the kiwifruit from water loss and premature shriveling. The ripening treatment should take place far away from any packing facilities to avoid ethylene contamination of long-term storage of kiwifruit.

Ethylene applied at 100 ppm for 12 hours within 32^{o}-68^{o}F temperature range will induce uniform kiwifruit softening and starch conversion into sugars (ripening). A 6 hour ethylene treatment is enough to precondition kiwifruit which have been in storage at least one week. After venting, cold ethylene-treated kiwifruit can be stored back in your cold storage but in a separate room away from your long term storage of kiwifruit. Kiwifruit treated at near 32^{o}F- 34^{o}F and maintained at near 32^{o}F may last up to 3 weeks for weak kiwifruit and up to 6 weeks for strong kiwifruit. After being transferred to higher temperatures, kiwifruit will soften according to flesh temperature (Table 1).

Table 1. Rate of kiwifruit softening after cold ethylene preconditioning treatment (32-36F) on cold kiwifruit.

Temperature	Pounds Lost Per Day
32°F	1.2
41°F	1.4
55°F	1.5
68°F	2.7
77°F	3.0

Preconditioning for Short Distance Shipping (4-7 days) - Place warm or cold palletized kiwifruit in a 40-48 ft. truck or room at 68°F and high relative humidity. The types of kiwifruit containers such as tray packs, volume fill packages, or tri-wall containers with box polyliners does not interfere with the preconditioning treatment. We recommend use of polyliners to protect the kiwifruit from water loss and premature shriveling. The ripening treatment should take place far away from any packing facilities to avoid ethylene contamination of long-term storage of kiwifruit.

The temperature during shipping should be set near 32-36°F. We recommend precooling kiwifruit before preconditioning to reduce potential decay, shriveling and undesirable fast fruit softening during postharvest handling.

The post treatment temperature management should be adjusted according to the anticipated consumption schedule using Table 2.

Table 2. Rate of kiwifruit softening after warm ethylene treatment (68F)

Temperature	Pounds lost per day
32°F	1.5
45°F	2.0
68°F	3.0 to 4.0

If shipping is delayed after treatment, kiwifruit will reach 3 lbs. within approximately six days when held at 32°F. To assure reaching maximum storage potential, the kiwifruit temperature during storage and shipping should be close to 32°F.

II. ETHYLENE TREATMENT SYSTEMS

The "Shot" and "Flow-Through" systems are the two techniques by which ethylene can be applied to kiwifruit. In either case, make sure your ripening room or truck are “well sealed”. These two ethylene application systems can be done by using compressed ethylene from a cylinder.

The Shot System - A measured amount of ethylene is introduced into the room. The room can be completely full. Ethylene shots from a cylinder may be applied by flow using a gauge that registers the discharge of ethylene in cubic feet per minute. The required ethylene application is made by adjusting the regulator to give the appropriate flow rate and then timing the delivery of gas. The amount of gas needed for a room is calculated by using the following information:

C = ppm of ethylene required (100 ppm)
V = volume of room in cubic feet
F = flow rate of gas (measured from flow meter) in cubic feet per minute (CFM)
T = time (in minutes) for which gas is allowed to flow

Plug this information into the following formula:

$$T = (C \times V) / (F \times 1{,}000{,}000)$$

For a 48-foot trailer (2,825 cubic feet), a desired ethylene concentration of 100 ppm and an ethylene flow rate of 0.018 CFM, (or approximately 0.5 liters per minute), the equation would be as shown below:

$$(100 \times 2{,}825) / (0.018^* \times 1{,}000{,}000) = 15.7 \text{ minute}$$

* To convert the above equation from cubic feet per minute to milliliters per minute, multiply by 28.32.

Flow time is easily measured with a stopwatch. The room should be ventilated before each application by opening the doors for at least one-half hour. In the case of kiwifruit just harvested or stored for less than a week, kiwifruit should be treated for at least 12 hours. If kiwifruit have been in cold storage for more than a week, a 6 hour ethylene treatment will trigger ripening. In both cases, a ventilation fan should be provided.

The Flow-Through System - With the "Flow-Through" system, ethylene is introduced into the room continuously rather than intermittently by using compressed ethylene from a cylinder or ethanol from a catalytic generator. The room can be filled to capacity with fruit. The flow of ethylene is very small and it must be regulated carefully. Regulate ethylene by reducing pressure using a two-stage regulator and passing the gas into the room through a metering valve and flowmeter. To prevent buildup of CO_2 or C_2H_4, fresh air is drawn into the ripening room at the rate which ensures a change of air every six hours (360 min.). The

air should be vented through an exhaust port in the rear of the room. Fan size or Ventilation Fan Delivery, (measured in cubic feet per minute), is calculated using the following formula:

Ventilation Fan Delivery = Volume of Room (cubic feet) / 360

The ethylene flow rate (in CFM) needed to maintain 100 ppm in the room is calculated as follows:

Ethylene Flow Rate (CFM) = Ventilation Fan Delivery (CFM) x 100/1,000,000

In milliliters per minute, the flow rate is:

Ethylene Flow Rate (ml/min.) = Ventilation Fan Delivery (CFM) x 2.8

Monitoring gas in a "Flow-Through" system can be done with a "sight glass" in which ethylene bubbles through a water trap on its way to the ripening room.

III. ETHYLENE SOURCES

Presently, there are two sources to commercially apply ethylene to kiwifruit: (1) ethylene generated from alcohol as ethylene source (catalatic) and (2) compressed ethylene from a cylinder.

Ethylene Generator - The ethylene generator is a machine in which a liquid (ethanol and catalyst agent) produces ethylene when heated. The generator combines a simple heater with a system for attaching a bottle of a generator liquid. Ethylene can be applied by using ethylene generators in position 1, in a “well sealed” 48 foot-trailer (2,825 cubic feet) or position 2, in a trailer not well sealed. We recommend measuring ethylene levels initially in the season for each operation.

There are two companies who have included kiwifruit on their California labels:

American Ripener Company Inc.
803 Presley Road, Suite 106
Charlotte, NC 28217
Tel (800) 338-2836

Precision Generators Inc.
200 Golden Oak Court
Reflections II, Suite 117
Virginia Beach, VA 23452
Tel (757) 498- 4809

Ethylene Cylinder - Use only explosion-proof mixtures. Check with your provider.

Dual Stage Regulator - Ethylene tanks require a regulator with a CGA-350 fitting. Regulator delivery pressure should not exceed 250 psi.

Product Example - Matheson Model 3122

Flowmeter - Two types available:

1. Direct read, scaled in liters per minute of air.

2. Flow rate determined by chart, scaled in millimeters. Both meters measure only air content.

Product Example - Matheson (ordered as separate components)
Tube Cube Model J409, 0.5 - 5.0 liter/min (0.018- 0.18 CFM)
Flowmeter FM-1000S-HA with 1/8" FPT fittings

Connecting Fittings - Flowmeter must be securely attached to the regulator. It must be oriented vertically to operate properly.

Product Example - Sunnyvale Valve and Fitting Company
Brass 4" hex long nipple (B-4-HLN-4.00)
Reducing street elbow (B-4-RSE-2).
1/8" NPT to 1/4" ID hose connector (B-4-HC-1-2)

IV. SAFETY PRECAUTIONS

Mixtures of ethylene gas and air are potentially explosive when the concentration of ethylene rises above 3.1 percent by volume, which is 30,000 times greater than the concentration required to initiate kiwifruit ripening.

1. Do not permit open flames, spark-producing devices, fire, or smoking in a room containing ethylene gas or near the generator.

2. All electrical equipment, including lights, fan motors and switches, should comply with the National Electric Codes for Class 1, Group D equipment and installation.