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VAPOR-HEAT TREATMENT FOR FRUITS AND VEGETABLES GROWN IN HAWAII

by

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The potentialities of the papaya industry led to studies on sterilization of this fruit by heat treatment even before the quarantine regulations were modified. Since the authorization for entry of Hawaiian fruits and vegetables to the mainland, these experimental studies have been more intensive and the scope of the work has been extended to other local fruit and vegetable hosts of the Mediterranean fruitfly or the melonfly.

The procedure and conditions for vapor-heat treatment are fixed by the quarantine laws. The temperature of the fruit or vegetable must be held at 110° F. for at least 8 hours, during which time the air must be fully saturated with water vapor. In some instances a conditioning treatment is necessary before the fruit will tolerate sterilization by this method (*1*).

The handling and movement of vapor-heat-sterilized fruits and vegetables are under the supervision of the U. S. Bureau of Entomology and Plant Quarantine, and certain restrictions have been placed on the movement of the sterilized produce. One of these restrictions, in relation to cold storage, should be mentioned here; it reads as follows: "Following completion of treatment, fruits or vegetables destined for shipment to the mainland shall be moved in commercial containers by the most direct route from the treating establishment to shipside and such movement should be timed by the shipper so that the shipment will be loaded in an approved *refrigerated* space on the vessel immediately after arrival on the dock." It is possible that this restriction will be modified to permit shipment in nonrefrigerated space, but since cold storage is necessary in most cases to maintain the quality of the produce and to control decay organisms this restriction works no detriment to the shipper.

Since no deviations from the prescribed conditions for treatment are possible, the work of the station has been to determine the tolerance of the produce to the heat treatment and the subsequent handling and storage conditions which will enable the fruits and

vegetables to reach the mainland in marketable shape. The purpose of this circular is to give practical recommendations for commercial handling of the Hawaiian-grown fruits and vegetables which are most likely to be shipped to the mainland. Included are results of experiments at the Hawaii Agricultural Experiment Station as well as recommendations found in the literature (*2, 3*).

General Recommendations

Fresh fruits or vegetables harvested for vapor-heat treatment and subsequent shipping should be free from skin breaks, bruises, and decay. Since treatment may cause an increased rate of ripening, the maturity of the produce must also be given careful consideration. The fruits or vegetables should be treated immediately after harvesting, then cooled to room temperature and placed at the recommended cold temperature.

Cold storage after the vapor-heat treatment is designed primarily to prevent deterioration and decay and to delay ripening. Many of the tropical fruits and vegetables are subject to cold injury; however, the subject is too broad for detailed discussion in this circular. The conditions presented should not be considered as absolute and final, but rather as the limits under which the various products can ordinarily be treated and stored. At lower storage temperatures decay organisms are controlled but cold injury occurs, so that subsequent ripening is not satisfactory; at higher temperatures, although there is no cold injury, the fruits or vegetables tend to wilt and become moldy. Seasonal variations in tolerance to treatment and storage have also been noted, and rigid conclusions should not be drawn on experience from one season to the next.

On removal of the fruits or vegetables from cold storage, the possibility of injury from sweating can be minimized by allowing the produce to return to room temperature under a draft of forced air. Such fruits or vegetables should then be marketed without delay.

The prescribed storage conditions for specific crops are summarized in table 1. More detailed information is given in the text thereafter.

Papaya

The papaya, if not properly handled, may be severely injured by the vapor-heat treatment (*1*). Papayas should preferably be firm

Table 1. Recommended storage conditions for fresh fruits and vegetables[1]

Commodity	Storage after sterilization	
	Temperature	Humidity
	° *F.*	*Percent*
Papaya	50 - 60	80 - 85
Eggplant	45 - 50	85 - 90
Litchi	35 - 40	80 - 85
Chinese peas	35 - 40	85 - 90
Green snap beans	32 - 40	85 - 90
Yellow wax beans	32 - 40	85 - 90
Cucumbers	45 - 50	80 - 85
Lima beans	32 - 40	85 - 90
Tomatoes (pinks or mature greens)	55 - 70	85 - 90
Bell peppers	36 - 50	85 - 90
Avocado	No successful treatment	

[1]The recommended storage conditions are taken in part from Circular 278, U. S. D. A. (*3*)

ripe when treated. They should be given a conditioning period of 8 hours at a temperature of 100° to 110° F. and a relative humidity of 55 to 60 percent. After this period the fruits will tolerate sterilization at 110° F. and 100 percent relative humidity. They should then be cooled to room temperature and placed in cold storage at 50° to 60° F. They may be held at 50° F. for 10 to 15 days and still ripen after removal to room temperature. At a temperature below 50° F. the fruits are chilled and will not ripen properly. Ripe fruits may be held at a lower temperature, since ripening is not a factor. However, the treatment of ripe papayas is not recommended as such fruits are more apt to be injured in the sterilization process or bruised in subsequent handling. A more complete discussion of this subject has been published (*1*).

Eggplant

The eggplant also appears to require a conditioning period before treatment. Experimental work is still in progress but the indications to date are that the fruits should be about two-thirds the size of fully mature fruits. The same conditioning period as for papayas should be used, and even so, some injury is likely to occur. After the treatment the uninjured fruits may be held at 35° F. with a relative humidity of 85 to 90 percent for 10 to 14 days.

Litchi

Litchis should be harvested ripe and given the vapor-heat treatment immediately. As no conditioning period is required, the conditions of the sterilization should be attained as soon as possible. Even with the time of the vapor-heat treatment held at the minimum, red-fruited varieties lose about 25 percent of the characteristic bright red color, becoming brownish-red. No treatments have been made with the green varieties. There is no noticeable effect on the flavor, and storage at 35° to 40° F. checks further loss in color to a large extent. At 35° to 40° F., the fruits may be expected to keep for 2 to 3 weeks without loss of flavor and with only a slight additional loss in color. At temperatures above 40° F. fermentation occurs and the fruits are spoiled in the course of a few days or a week.

Chinese Peas

Chinese peas that are to be given the vapor-heat treatment should be harvested at the same stage of maturity as for the local market. If immature when harvested, they are likely to become badly wilted before they can be marketed. The peas should be treated immediately after harvesting, with the air saturated with water vapor throughout the treatment. Immediately thereafter the peas should be spread in a thin layer and the surface moisture removed by a forced draft of air. Between 1 and 2 hours are required. The peas should then be stored at 35° to 40° F., at which temperatures they can be held for 10 days to 2 weeks provided the relative humidity is maintained at 80 to 90 percent. At room temperature treated peas wilt within 4 to 5 hours.

Green Snap Beans

Green snap beans should be harvested, treated, and handled in the same manner as Chinese peas. The removal of surface moisture after the vapor-heat treatment is even more important with snap beans than with Chinese peas. The beans should be stored or shipped at a temperature of 32° F., and may be expected to keep from 2 to 3 weeks if the relative humidity is maintained at 85 to 90 percent. At room temperature green beans become wilted and moldy and are unmarketable within 2 or 3 days.

Yellow Wax Beans

The recommendations for handling wax beans are the same as for green beans. The wax beans are slightly more resistant to wilting and fungus growth.

Lima Beans

Lima beans show least injury from the vapor-heat treatment of any of the beans treated. They should be harvested as for the local market and treated unshelled, with the air saturated throughout the entire period. After treatment, the beans may be shelled and stored at 32° F. for about 15 days. If they are to be stored unshelled all surface moisture should be removed by means of a forced draft of air. Unshelled lima beans may be expected to keep for about 3 weeks at 32° F. Lima beans cannot be held at room temperature for more than 2 or 3 days after the vapor-heat treatment.

Cucumbers

Cucumbers also tolerate the vapor-heat treatment without a conditioning period. The only noticeable change is an increase in the rate of yellowing; therefore it is of upmost importance that the fruits should not be overmature. After treatment, cucumbers can be held for 10 to 15 days at 45° to 50° F., with a relative humidity of 85 percent. Cold injury is likely to occur at a temperature below 45° F.; if the temperature is higher than 50° F., the cucumbers tend to ripen and are likely to decay.

Tomatoes

Tomatoes tolerate the vapor-heat treatment without a conditioning period. Due to difficulty of handling ripe fruit, only "pinks" or "mature green" fruits should be treated. These treated fruits should be stored and shipped at a temperature not lower than 55° or higher than 70° F. At these temperatures ripening progresses slowly and the tomatoes can be kept from 1 to 4 weeks, depending upon the maturity of the fruits at time of treatment. At lower temperatures ripening does not progress satisfactorily, even on removal to room temperature.

Bell Peppers

Full-grown but not overmature bell peppers may be given the vapor-heat treatment without a conditioning period. After treatment

they may be held at 50° F. for about 10 days; at lower temperatures cold injury is likely to occur. According to Rose et al (*3*), peppers may be held at 35° F. for 3 or 4 weeks before cold injury becomes serious, if the relative humidity is maintained at 85 to 90 percent. They cannot be held at room temperature for more than 1 or 2 days.

Avocados

Avocados of the Panchoy and Nabal varieties did not tolerate the vapor-heat treatment. Various conditioning periods were studied, but none proved satisfactory.

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