MAP PACKING TO MEET QUARANTINE SECURITY REQUIREMENTS FOR SWEET CHERRIES

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To date, Northwestern sweet cherry growers shipped 37,961 metric tons of mahogany colored and 3117 mt 'Rainier' sweet cherries (8-12-99). In 1998, the Pacific Northwest shipped 60,919 mt of mahogany and 3,687 mt of yellow 'Rainier' sweet cherries to market (Washington State Fruit Commission). The sweet cherry market is built on the size and quality of one dark mahogany cultivar, 'Bing'. A second cultivar of importance is the red blushed yellow 'Rainier'. There are a number of excellent cultivars which ripen before, during, and after 'Bing'.

In 1998, 20,507 mt (~ 34 percent) of the Pacific Northwest sweet cherries were exported. The export destinations vary from year to year, but in 1998, the 5 largest export destinations were as follows; Taiwan (5722 mt tons), Canada (4052 mt), United Kingdom (3531 mt), Japan (2883 mt), and Hong Kong (2025 mt). In 1999, the largest Northwest export markets appear to be Japan, Taiwan, Canada, and the United Kingdom, respectively. In 1999, California shipped 9425 mt to Japan. The quantity of sweet cherries exported from the Pacific Northwest is substantial, offering a profitable return for fruit growers.

Methyl bromide is the accepted treatment for export to Japan to prevent any accidental importation of codling moth (*Cydia pomonella*). Sweet cherries, however, do not appear to be a host for codling moth. Not all exported sweet cherries are fumigated.

In 1998 we found heating infested sweet cherries for 30 minutes at 45^0C produced 99 % mortality of 4^{th} and 5^{th} instar codling moth larvae . We wanted to put more stress on the infested cherries by changing the environmental conditions. Also, 45^0C is very close to or may cause some fruit damage. We wanted to investigate methods which could readily be instituted. The tactics were to modify the atmosphere by reducing the oxygen level and at the same time put stress on the larvae to induce mortality. A 0.5% oxygen level on 2-24 hr codling moth eggs showed a 95% mortality in less than 2 days (Soderstrom, E. et al. 1991. J. Stored Prod. Res. 27(2):95-101.

We selected a combination of cold and a low oxygen level to induce a high mortality in codling moth larvae. We felt that the combination of low oxygen and cold could result in high mortality sufficient to meet quarantine requirements. All sweet cherries are handled under refrigeration. The standard dogma for sweet cherries is to move the fruit from the field as soon as possible and remove the field heat. Hydro-cooling and cold storage are

used to maintain fruit quality. Cold is effective in killing non-diapausing codling moth larvae.

We expected sweet cherries to tolerate very low levels of oxygen, even going anaerobic for a short period of time without suffering long term anaerobic damage. Sweet cherries are considered non-climacteric fruit and therefore we expected to maintain sweet cherry quality with modified atmosphere, even extending fruit life. Sweet cherry respiration has been measured at 10 to 20 mg / Kg hr^{-} at 0^0C (Sekse, L. 1988. Acta Agric. Scand. 38:59-66. Crisosto, C. 1993. HortScience 28(2):132-135). A limited amount of commercial modified atmosphere packaging is utilized for sweet cherries.

The 3rd and 4th instar codling moth larvae were obtained from a culture reared at the USDA-ARS Laboratory in Yakima, where it is maintained on a soya-wheat germ-starch artificial diet at ~ 27ºC, 40 to 50% RH, with a 16:8 hr light : dark photo-period to prevent induction of diapause.

Oxygen depredation experiments were conducted in a 28.3 liter fiberglass chamber (Labconco vacuum desiccator). Low levels of oxygen were found to stop 3rd and 4th instar larval motion and web spinning of naked 3rd and 4th instar codling moth larvae in comparison to control larvae. The larvae were held in perforated polystyrene cups. A vacuum was pulled down to ~ 700mm of Hg. After the vacuum was pulled, a balloon was used to transfer a mixture of 90 % nitrogen and 10 % carbon dioxide from a gas cylinder to the chamber to replace the atmosphere. The vacuuming and gas flushing was repeated two additional times. The experiments were conducted at ambient laboratory temperatures. The larvae were held in the chamber under a modified atmosphere for 5 hours. At the end of 5 hours, the chamber was opened, and the treated larvae and controls were transferred to 'Golden Delicious' apples cut into 1/8's. The larvae infested apples were held 3 days at 25^0C, cut open and evaluated for survival. Unfortunately, the survival rate was equally high for both treated and untreated larvae, in excess of 85%. We were not able to measure the atmosphere of the chamber.

We placed trays of 3rd and 4th instar diet infested codling moth larvae in cold storage to obtain a measurement of larvae mortality in cold. Larval mortality is high at 4 weeks storage at 1- 3ºC.

Third and Fourth instar codling moth larvae were removed from artificial diet and placed on 500 grams of sweet cherries. We used 2 cultivars, 2 lots of 'Bing' sweet cherries and one lot of 'Lapin'. The infested cherries were then held 24 or 48 hours at ~ 24ºC and 60-70% RH, with constant light to allow the larvae to enter the fruit before starting the experiment. The fruit was washed with ~ 100 ppm of sodium hypochlorite to reduce the rate of decay.

This year we flushed and vacuum sealed control and codling moth larvae infested sweet cherries and placed them under refrigerated storage at 1 - 2.5 ^{0}C. The packages were

flushed with a 10% carbon dioxide - 90% nitrogen gas mix. Sample bags were removed from refrigerated storage and the gas concentration was sampled on a weekly interval. MAP packed control fruit was removed at the same time and evaluated for quality.

We found the atmosphere in the MAP packaged fruit quickly returned to ~ 2% carbon dioxide or less, 10% oxygen, and 88% nitrogen. We had hoped for a lower level of oxygen with the selected bags. Balancing the amount of fruit, the oxygen transmission rate of the polyethylene film, and the temperature is a difficult task. A 10% oxygen concentration within the polyethylene bag would not increase the codling moth mortality rate.

We expected sweet cherry quality to respond to modified atmosphere packaging. A loss of perhaps 3 percent of the stem moisture may result in stem browning. Sekse (1988. Acta Agric. Scand. 38:59-66) indicates stem respiration is greater than fruit. Brown or dried stems are an indication of sweet cherry aging. Damaged or non-green stems are detrimental to the sale of sweet cherries. Modified atmosphere can substantially slow moisture loss from the fruit. We felt MAP packaging extended the fruit life.

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- Cold is effective for inducing mortality of codling moth larvae.
- Modified atmosphere packaging lengthened sweet cherry storage life maintaining quality.
- Matching packaging gas transmission rates, sweet cherry respiration rates, and storage temperatures will be a critical factor for any quarantine benefit from MAP.

Percent In-Situ Mortality Of 3rd and 4th Instar Codling Moth Larvae Chilled In Artificial Diet At 1.0 - 2.5 ^{0}C

Chilling Time (Days)	Replication 1	Replication 2	Replication 3	Mean * %
2	4.9	0.5	1.5	2.3
8	18.5	19.4	9.9	15.9
14	53.2	64.2	35.6	51.0
21	98.6	96.9	99.3	98.3

*** > 300 larvae**

Percent Mortality Of 3rd and 4th Instar Codling Moth Larvae Within Artificially Infested Mature Sweet Cherries Modified Atmosphere Packaged And Chilled To 1.0 - 2.5 ^{0}C

Weeks	Bing I	Bing II	Lapin
1	54.2	22.3	29.0
2	37.6	36.6	44.4
3	60.8	66.7	63.4
4	97.2	100.0	

Quality Of Modified Atmosphere Packaged Bing I Sweet Cherries

Week	Stems* % Acceptable	Smell	Taste	Visual
1	70	Good	Good	Good
2	65	Good	Good	Good
3	66	Good	Good	Fair
4	52	Good	Good	Fair

*** 1-4 Scale, Acceptable (3 + 4)**