# CONTROLLED ATMOSPHERE/TEMPERATURE TREATMENTS TO CONTROL CODLING MOTHS IN BARTLETT PEARS

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The first controlled atmosphere/temperature treatment (CATTS) system was conceived and designed by Lisa Neven, USDA ARS Wapato, WA and Elizabeth Mitcham, Dept. Plant Sciences, University of California, Davis and was installed at UCDavis. The concept was to increase the speed with which pest mortality could be achieved with forced hot air treatments by adding a modified atmosphere. One of the first studies conducted was for control of codling moth larvae in Bartlett pear fruit. Demonstrated control of this pest is a requirement for export of U.S. pears to many other countries. Bartlett pear fruit do not tolerate methyl bromide fumigation, so this was never an option, even in the past.

Heating rate is very important to the efficacy of a heat treatment for insect control. The slower the heating rate, the longer the insect must be exposed to the high temperature to achieve quarantine security. Therefore, it is important to determine the fastest heating rate that will be tolerated by the commodity to maximize pest control and shorten the treatment time. The addition of low oxygen or elevated carbon dioxide to the heat treatment can reduce the length of heat exposure required for pest mortality by as much as 50%. The goal of this study was to determine the effects of CATTS for control of codling moth and the tolerance of Bartlett pears to different heating rates.

Bartlett pears (*Pyrus communis* L.) were harvested in California in 1996 and 1997. Pears were sorted to eliminate damaged fruit and to obtain fruit of uniform size and color. Unless otherwise stated, materials and methods, treatments and results for the two years of this study were similar thus this paper will focus particularly on the 1997 experiments and results. Pears were selected for quality evaluation immediately after harvest. Flesh firmness was determined on opposite cheeks of each fruit with a penetrometer fitted with an 8-mm probe. Skin color on opposite sides of each fruit was measured with a Minolta Chroma Meter. Carbon dioxide and $C_2H_4$ production rates were measured daily at 68°F (20 °C).

Four fifth instar codling moth larvae were placed on each infested pear in an enclosure for 24 hours prior to CATTS treatment. The atmosphere was established prior to heating. The rate of heating for the supply air and fruit surface was slower in 1997 (12°C/hour) as compared with 1996 (100°C/hour). It took >60 minutes for the supply air to reach 115°F (46°C) in 1997, while in 1996 it reached 115°F (46°C) in about 45 minutes. The different heating rates affected both the fruit response to the treatments and codling moth mortality.

In 1996, heat treatments inhibited fruit ripening after three weeks of cold storage, as determined after 5 days of ripening. The longer the treatment, the greater the inhibition, and addition of CA increased ripening inhibition (Figure 1). In 1997, fruit were ripened at harvest and after cold storage. Fruit subjected to longer treatments (hot air or CATTS) were more firm than untreated fruit after 4 days of ripening, but all fruit were fully ripe by 7 days (Fig. 3). Treating with exogenous ethylene did not overcome the inhibition in the rate of ripening although fruit from all treatments softened faster (data not shown). After three weeks of cold storage, there was little difference in initial firmness. During ripening, fruit firmness was higher for fruit heat treated for 2 or 3 hours in air and especially in CA as compared with untreated fruit, but all the fruit were soft within 7 days (Fig. 4).

In 1996, there was a trend to more skin brown discoloration following pear handling after storage and 5 days ripening at 68°F (20°C), especially in the heat with CA treatments (Fig. 2). This increased susceptibility to skin browning was not observed in 1997 (data not shown).

Heating the fruit to 115°F (46°C) in CA instead of air greatly increased the mortality of codling moth larvae (Table 1). Mortality was only 50% with a 3 hour heat treatment in air, but was 100% with CA. Mortality was higher when the heating rate was faster. One hundred percent mortality was achieved in 2.5 hours with the faster heating rate in 1996, while it took 3 hours to achieve one hundred percent mortality with the slower heating rate in 1997. The CATTS treatment at 115°F (46°C) appears promising to control codling moth in exported Bartlett pears.

Table 1. Mortality (percent corrected) of codling moth after heating to 46°C in air or controlled atmosphere of 1% oxygen and 15% carbon dioxide.

| Treatment Time (hours) | Air | CA |
|---|---|---|
| Fast Heating (1996) | | |
| 1.0 | - | 43.3[a] |
| 1.5 | - | 89.6 |
| 2.0 | - | 96.6 |
| 2.5 | - | 100.0 |
| Slow Heating (1997) | | |
| 1.5 | 11.3 | 13.0[b] |
| 2.0 | 14.6 | 49.0 |
| 2.5 | 22.5 | 92.0 |
| 3.0 | 52.6 | 100.0 |

[a]550 insects per time point
[b]231 insects per time point

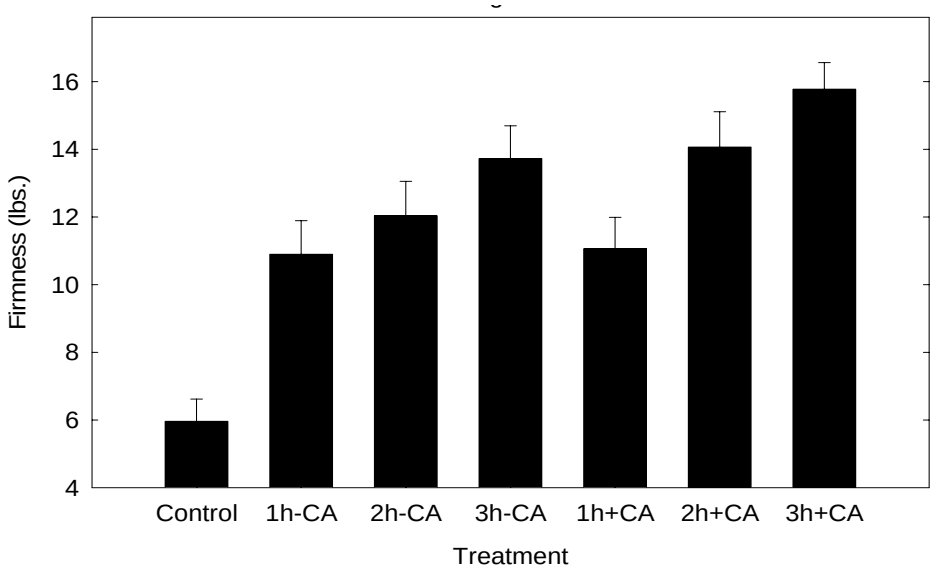


Figure 1. Firmness of Bartlett pear fruit after exposure to rapid heating at 46°C (115°F) for 1, 2 or 3 hours in air or CA (1% $O_2$ + 15% $CO_2$) followed by 3 weeks storage at -1°C and 5 days ripening at 20°C (68°F).

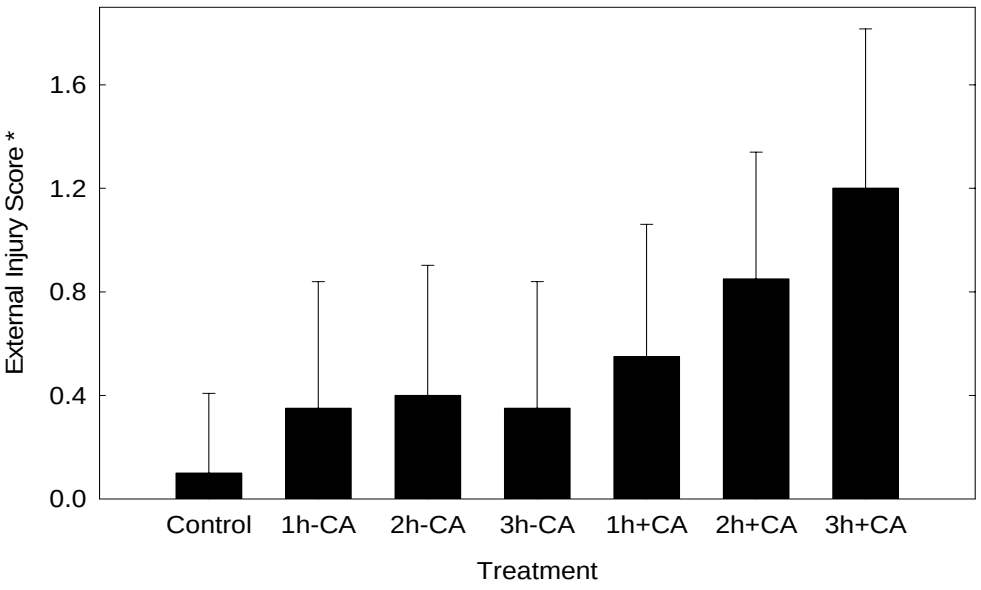


Figure. 2. External injury (skin browning) of Bartlett pear fruit after exposure to rapid heating at 46°C (115°F) for 1, 2 or 3 hours in air or CA (1% $O_2$ + 15% $CO_2$) followed by 3 weeks storage at -1°C and 5 days ripening at 20°C (68°F). Injury became apparent after handling of the fruit following 5 days at 20°C (68°F). Injury score: 0 = none; 1 = slight; 2 = moderate; 3 = severe.

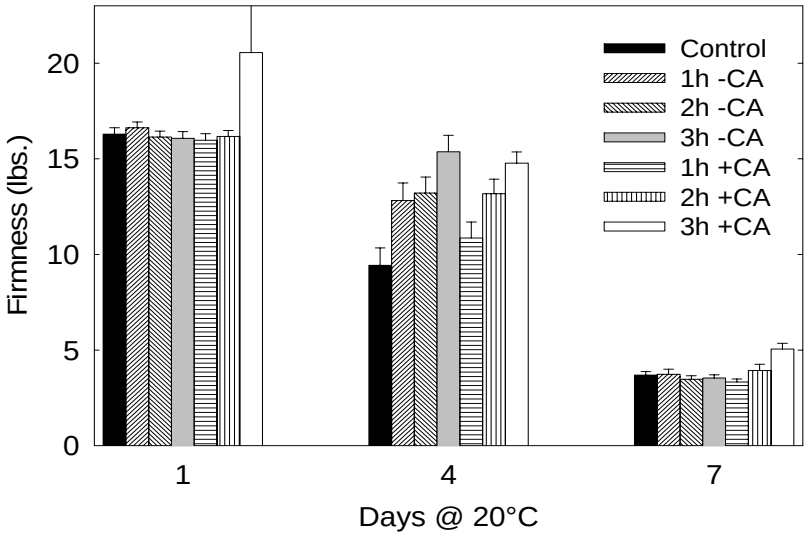


Figure 3. Firmness of Bartlett pear fruit during 7 days ripening at 20°C (68°F) immediately after exposure to slow heating at 46°C (115°F) for 1, 2 or 3 hours in air or CA (1% $O_2$ + 15% $CO_2$).

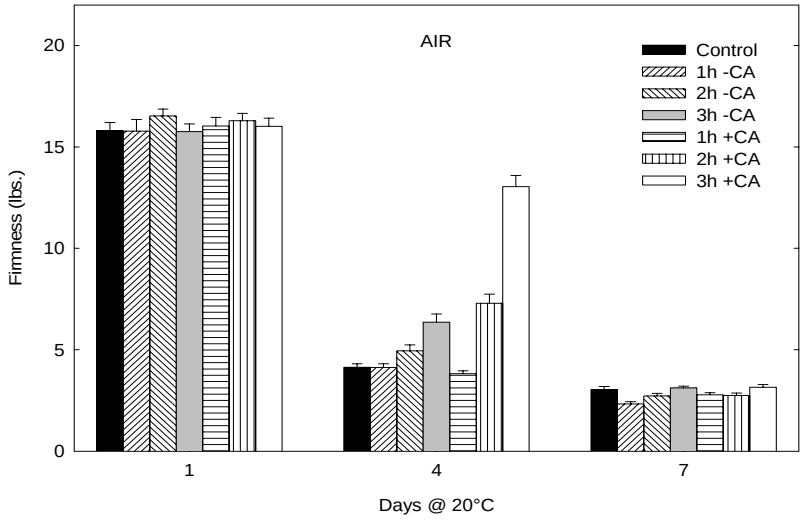


Figure 4. Firmness of Bartlett pear fruit during 7 days ripening at 20°C (68°F) after exposure to slow heating at 46°C (115°F) for 1, 2 or 3 hours in air or CA (1% $O_2$ + 15% $CO_2$) and 3 weeks of storage at -1°C.