# HIGH TEMPERATURE $CO_2$ TREATMENTS FOR INSHELL WALNUTS

B. D. Rohitha Prasantha[1], David Obenland[2], Spencer Walse[2], and Judy Johnson*[2]
[1]Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Sri Lanka
[2]San Joaquin Valley Agricultural Sciences Center, USDA-ARS, Parlier, CA, USA

California walnut processors normally fumigate inshell nuts shortly after drying to disinfest product of field pests such as navel orangeworm or codling moth. Environmental restrictions on currently used fumigants require that non-chemical alternatives be considered. Earlier work (Soderstrom et al. 1996a, b) found that 98% $CO_2$ at 43°C for 7.3 hours should be an effective phytosanitary treatment for these insects, as it is the estimated probit 9 upper 95% confidence limit for the most tolerant stage (diapausing codling moth larvae). This paper evaluates the treatment as a potential alternative to fumigation.

A laboratory CATTS unit (Controlled Atmosphere/Temperature Treatment System, Neven 2005) was used to apply the treatment. The humidity controls normally used to obtain high humidity for fresh fruit were not applied. Inshell walnuts artificially infested with laboratory-reared diapausing codling moth were placed in onion bags and buried in uninfested walnuts held in perforated crates within the treatment chamber. Nutmeat temperatures were monitored with thermisters. Relative humidity and gas levels were also recorded (Fig. 1). A treatment time of 8 hours was selected. Uninfested walnut samples were weighed before and after treatments to estimate moisture loss during treatments. Additional samples were held after treatment under accelerated storage conditions (35°C for 10 and 20 days, comparable to normal storage for 1 and 2 years), and then sent to an industry laboratory for quality analysis. Results will be discussed.

Ancillary studies showed that walnut moisture levels were reduced from about 8.4% to about 6.5 and 5.5% after 7 hours in hot forced air ovens kept at 38 and 43°C, respectively (Fig. 2). This suggests that some humidity control in the treatment may be necessary to prevent excessive drying of the product. Additional studies examined the amount of $CO_2$ sorbed by walnuts under high $CO_2$ conditions. The possibility of $CO_2$ sorption by the product may play an important role in determining the amount of $CO_2$ required for treatment. The experimental procedure used was modified from that of Cofie-Agblor et al. (1998). Single armed one liter glass flasks were fitted with 2-hole rubber stoppers into which copper tubes were inserted. Side arms of the flasks were connected to pressure-temperature sensing data loggers. 250 g of walnut halves (8% moisture), were placed in the flasks which were tightly sealed with the stoppers and vacuum grease. Flasks were conditioned for about 6 h at 43°C before being flushed with $CO_2$ (99.9% purity) for 5 minutes under atmospheric pressure immediately after which the flasks were tightly closed. Flasks were held at 43°C for 100 h and the pressure (kPa) inside the flasks was recorded every 30 minutes. The amount of $CO_2$ inside the flasks was determined with a gas chromatograph. Control samples were flushed with normal atmosphere. The pressure drop inside the $CO_2$-treated flask was proportional to the amount of $CO_2$ sorbed (g/ kg of walnut), and was calculated using the universal gas equation (Cofie-Agblor et al. 1998). The pressure did not change in the control samples (Fig. 3) indicating no gas sorption occurred. The mean initial $CO_2$ concentration was 95.3% at 43°C.The sorption rate of $CO_2$ by the walnuts in the first 5 h was very rapid (Fig. 4), and thereafter sorption increased linearly with time. Walnuts sorbed 4-5% of the $CO_2$ within the first 8 h of the treatment. This was much higher than $CO_2$ sorption by grains at 43°C (Cofie-Agblor et al. 1995, 1998), probably due to the high oil content in walnuts, and indicates that care must be taken to maintain the $CO_2$ levels in commercial applications of this method to walnuts.

**Acknowledgements**

We wish to thank Richard Gill, Paul Neipp, Dave Bellamy and Steve Tebbets, all of the Commodity Protection and Quality Unit of the San Joaquin Valley Agricultural Sciences Center, for their hard work and expertise.

**References Cited**

**Cofie-Agblor, R., W.E. Muir, R. Sinicio, S. Cenkowski, and D.S. Jayas. 1995.** Characteristics of carbon dioxide sorption by stored wheat. Journal of Stored Product Research 31:317-324.

**Cofie-Agblor, R., W.E. Muir, D.S. Jayas, and N.D.G. White. 1998.** Carbon dioxide sorption by grains and canola at two CO2 concentrations. Journal of Stored Product Research 34:159-170.

**Neven, L. G. 2005.** Combined Heat and Controlled Atmosphere Quarantine Treatments for Control of Codling Moth in Sweet Cherries. Journal of Economic Entomology 98:709-715.

**Soderstrom, E. L., D. G. Brandl, and B.E. Mackey. 1996a.** High temperature alone and combined with controlled atmospheres for control of diapausing codling moth (Lepidoptera: Tortricidae) in walnuts. Journal of Economic Entomology 89:144-147.

**Soderstrom, E. L., D. G. Brandl, and B. E. Mackey. 1996b.** High temperature and controlled atmosphere treatment of codling moth (Lepidoptera: Tortricidae) infested walnuts using a gas-tight treatment chamber. Journal of Economic Entomology 89:712-714.

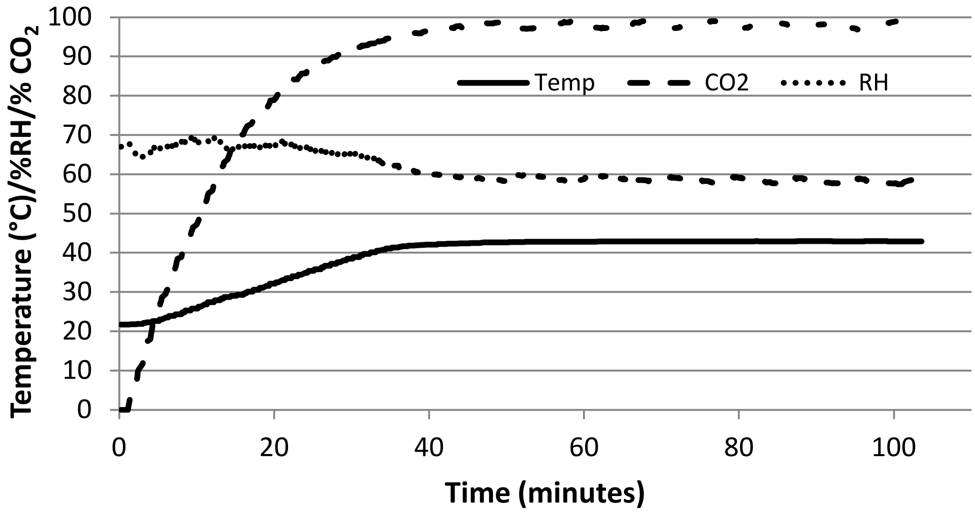


Figure 1. Typical temperatures, $CO_2$ levels and relative humidities (RH) recorded during preliminary tests using the CATTS unit.

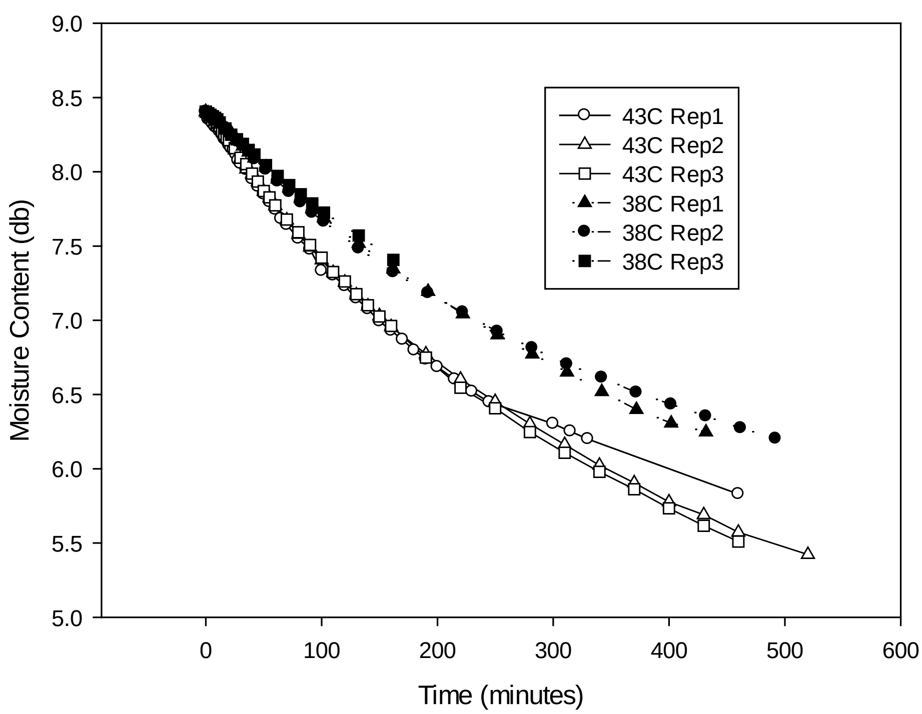


Figure 2. Moisture content changes (dry basis) in walnuts held in a 38 or 43°C hot forced air oven.

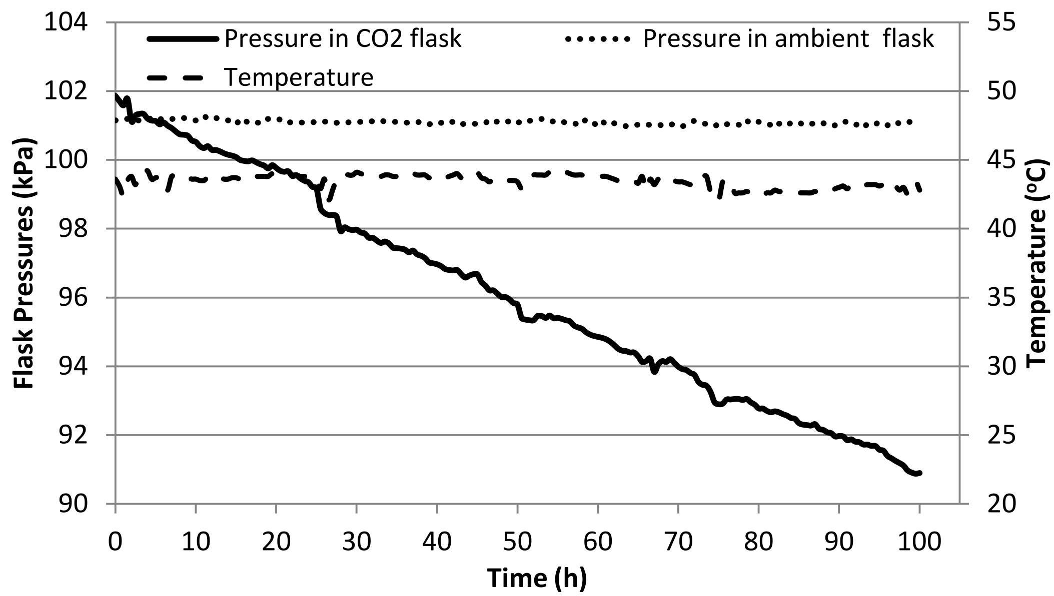


Figure 3. Pressure changes inside flasks containing walnut treated with and without $CO_2$.

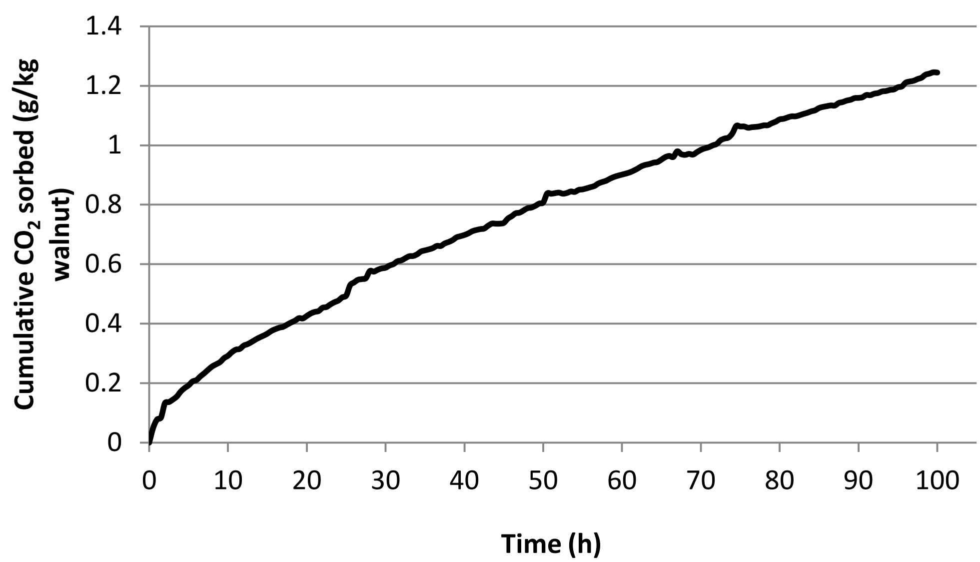


Figure 4. $CO_2$ sorption by walnut at 8% (dry basis) moisture content and 43°C.