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**Prestorage Heat Treatment to Inhibit Chilling
Injury and Delay Ripening in Tomato Fruit**

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Prestorage Heat Treatment to Inhibit Chilling Injury and Delay Ripening in Tomato Fruits

Abstract

The research had two specific goals; (1) to develop and optimize a postharvest heat treatment and characterize the response of tomato to the heat and subsequent cold storage, and (2) to investigate the involvement of heat shock proteins (HSP) in resistance to chilling injury. For the first goal we have investigated many time-temperature treatments using dry heat and found that 48 h at 38°C is optimum for Israeli cultivars, while 48 h at 42°C worked better for American cultivars in preventing chilling injury. We have also compared hot water to hot air and found hot water to effective, but less so than hot air. Membrane lipid composition in relation to chilling injury was investigated after hot water and hot air treatments. Investigation of fruit ripening found that mRNAs of ripening-related genes were inhibited by high temperature, but recovered during the subsequent storage period and allowed normal ripening to proceed. Sensory studies showed no difference in the taste of heated or nonheated fruit.

Following the production of HSP in heated and stored fruit allowed us to determine that during low temperature storage the HSP remained present in the fruit tissue, and their presence was correlated with resistance to chilling injury. HSP clones have been isolated by both differential screening of a cDNA library of heated and chilled tomatoes (Israel) and by mRNA differential display (United States). These clones are being characterized.

Objectives

The long term goal is to improve control ripening, ameliorate chilling injury, and reduce the input of questionable chemical agents during postharvest handling and storage.

Specific goals:

1. To continue development, optimization and characterization of a commercially applicable, high through-put method of postharvest heat treatment for cold storage of tomato.
2. To investigate the involvement of heat shock proteins in the resistance to chilling injury.

Results

Goal 1.

The research has concerned itself with the development of a postharvest heat treatment for cold storage of tomato. We have been trying to develop a shorter time of heating than the 3 days which we originally reported, and to this end have attempted various time-temperature manipulations using dry heat. The results are presented in the following manuscript: Prestorage Temperature Manipulations to Reduce Chilling Injury in Tomatoes, which is in press in Postharvest Biology and Technology.

Description of Cooperation

The scientist from the two countries met yearly. The first year Dr. Lurie traveled to the United States and as a result of this visit determined that the experiments in the US were using the wrong storage temperature. This allowed extensive experiments to be performed the following season and the establishment that the US field grown tomato cultivars could develop resistance to low temperatures similar to the Israeli greenhouse cultivar. It also allowed tissue to be collected from successful experiments for differential display experiments. The second year Dr. Dilley visited Israel and presented a seminar on the progress of his group. The third year both scientists and some of the researchers from the US group met at a meeting in Greece and discussed progress. The clones isolated by both groups, corresponding to different HSPs are being exchanged so that future work can be done in both labs. In conclusion, the cooperation has been quite close, and between meetings contact was maintained by e-mail and fax.

Evaluation of the Research Achievements

We have achieved both major goals of the project, although not completely. The first goal was the development, optimization, and characterization of a high-through-put method of postharvest heat treatment. We have shortened the dry heat treatment by one-third with no loss in quality, and begun the development of hot water dips. We have characterized the basic biochemical and physiological changes caused by the differing heating regimes, and compared dry heat and hot water. We have not, however, yet tried heat treatments on a commercial scale.

The second goal, to investigate the involvement of HSP in the resistance to chilling injury, has been well documented in this research. Correlations of accumulation of HSP and resistance of the tissue to chilling injury, versus disappearance of HSP and reappearance of sensitivity to chilling injury were established. Specific HSP clones which are up-regulated by heat and maintained in the cold were isolated by both groups. Characterization of these clones is well under way at present. We are currently putting the clones into *E. coli* expression vector and plan to purify antibodies for further use. And we have submitted a new proposal to BARD to conduct transgenic studies using the clones.

The benefit to agriculture from this research can come from a number of findings. The fact that most tomato cultivars respond to heat by developing resistance to low temperature means that this is a general adaptation response. Studies together with other scientists in the department in Israel have shown that other commodities - avocados, citrus, cucumbers and mango - also respond similarly. Work is being done on the development of a hot water apparatus to be part of the packinghouse line, so that in the future this work may have very practical application to postharvest treatment of fruits and vegetables.

One additional benefit of the heat treatment, which was not touched upon in this report, is that it can decrease fungal rots, both by killing the fungal spores, and by activating defense mechanisms in the fruit tissue, similarly to the activation of resistance to low temperature. Therefore, a practical application of the heat treatment may slow ripening, decrease sensitivity to low temperature storage, and decrease fungal infections.

The molecular biology studies may well benefit agriculture in a longer time span. To actually prove that the HSPs are inducing the resistance to low temperature, we have to prevent their induction and show that in parallel resistance does not increase. We hope to do this by using overexpression and antisense plants in a continuing project (if funded). However, if true, this has implications far beyond postharvest. If we can make plants with some constitutive levels of HSP present and if this does not cause a large yield penalty, then these plants should be more tolerance of temperature extremes, both high and low. This possibility has far reaching consequences for field grown crops.

List of Publications

A. Sabehat, D. Weiss and S. Lurie. 1995. Persistence of heat shock proteins in heated tomato fruit and the resistance to chilling injury of the fruit. *Acta Hortic.* 298:11-21.

A. Sabehat, D. Weiss and S. Lurie. 1996. The correlation between heat-shock protein accumulation and persistence and chilling tolerance in tomato fruit. *Plant Physiol.* 110:531-537.

S. Lurie, A. Handros, E. Fallik and R. Shapira. 1996. Reversible inhibition of tomato fruit gene expression at high temperature: Effects on tomato fruit ripening. *Plant Physiol.* 110:1207-1214.

M. Laamin, Z. Lapsker, E. Fallik and S. Lurie. 1997. Heat treatments to decrease chilling injury in tomato fruit: Effects on lipids, pericarp lesions and fungal growth. *Physiol. Plant.*, in press.

S. Lurie and A. Sabehat. 1997. Prestorage temperature manipulations to reduce chilling injury in tomatoes, *Postharv. Biol. Technol.*, in press.

J.D. Klein, W. Conway, S. Lurie etc. 1997. Sensory studies of heated apples and tomatoes. *Acta Hortic.*, in press.

D. Kadyrzhanova, K. Vlachonasios, P. Ververidis and D. Dilley. Molecular cloning of a novel heat induced/ chilling tolerance related cDNA in tomato fruit by use of mRNA differential display, *Plant Mol. Biol.* submitted.