Persimmon and Guava Fruit Response to Radio Frequency Heating as an Alternative Quarantine Treatment

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INTRODUCTION

Fruit fly infestations limit fruit marketability and many countries/regions require that potentially infested fruits be quarantine treated to assure insect mortality. The Mexican fruit fly is a common pest that infests many subtropical and tropical fruits. Persimmon and guava fruits are hosts of the Mexican fruit fly. Quarantine treatments against fruit flies often involve heat treatments, and the most frequently used are heated air (HA) or hot water dips (HWD). HA or HWD treatments involve exposure of fruits to heat for one or more hours to allow conduction of heat to the fruit center. These long exposures may alter fruit appearance, flesh quality, aroma or flavor. Recently, heat treatments provided with radio frequency (RF) energy have been studied as a possible novel treatment for insect control in nuts and fresh fruits. RF treatments expose fruit to short wavelengths that activate bipolar molecules in the fruit generating heat throughout the fruit by molecular agitation, consequently raising fruit temperatures much faster and more evenly. RF heat treatments may have less negative effects on fruit quality. The objective of this study was to determine the tolerance of persimmon and guava fruit to exposures to RF energy capable of controlling Mexican fruit fly larvae.

MATERIALS AND METHODS

Persimmon and guava fruit were heated with 27 MHz RF energy. Distilled water was used as a medium to avoid overheating of fruit caused by contact points and to assure heating uniformity. Depending on fruit dielectric properties (Piyasena, et al., 2003; Wang, et al., 2003) different NaCl solutions were used to obtain an even heating rate of the fruit and solution. Fruit were treated in a circulating water system to improve heating uniformity (Birla, et al., unpublished).

Preliminary studies with a heating block system developed the thermal-death-time (TDT) curve for third-instar Mexican fruit fly (Fig. 1), the most heat resistant larval stage. Based on the TDT curve for third-instar Mexican fruit fly, we chose a total of 11 treatments (Table 1). During RF treatment, fruit were heated from 20°C to 48, 50 or 52°C. After reaching the target temperature, the fruit were held in the hot water for various holding times designed to provide 100% insect mortality (phytosanitary control), an estimated time for Probit 9 control (99.9968 % mortality rate), and an extra holding time to test the upper limit of tolerance to the treatment. Untreated fruit and fruit treated in water at 24°C were included as controls. Persimmon and guava fruit were treated, hydro-cooled, and stored at 20°C until commercially ripe, 12 and 7 to 11 days, respectively. The internal and external quality of the fruit were assessed by skin color, firmness, soluble solids content, titratable acidity, weight loss, skin browning, flesh browning, decay and shrivel.

RESULTS AND DISCUSSION

RF had no commercial affect on the soluble solids content, titratable acidity, firmness, weight loss, decay, and shrivel of persimmon fruit. Persimmon fruit showed no external damage following RF treatment, but browning developed in the center of the fruit following treatments above 50°C, especially treatments of 52°C with longer holding times. Calyx browning was increased by longer exposures to heat. Persimmons exposed to temperatures above 50°C were redder compared to the controls. RF treatment at 52°C for 2 min resulted in slightly softer fruit.

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Persimmon fruit showed good tolerance to RF treatments; internal and overall quality was least affected by lower temperature treatments. Heating fruit to 48°C for 12 min. or 50°C for 3 min., both of which should meet estimated time for Probit 9, were promising.

Compared with persimmon, guava fruit were more susceptible to external browning, but less susceptible to internal browning following RF treatment. There was no commercial damage on the internal quality of the guava fruit. However, RF had an affect on the appearance of small circular brown spots on the skin of the fruit which seemed to be affected by the longer treatments. The most promising treatments appear to be 50°C for 1.5 or 3 min. and 52°C for 1 min.

Literature Cited

Birla, S.L., Wang, S. and Tang, J. 2004 (unpublished). Improving heating uniformity of fresh fruits in radio frequency treatments for pest control. Postharvest Biology and Technology.

Piyasena P., Dussault, C., Koutchma, T., Ramaswamy, H.S. and Awuah, G.B. 2003. Radio frequency heating of foods: principles, applications and related properties – a review. Food Sci. Nutrition, 43 (6): 587-606.

Wang, S., Tang, J., Johnson, J.A., Mitcham, E., Hansen, J.D., Hallman, G., Drake, S.R. and Wang, Y. 2003. Dielectric properties of fruits and insect pests as related to radio frequency and microwave treatments. Biosystems Eng., 85 (2), 201-212.

Tables

Table 1. Target temperature and holding times for RF treatments for persimmon and guava fruit designed to provide 100% mortality (TDT), estimated Probit 9 mortality, and beyond Probit 9 mortality (extra timing).

Target	Holding times (minutes)		
Temperature	**TDT[z]**	**Estimated Probit 9[y]**	**Extra timing**
48°C	6	12	18
50°C	1.5	3	4.5
52°C	0.5	1	2

[z] Thermal-death-time necessary to reach 100% insect mortality of third instar Mexican fruit fly larvae
[y] Estimated time to reach 99.9968 % mortality of third instar Mexican fruit fly larvae

Figures

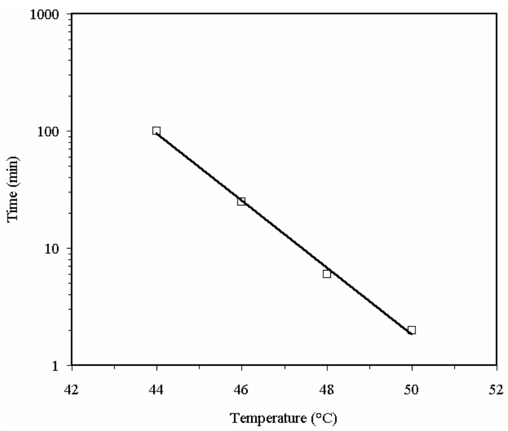

Fig. 1. Thermal-death-time (TDT) curve for third-instar Mexican fruit fly (n = 600) at a heating rate of 15°C/min. Line represents linear regression equation log t = 14.554-0.286T (R^2=0.997) where t = time (min) and T = temperature (°C).