STATUS OF MICROWAVES AND RADIOFREQUENCY AS ALTERNATIVE TREATMENTS FOR SOLID WOOD PACKING MATERIALS

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ABSTRACT

Microwave (MW) and radiofrequency (RF) irradiation are forms of dielectric heating; both heat by waves that penetrate throughout the profile of wood, which heats the water in the wood and organisms in the wood simultaneously, in contrast to conventional heating, which depends on radiant heating from the outside to the inside of the wood. For example, after approximately 3 minutes of MW exposure of red pine logs *(Pinus resinosa* Ait.*)*, temperatures measured in the log with fiber optic probes showed 62 °C in the core, 60 °C in the cambium, and 53 °C at the surface, indicating that the core and the cambium heat up rapidly with dielectric heating. For several years, we have been testing microwave energy (MW) as an alternative method for destruction of wood-boring insects and pinewood nematode in wood used for international shipping as part of a formal NPPO submission of MW as an alternative method of phytosanitation under ISPM-28 (alternative treatments to conventional heat and methyl bromide). This submission is currently before the Technical Panel on Phytosanitary Treatments (TPPT) for review and is expected to move forward to country consultation and approval by the International Plant Protection Convention (IPPC).

MW kills 100 percent of adults, larvae, and pupae of a number of insect species and pinewood nematodes through short irradiation treatment times. To date, we have shown that microwaves kill several species of cerambycids including *Anoplophora glabripennis* (Motschulsky), pinewood nematode (*Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle), bark beetles (*Ips* spp.), and white pine weevil (*Pissodes nemorensis* Germar) in wood of various species, sizes, and moisture contents. Most recently, we tested MW treatment of fresh red pine bolts naturally infested with bark beetles (*Ips pini* (Say)). All life stages were successfully eradicated with MW irradiation. Temperatures of 55 º to 60 ºC measured in the cambium with exposure times of 2:40 ± 10 (min:sec) at 3.2 kW killed 100 percent of all life stages. Also, we examined the relationship between temperatures reached simultaneously at the bark surface vs. the cambium or the core. Regression analysis showed that the temperature at the bark surface could be used to accurately predict the temperature in the cambium ($R^2 = 0.77$, $p = 0.022$) and the core ($R^2 = 0.70$, $p = 0.013$) to ensure that lethal temperatures are reached in all regions of the log. Interestingly, the cambium and the core are always hotter than the outer surface of the wood (due to convection cooling from the surface). This is important because it is more practical for operators to monitor surface temperature during treatment.

Our experiments on dielectric irradiation of wood samples infested with insect pests have mostly been done using MW because we have had limited access to RF equipment for long-term studies, so we cannot make direct comparisons to our results from microwaves trials. However, of the insects we tested with RF, cerambycid larvae required slightly lower levels of RF irradiation to achieve the same level of efficacy compared with microwaves. Also, RF is very effective against sapstain and wood decay fungi. Moreover, RF has some important advantages over MW because it is less sensitive to volume effects when heating wood to reach a critical lethal temperature, and this could be important when scaling up to treat larger volumes of firewood or larger log sections, particularly for treatment of valuable saw logs.

Future research includes collaborations with USDA personnel on MW and RF testing of wood infested with emerald ash borer (*Agrilus planipennis* F.) and *Sirex noctilio* F. Equipment that can operate by batch or pass-through (conveyance) processing is commercially available, but design types are currently limited. As cost-benefit analyses are conducted to demonstrate the efficacy and cost-effectiveness of dielectric methods compared with conventional heating, we anticipate a considerable effort by companies to produce the necessary equipment.