Title Potential of radio frequency heating of fresh fruits as an alternative quarantine method

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Abstract

Methyl bromide fumigation, the most widely used contemporary quarantine method for fresh fruits, has raised public concerns because of its high ozone-depletion potential. To respond to the urgency of finding alternative methods, many researchers have explored radio frequency (RF) energy to disinfest fresh fruits. Although damage to fruit has been a major stumbling block for commercial applications, there is renewed interest in RF energy stems after successful demonstration of its ability to control fruit flies in dry nuts. The research upon which this dissertation was based has the broad objective of developing RF energy-based treatment protocols for apples and citrus fruits.

A computer model that solves electro-magnetic field and Navier-Stokes equations using FEMLAB software was developed to predict transient temperature profiles in fruits. Simulation results suggested that the problem of non-uniformity can be resolved by continuously moving and rotating fruits in an RF field, so a fruit mover was designed and developed to impart 3-D movement and rotation of fruits in a saline water solution. This resulted in a significant improvement in heating uniformity of fruits. Dielectric properties of constituent parts of fruits, namely oranges, grapefruits, apples, avocados, and peaches, were measured to understand the RF heating charteristics of the fresh fruits using the developed model. The simulation and experimental results corroborated that the physical and dielectric properties of peel and pulp, geometric shape of fruits, and the medium around the fruits all play crucial roles in their heating patterns. The model also helped to determine the effects of parameters on heating patterns and design of practical RF treatments.

RF treatments were designed based on literature about the thermal death kinetics of fruit flies. Evaluation of quality parameters such as weight loss, peel and pulp color, and change in volatile flavor profiles after simulated storage for 30 days revealed that an RF treatment including a 48°C temperature exposure for 15 min can be an effective. RF-assisted hot water heating (preheating fruits in hot water at non-damaging temperatures for specific times and then exposing to RF heating) was efficacious against codling moth in apples. However, the margin for maintaining the quality of treated apples was small.

Because of significant changes in volatile flavor profiles in the fruits subjected to RF-based high-temperature-short-time treatment hence low temperature RF treatment should be explored.

Lastly, issues of energy and induction in current packing house operations were addressed. By demonstrating the feasibility of designing a continuous RF heat treatment for packing houses, this research opened up a new vista for exploring RF energy-based treatment for disinfecting fresh fruits. Due to specific heating patterns in RF fields, each fruit category needs a special approach to ascertain the benefits associated with RF heating.