ON POTENTIAL OF RADIO FREQUENCY HEATING OF FRESH FRUITS AS AN ALTERNATIVE QUARANTINE METHOD

ABSTRACT

By Sohan L. Birla, Ph.D.
Washington State University
December 2006

Chair: Juming Tang

Methyl Bromide fumigation, current quarantine method for fresh fruits, has raised public concerned because of it's high ozone potential depletion. Therefore, its uses are being restricted or eliminated for most applications starting from year 2005, according to the Montreal Protocol. To respond to the urgency, many researchers have explored uses of Radio Frequency (RF) energy for disinfestation of fresh fruits. But damage to the fruit was a major stumbling block for commercial applications. Recently renewed interest in use of RF energy has stemmed from the successful demonstration of the control of fruit flies in dry nuts using RF energy. This research was taken up with a broad objective to develop RF energy based treatment protocol for apple and citrus fruits.

A simulation computer tool, that solves a set of electro-magnetic field and Navier-Stokes equations using FEMLAB software, was developed to predicate the transient temperature profile in fruits. The simulation results have suggested that the problem of non-uniformity can be resolved by continuously moving and rotating of fruits in RF field. Hence a fruit mover was designed and developed to impart 3-D movement and rotation of fruits in a suitable saline water solution. This resulted in a significant improvement in heating uniformity of fruits. A computer simulation model developed in this study helped in the study of the effect of various parameters on heating pattern and design of practical RF treatments. RF thermal treatments were designed using available information on thermal death kinetics information fruit flies. Quality parameters such as weight loss, peel and pulp color, change in volatile flavor profile were evaluated after simulated storage time for 30 days. It was concluded that a RF treatment that includes a 48°C temperature exposure for 15 min can be a potential treatment. However, change in the treated orange volatile flavor profiles may be a concern to consumers.

Dielectric properties of constituent parts of various fruits, namely orange, grapefruit, apple, avocado and peach were measured to understand the RF heating of the fruits using the developed model. The simulation and experimental results corroborated that the physical and dielectric properties of peel and pulp play a crucial role in characterization of heating pattern of the fruits. The concept referred in this thesis as 'RF assisted hot water heating' involves preheating of fruits in hot water at non-damaging temperature for a specific time and then exposing to RF heating. It was successfully applied for apples. The RF assisted treatment was efficacious against the 'codling moth' fruit fly. However, the window of safety margin for quality of treated apples was very small. Therefore, prospectus of commercial feasibility of RF based high temperature short time treatment for apples is uncertain.

In the last, issues such as energy, induction in current packaging house operation, were addressed. To accomplish moving and rotation fruits in continuous RF treatment process, a RF MegnaTube^{TM} system was used. This study demonstrated the feasibility of design of continuous RF heat treatment for packaging house. This research opened up a new vista for exploring RF energy based treatment for disinfection of fresh fruits. Due to specific heating pattern in RF field, each category of fruit needs special approach to avail the benefits associated with RF heating.

Full thesis : http://www.dissertations.wsu.edu/Dissertations/Fall2006/s_birla_010807.pdf