LARGE-SCALE RADIO FREQUENCY TREATMENTS FOR INSECT CONTROL IN WALNUTS

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Prior to the 2005 ban, inshell walnuts were routinely fumigated with methyl bromide for insect control prior to export. Several pilot scale radio frequency (RF) studies have been reported as a new means to rapidly deliver thermal energy to walnuts for insect control without significant quality degradation (Wang et al., 2001; Wang et al., 2002c). These protocols are developed based on thermal-death-time (TDT) curves determined for three important insects infesting postharvest walnuts: codling moth (Wang et al., 2002a), Indianmeal moth (Johnson et al., 2003) and navel orangeworm (Wang et al., 2002b). However, it is important to transfer pilot-scale or laboratory research results to large-scale industrial implementations.

Heating uniformity is one of the most important considerations in scaling up of the established treatment protocol for walnuts. Temperature variations after RF heating may result from the different properties of walnuts and non-uniform electromagnetic field. It is desirable to determine the heating uniformity for a given RF unit and minimize the effect of walnut orientations and positions by stirring the walnuts during RF treatment.

To determine heating uniformity, a 25 kW, 27 MHz pilot-scale RF system (Model, S025/T, Strayfield International Limited, Wokingham, UK) (Fig. 1) was used to heat polyurethane foam sheets and in-shell walnuts. The RF unit had two identical electrodes (1.3m L x 0.6m W x0.4m H). The gap between the electrodes was adjusted from 260 mm to 400 mm to produce different heating rates. Conveyor belt speeds from 4.8 to 57m/h were possible. Heating uniformity tests were conducted under a maximum speed (57m/h) of conveyor belt in the RF unit using 7 polyurethane foam sheets or 11 kg of in-shell walnuts in a 24 x 16 x 9" container. The surface temperature was mapped by a thermal imaging camera having an accuracy ±2°C. Temperature uniformity was also determined for walnuts that were passed once through the RF unit, mixed, and then passed back through the RF unit for a second treatment.

Fig. 2 shows average temperature profiles as a function of the height of polyurethane foam sheets after RF treatments. The middle layers were found to be warmer than the top and bottom layers. The temperature at the bottom was a little lower than that at the top, which was probably due to the hot forced air system being turned off. With the movement of the belt, the heating uniformity was slightly improved.

The heating uniformity in RF heated walnuts was improved when nuts were moved through the unit on the belt, and when hot forced air and mixing of the nuts were added. Energy efficiency during continuous processing was determined to be about 70% when the power was relatively constant (Fig. 3).

The uniformity index, initial mean temperature, and initial standard deviation were obtained for one container moving through the unit on the convey belt. The minimum number of mixings was estimated as 1.1 times using the predictive equation developed by Wang et al. (2005). Therefore, we may use a single mixing of nuts in between RF units to meet the requirements for insect control at the probit 9 level. A comparison was also made between the predicted standard deviation both with and without mixing. The predicted standard deviations were in good agreement with the experimental values after a single mixing of nuts between RF treatments (data not show).

The commercial process used by industry is shown in Fig. 4. Three options are suggested to replace chemical fumigation with RF treatments. Option 1 is to apply RF treatments at the same point in the process as fumigation; directly after the pretreatment. The RF treatment would have non-uniformity problems caused by different nut sizes and dirty shells and does not take advantage of the drying effect of the RF treatment because it is located far before the washing/bleaching process. The third option of RF treatment is to replace both the fumigation and static air drying completely. This is an attractive option but might not work because the difference in moisture content between the shell and the kernel could cause unacceptable heating non-uniformity and walnut cracks. The option 2 is to locate the RF treatment between static air drying and packing. This arrangement may replace fumigation completely for insect control and partially reduce the air drying process from 4 h to about 1 h. This is more practical than the other two options, because air drying can reduce moisture levels to those more appropriate for RF heating. We'll concentrate on option 2 to develop the treatment protocol.

References

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Fig. 1. A 27.12 MHz, 25 kW RF unit for large-scale tests

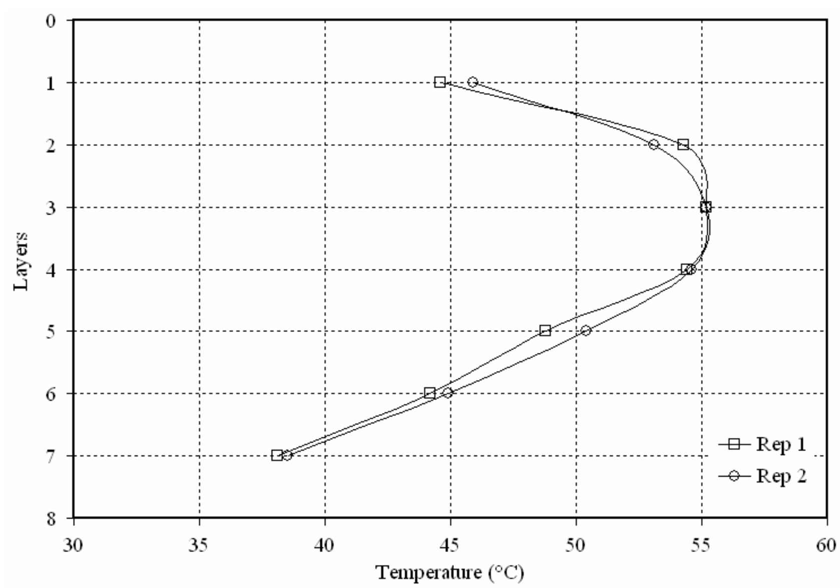

Fig. 2. The average temperature profiles as a function of heights of polyurethane foams after RF treatments

Fig. 3. Continuous process of RF treatment on inshell walnuts

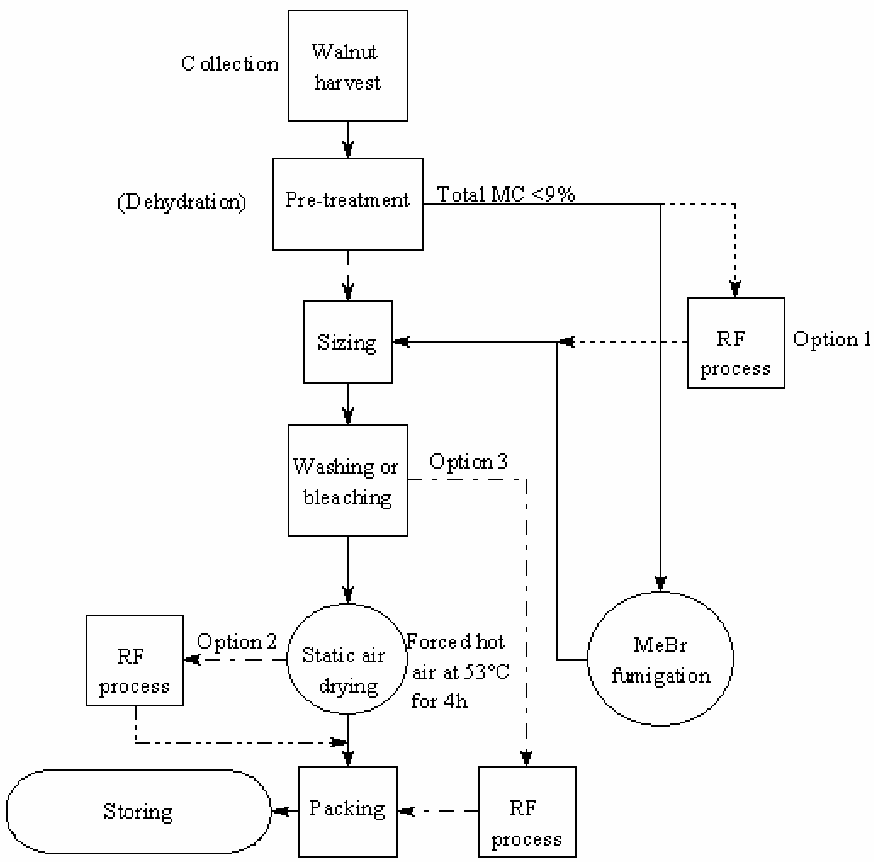

Fig. 4. Three options of RF treatment replacing fumigations to control pests in walnuts during industrial process