LETTER TO THE EDITOR

To the Editor:

In the article titled "Electromagnetics, Heat Transfer, and Thermokinetics in Microwave Sterilization," (September 2001), Zhang et al. simulated the sterilization of solid foods in microwave radiated systems using two separate finite-element programs. The first program was used to solve Maxwell's equations, and the second one was used to solve the heat balance equation.

In this letter I do not wish to make any criticism about the article presented. In fact in my opinion, this article is not only very clear, but also represents a fundamental stage in the study of the use of microwave radiation to promote the evolution of chemical and biological transformations. I also found very interesting the use of the chemical markers made in the article to obtain experimental results.

In spite of these main considerations, a limitation can be highlighted. The solution of Maxwell's equations and the heat balance equation needs to be considered and solved together, since they are linked by the power (Eq. 8 in the article) and by the dielectric properties of the food which change, as the temperature changes. However, both electric and magnetic fields that give the power transmitted by the radiation completely change 2.45 billion times in one second. The other variable, the temperature, provides a change capable of giving a significant variation of the dielectric properties in a time that is millions of times greater than that typical of the radiated power (which changes with the frequency of the electric field). In these conditions, I believe, it would have been easier (and, from an engineering point of view, equally correct) if the electric and magnetic fields are considered constant and their value equal to E_{RMS} and to H_{RMS} (where E_{RMS} and H_{RMS} are the effective electric and magnetic values, respectively).

If this conclusion is accepted, one can calculate the electric and the magnetic excitation reduction as the radiation gets into the food container; the local amount of the variable can be obtained from the equation (Metaxas and Meredith, 1993).

$$E = \sqrt{2} \cdot E_{RMS} \cdot e^{-\alpha(R-r)}$$

In this equation E is the value of the electric field at the position $(R-r)$, where R is the external radius of the food container and E_{RMS} is the effective electric field for $r = R$; a similar equation can be written for the magnetic field H. The variable α, the attenuation factor, can be calculated using the relation (Metaxas and Meredith, 1993)

$$\alpha = \omega \cdot \left[\frac{\mu_0 \mu' \epsilon_0 \epsilon'}{2} \right]^{1/2} \times \left[\left[1 + (\epsilon_{eff}/\epsilon')^2 \right]^{1/2} - 1 \right]$$

in this equation μ_0 and μ' are, respectively, the magnetic permeability in free space and the real part of the complex magnetic permeability. The symbol ϵ_0 is used to represent the dielectric constant in the free space, ϵ' is the relative dielectric constant, ϵ_{eff} is the imaginary part of the complex permeability (also called effective loss factor), and the symbol ω represents the angular frequency.

Even though this limitation is of secondary importance to the general meaning of the article, we can quote Lord Rutherford's words and say that, "It is like shooting a gun to make a hole in a sheet of paper."

Literature cited

Metaxas, A. C., and R. J. Meredith, *Industrial Microwave Heating*, Peter Peregrinus Ltd. London, p. 79 (1993).

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