2P01

Numerical Analysis of Radiation Induced Radicals in Foods

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【 Introduction 】 The γ-ray irradiation sterilizes foods effectively. Electron spin resonance (ESR) spectroscopy has been applied as a detecting method of irradiated foods. In the present study, we analyzed the radical behavior of the irradiated pepper under the heat-treatment process by ESR. To evaluate the radical decay during heating, we defined a time-dependent master equation. Based upon the general solution of the equation, we evaluated the time constant of the radical decay through the nonlinear least squares method.

【Method】Upon heating, quantity of radicals decreases with a speed $\dot{\Phi}$ that is proportional to the residual quantity at a certain time. An ordinary differential equation (1) can describe the radical system varying with time.

$$\frac{d\Phi}{dt} = -\frac{1}{\tau_d}\Phi \qquad (1)$$

where τ_d is a time constant for the radical decay. Using the variable separation method, with the initial condition of $\Phi(t=0)=\Phi_0$ and the boundary condition $\Phi(t=\infty)=\Phi_\infty$:

$$\Phi = \Phi_0 e^{-\frac{t}{\tau_d}} + \Phi_\infty \qquad (2)$$

Eq. (2) described the decay fashion of radicals under the heating procedure. For the sake of Φ_0 and Φ_∞ are non-zero values, we have to employ the nonlinear least squares method to determine τ_d rigorously.

【Results and discussion】 Figure 1 shows an ESR signal of the black pepper as irradiated for 50 kGy. It consists of four signal components, a sextet centered at g = 2.0 (hyperfine interactions of Mn2+ ion), a singlet at the same g-value (organic free radical), a singlet at g = 4.0 (Fe3+ ion) and side peaks near g = 2.0. (see the insert of Fig. 1: organic free radical) The S1 and S2 signals are quite specific for the irradiated pepper. Figure 2 shows the change of the side peaks of irradiated (50 kGy) pepper by the heat-treatment (0 to 10 min). Although a strong radical intensity was presented before heating, the peak heights of S1 and S2 decayed dramatically by the heat-treatment. The estimation resulted in τ_d = 1.8 min for the time constant for the thermal decay process.

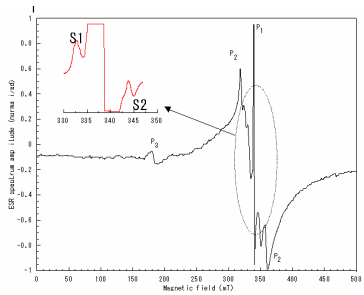

Fig. 1. ESR spectra.

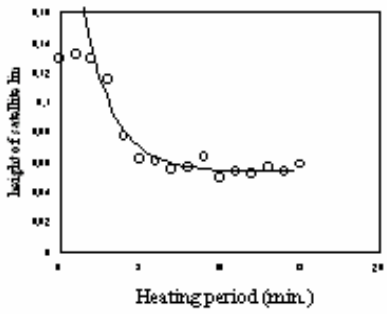

Fig. 2. Decay of side peaks.