J. Food Sci. Nutr.
Vol. 3, No. 1, p. 22~26 (1998)

Detection of Irradiated Model Food Containing Salt by Thermoluminescence Measurement

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Abstract

Model food containing common salt(NaCl) was subjected to the thermoluminescence(TL) detection whether it is irradiated or not. Salt irradiated with ^{60}Co-gamma ray and electron beam exhibited a characteristic TL glowcurve depending on the irradiation dose, showing major peaks at 206°C and 326°C. The intensity of TL glowcurves was directly proportional to the irradiated doses regardless of irradiation sources at each concentration of salt. A high correlation coefficient was observed for irradiated salt between the irradiation doses and the corresponding TL responses. At the same dose, the intensity of TL glowcurve increased as the concentration of salt increased in the test sample. TL glowcurves of nonirradiated salt and irradiated model food without salt were negligible and similar to a baseline. However, irradiated model food containing salt gave rise to a characteristic TL glowcurve with two major peaks at about 240°C and 300°C, respectively. The results showed that salt played a role as an internal as well as external indicator in TL measurements, indicating that TL will be applicable to other condiments and spices with salt for their detection whether they are irradiated or not.

Key words: model food with salt(NaCl), irradiation, detection, thermoluminescence

INTRODUCTION

Commercial applications of food irradiation have been steadily increased in recent years in the world. Thirty-nine countries have approved food irradiation of more than 50 different kinds of foods and 29 of these countries are commercially utilizing the irradiation process(1). From the late 1960s, Korean food scientists were interested in food irradiation and since the early 1980s the study on food irradiation has been performing on a semi-industrial scale in Korea(2). Based on results, a commercial food irradiation facility was built in 1987 and 19 different food items were permitted to be irradiated for certain purposes by the Korean government(3,4).

As the progression of a world open-market, to meet different national regulations in international trade and to ensure the consumer's free choice to buy an irradiated or a nonirradiated product, labelling and its control have become more important and indispensable(5). Detection methods for irradiated food have been investigated and some of them, such as electron spin resonance(6), thermoluminescence(7) and GC-MS(8), have been successfully tested. Nevertheless, application studies are needed to verify the methods. TL was approved in England as a detection method for spices(9). But in Korea few attempts were made in this field except for GC and GC-MS approach for the identification of irradiated meats(10) and irradiated sesames(11).

This paper elucidates the function of salt(NaCl) as a TL indicator for irradiated food. A TL measurment was applied to detect model food containing salt when it was exposed to gamma-ray and electron-beam irradiation.

MATERIALS AND METHODS

Materials

Common salt, sodium chloride(NaCl) and red pepper powder were purchased from a local supermarket and used without any further treatment. Model food was prepared with red pepper powder and certain concentrations(10%, w/w) of salt.

Irradiation of sample

Test samples were irradiated at dose levels of from 2.5 kGy to 15 kGy using ^{60}Co γ-irradiator and electron-beam(ELV-4) processing facility at room temperature. Absorbed doses were measured by ceric cerous and

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cellulose triacetate dosimeters, deviation of which were ranged from ±5.0% to ±3.4%. The whole samples following irradiation were used to measure TL without any pretreatment. Irradiated and nonirradiated samples were prepared in the same way.

TL measurements

TL glowcurves were obtained from nonirradiated and irradiated samples using a Harshaw system model 4000 (Germany). A linear heating rate was 5 °C/s, heating range was from 25 °C to 400 °C and reading time was 80 sec. Ten mg of samples were used for the TL measurement in an 10^4μl aluminum disc(8mm diameter, 0.5mm thickness)(5,12,13). TL reader automatically heated the sample and integrated the intensity of TL glowcurves in units of nano coulombs(nC). TL measurement was carried out to determine the influence of both salt concentrations in the test sample and irradiation doses on TL intensity for the test samples. The intensity of TL glowcurve was measured for each concentration(0~50%) of salt when exposed to different irradiation doses. Comparison of TL characteristics were made between irradiated and nonirradiated model food, red pepper powder with or without salt.

Statistical analysis

All measurements were made in 5 replicates for each sample. Microgal Origin(14) was used to confirm the role of common salt as a TL indicator and to determine the relationship between irradiation doses and the corresponding TL intensity in irradiated model food with salt.

RESULTS AND DISCUSSION

Confirmation of NaCl as a TL indicator

There are 10 food items containing salt permissible to gamma-irradiation in Korea. Therefore, it is very interesting to confirm the role of salt as a TL indicator. TL glowcurves and TL intensities for different concentrations of salt at each irradiation dose were shown in Figs. 1~3. As shown in Fig. 1 and Fig. 2, the intensity of TL glowcurves increased even at the same concentration of irradiated salt when the applied doses increased. It was also increased even at the same dose regardless of irradiation sources as the concentration of

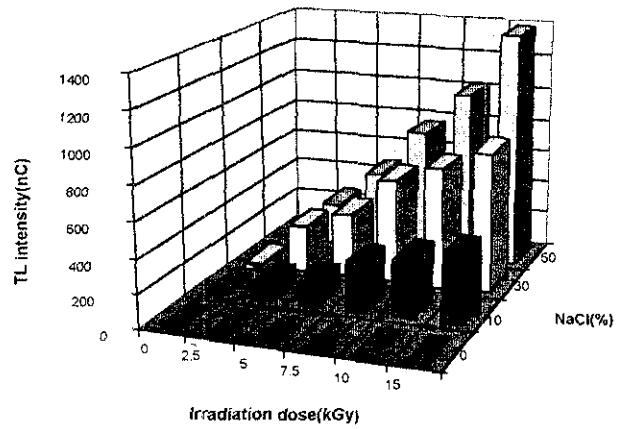

Fig. 1. Effects of NaCl amounts and gamma ray-irradiation doses on thermoluminescence intensity of the test sample.

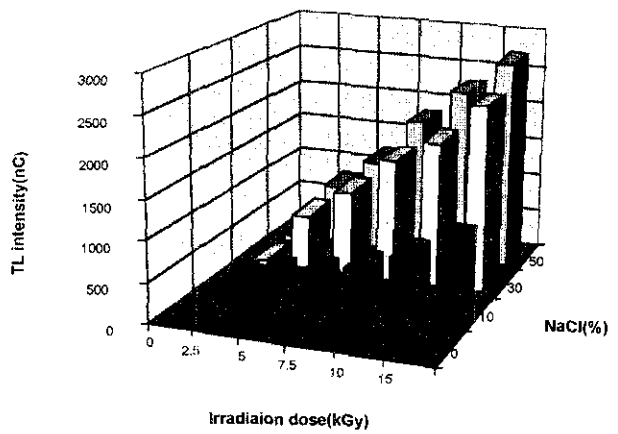

Fig. 2. Effects of NaCl amounts and electron beam-irradiation doses on thermoluminescence intensity of the test sample.

irradiated salt increased. TL glowcurve of gamma-irradiated salt at 10 kGy showed a characteristic profile with two peaks depending on the concentration of salt(Fig. 3). Although a little shift was observed in the TL glowcurves of the samples, the first peak was found at around 206 °C and the major second peak was exhibited at around 326 °C. The increase of TL intensity was proportional to the concentration of 10 kGy-irradiated salt, showing a baseline in case of nonirradiated sample. This result was similar to the report by Sanderson et al.(15). From the above results, it is evident that the overall TL pattern of irradiated salt was constant and stable even at different concentrations of salt although, the intensity of TL glowcurve was changeable. Therefore it is concluded that the common salt added to the processed foods could play a role as a TL indicator in the irradiated foods.

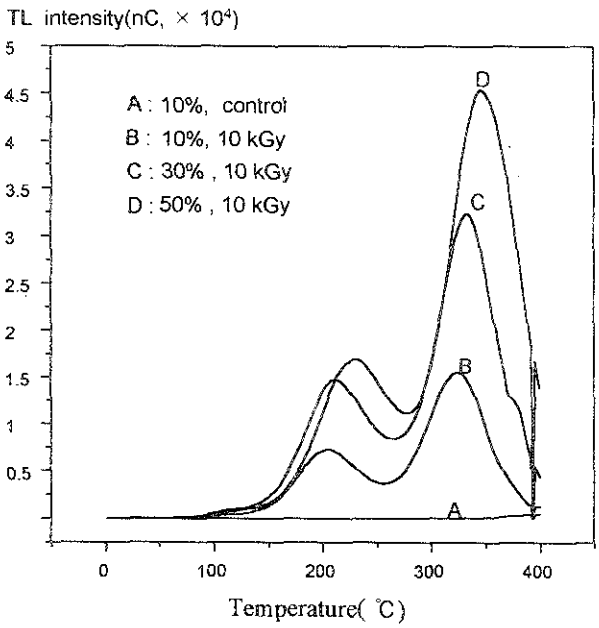

Fig. 3. Thermoluminescence glowcurves of gamma-irradiated(10 kGy) NaCl as influenced by its con-centration in test sample.

Correlation of TL intensity with salt concentration and irradiation dose

Correlation between irradiation doses and the corresponding TL intensity of the test samples with different concentrations of salt was shown in Fig. 4. Irradiated salt with both gamma ray and electron beam presented a high positive correlation between the irradiation doses and the corresponding TL responses in all concentrations. The correlation coefficients of gamma-ray irradiated samples were from 0.97 to 0.99 and from 0.98 to 0.99 in electron-beam irradiated groups, respectively. Thus, it was possible to reconfirm the role of salt as a TL indicator, thereby suggesting its possibility to as an internal TL indicator for irradiated foods containing salt.

Detection of irradiated model food containing salt

Commercial red pepper powders did not display any appreciable TL glowcurves, even they were irradiated at 10kGy of gamma-ray and electron-beam. A characteristic TL glowcurve with two peaks, however, was exhibited when red pepper powders containing salt (10%, w/w) were exposed to gamma-ray(Fig. 5) and electron-beam(Fig. 6).

From the results, the function of salt as an external

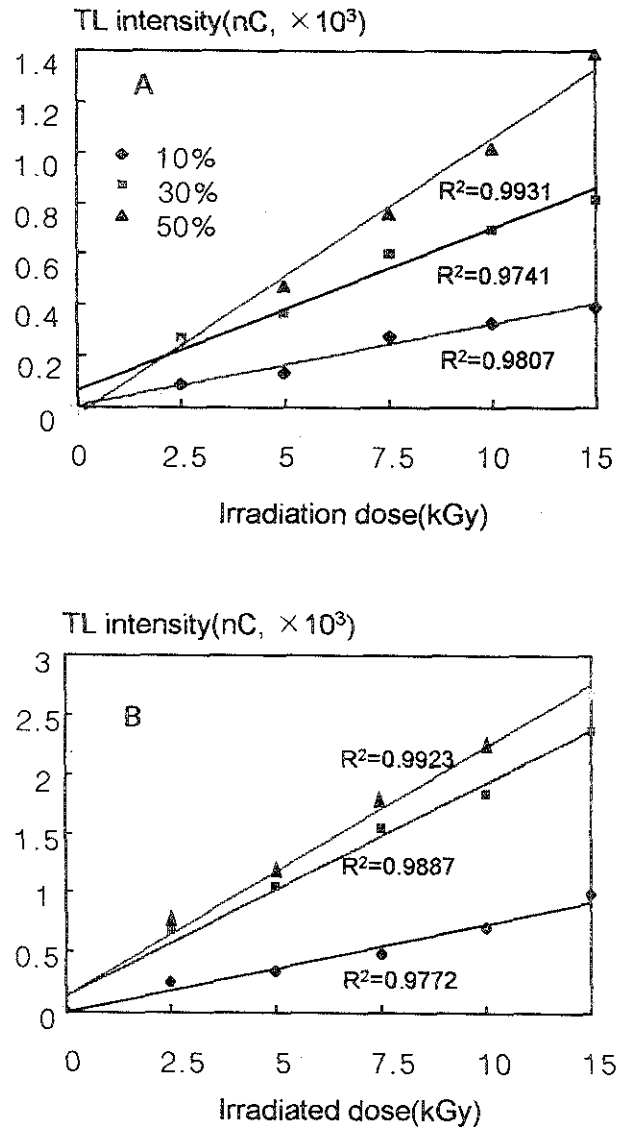

Fig. 4. Correlations between irradiation doses and TL intensity of the test samples with different amounts of NaCl.
A: gamma-ray, B: electron-beam

TL indicator was assured. However, TL profiles of irradiated red pepper powders containing salt were slightly different from that of nonirradiated red pepper powder as well as irradiated salt. That is, irradiated salt showed a characteristic TL glowcurve with two major peaks at about 206°C and 326°C, respectively, whereas TL glowcurve of irradiated red pepper powder was similar to a baseline. However, TL glowcurve of model food, irradiated red pepper powder with 10% of salt exhibited the first TL peak at about 240°C, followed by the second peak at around 300°C. The shift of TL

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(Received January 30, 1998)