AN ESR STUDY ON THE DETECTION OF IRRADIATED RED LENTIL

Ismail ERCAN, Mahmut EKEN
Ankara Nuclear Research and Training Center, 06100, Besevler-Ankara, Turkey

ABSTRACT

The purpose of this work is to investigate in detail detection of irradiated red lentil. In this way, red lentil powder was analysed by using Bruker EMX ESR spectrometer before and after irradiation between the doses 1-9 kGy at ambient conditions.

It was observed that seeds of non-irradiated and irradiated red lentil have a signal having six lines due to Mn$^{2+}$ content. However hull of the red lentil has a single line whose origin is still unknown. Besides, this signal has superposed with the radiation induced one. It was also found that the intensity of radiation induced signal was decreased logarithmically in time, and the change in the intensity was minimal at low doses.

INTRODUCTION

The radiation processing of raw and processed foods is now widely accepted, and is currently approved in over 40 different countries as a means of enhancing the hygienic quality, extending shelf life, reducing the incidence of food-borne diseases and eliminating quarantine pest [Kwon et al., 2000; Yang et al., 1987]. Laws and legislations in civilised countries on foodstuffs are forcing the communities to take severe sanctions on the irradiated food import (and export). Therefore it is very important to determine whether a particular foodstuff is irradiated or not and at what dose. The Joint Expert Committee on the Wholesomeness of Irradiated Food (JECFI) of the Food and Agriculture Organisation (FAO), the International Atomic Energy Agency (IAEA) and World Healthy Organisation (WHO) concluded that "Irradiation of any food commodity up to an overall average dose of 10kGy introduces no toxicological hazard; hence, toxicological testing of food so treated, is no longer required" [Joint F.A.O./W.H.O./I.A.E.A. Expert Committee, 1981]. Various studies have demonstrated that, Electron Spin Resonance (ESR) is one of the most promising technique which is relatively fast, simple and sensitive for detecting certain irradiated foods [Desrosiers and Simic, 1988; Dodd et al, 1989; Desrosiers, 1996; Declinee, 1998].

Many research groups have reported the effect of ionising radiation on legumes [Hepburn et al., 1986; Buchurov and Gantceff, 1984; Shootha and Gupta, 1976]. However, little work has been reported the effects of ionising radiation on lentil [Kiyak, 1993].

The purpose of this work is to investigate in detail, the detection of irradiated red lentil, the stability of radiation-induced radicals and the dosimetric properties of the latter by using ESR.
MATERIAL AND METHODS

Samples of red lentil harvested at East Anatolia in 1999. Their water content was found to be less than 10%. Samples were separated into three groups. First group had only seed, second group hull and third group seed with hull respectively. All the samples were powdered (less than 100 mesh) and filled into the pyrex tubes. The weights of the samples were about 0.2 grams. Irradiations were performed between 9 kGy with the steps around 0.5 to 1 kGy by using the $^{60}$Co source (dose rate 3kGy/h). All irradiations and ESR measurements were carried out at ambient conditions. A Bruker EMX 8/2.7 ESR spectrometer was used in ESR measurement at microwave frequency around 9.7 GHz, modulation frequency 100kHz, microwave power 0.6 mW. The reproducibility of ESR measurements was determined by the repetition of 10 measurements from the same sample. The ESR signal intensities were measured as the peak to peak height of the major component and were reported arbitrary unit.

RESULT AND DISCUSSION

ESR spectra of unirradiated seed, hull, and seed with hull are given in figure 1. As it is seen from this figure; seed consists of a six lines signal due to Mn$^{+2}$, and hull has a single line, which has g value g=2.005±0.0004, whose the origin is unknown, and seed with hull has a single line in between six line signal. This single line is originated from the hull itself.

ESR spectra of irradiated seed, hull, and seed with hull are given in figure 2. Ionizing radiation caused a single line which has g value g=2.005±0.0004 at all sample. This single line appeared at the center of sextet in seed, was superposed with the signal of unirradiated hull. The peak to peak signal intensity of seed showed a linear behaviour as a function of applied dose between 1 and 9 kGy, as shown in figure 3. This figure shows as an example the ESR signal intensity of radiation induced radical and the first peak of Mn$^{+2}$ as a function of the absorbed dose in the first 5 hours after irradiation. As it is seen, ionizing radiation was found to have no effect on Mn$^{+2}$ signal. The best least square fit to the line of radiation induced signal, is given by the following equation:

$$I = 6292 \times D + 24995 \quad (R^2 = 0.9473)$$

where $I$ is the peak to peak signal intensity, and $D$ is the absorbed dose in kGy.

To study the stability of the free radical, the intensity of the ESR signal as a function of time after irradiation, was examined. ESR signal intensity decreased logarithmically in time as seen in figure 4. The decrease of the signal intensity in time at each irradiation dose can be expressed as,

$$I = -A \times \ln(t) + B$$

In this equation; $I$ is the radical signal intensity, $t$ is the time in hour, and $A$ and $B$ are the constants which are obtained from figure 5 by calculating the $A$ and $B$ values for each irradiation dose from the logarithmic curve in figure 4. Besides, the $A$ and $B$ values were plotted as a
function of irradiation dose as shown in figure 5 in order to find these values for the other doses that we did not apply, easily.

CONCLUSION

It could be understood whether the seed of red lentil irradiated or not, according to the g value and the shape of radiation induced radical, as it was stated in literature [Kiyak, 1993]. However it is very difficult to understand at what dose it is irradiated. But if the storage time and conditions of a lentil seed after irradiation, are precisely known; then this absorbed dose may be estimated.

REFERENCES

**Figure 1.** ESR spectra of unirradiated seed, hull and seed with hull.

**Figure 2.** ESR spectra of irradiated seed, hull and seed with hull at 1kGy.
Figure 3. ESR signal intensity of radiation induced radical and the first peak of Mn$^{2+}$ as a function of the absorbed dose in the first 5 hours after irradiation.

Figure 4. Variations of A and B as a function of absorbed dose.

Figure 5. ESR signal intensity of irradiated seed of red lentil plotted as a function of time after irradiation.