Characterization of Fresh Cut Locally Available Vegetables Before and After Co-60 Irradiations

P Kohila[1], J Jeyasugiththan[2], A Ramalingam[2] and V.Senthil[1*].
[1]Department of Physics, University of Jaffna. Jaffna, Sri Lanka.
[2]Provincial Teaching Hospital Jaffna, Jaffna, Sri Lanka.

Abstract
Irradiation has received much attention as an effective method for food preservation and as a staple tool for assuring food safety. Thus, it is important to know how much radiation is absorbed as well as what changes are observed in food sample during the irradiation process to find minimally processed fresh foods. Fresh cut locally available vegetables, namely, potato, pumpkin, radish, elephant-yam, beetroot and sweet potato and their juices were chosen for irradiation with low dose gamma radiation from cobalt-60 source which emits photons 294.12 ^{cGy}/min in air at a distance of 55 cm from head of the source. The vegetable and juice samples were exposed to low dose radiation of 0, 1, 3, 5, 9, 12, 15, 20, 25, and 30 ^{GY} in air. I-V (Current-Voltage) characteristic curves for the rectangular parallelepiped shape of irradiated samples were obtained, where the computer interfaced Keithley source meter by LabVIEW program is used. The pH values were measured for vegetable juice samples before and after irradiation. The gradient of the conductivity against the dose variation calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato were 0.396, 0.785, 0.961, 1.081, 1.211 and 1.66 $\mu Sm^{-1}GY^{1}$, respectively. The increasing nature of the conductivity with dose in samples appears to be due to the increasing damage of tissue membrane with dose. The radiation compensation constant calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato were 0.006, 0.012, 0.024, 0.02, 0.043, and 0.022 GY^{1}, respectively. The gradient of the pH variation against the dose of irradiation was calculated for radish, elephant yam, pumpkin, beetroot, and potato. The gradients were -0.00104, -0.00133, -0.0033, -0.00435 and -0.037 GY^{1}, respectively. A mathematical model can be predicted for the variation of conductivity of vegetables with radiation. Acidity is increased with the increased dose of irradiation due to the formation of H^{+}.

Key words: Irradiation, IV characteristics, Acidity, Membrane and conductivity

Introduction

Food irradiation is a one method of processing technologies which is safe, efficient, environmentally clean, and energy efficient. The food preservation by ionizing radiation such as gamma-rays, X-rays, and electron-beam is a commercially approved technology in order to killing pathogens, disinfection, inhibiting growth, delaying ripening, controlling sprouting, and replacing chemical fumigation, without significantly increasing the temperature of food. The development of analytical detection of radiation processing of food is very important to implement quality control and safety measures at all levels (Chauhan et al. 2008). Electrical impedance (Hayashi et al. 1996) and pH measurements (Zaman et al. 2007) are the simple, accurate, easy to perform, rapid and inexpensive detection methods of irradiated foods. Even though the different expensive forms of energy sources are used in the food processing operations Co-60 is a radio isotope most extensively employed for gamma irradiation of food. It emits highly penetrating gamma rays that can be used to treat food in bulk or in its final packaging but it is not like a machine sourced ionizing radiation to switch off after its use.

The radiation damage of tissue cells can be classified into two; one is radiation hitting directly on DNA and other is creating highly reactive species, including free radicals such as hydroxyl radical and hydrogen peroxide and reaction of these spices with DNA of micro-organism (Hayashi et al. 1996). Vegetable samples contain semi permeable membranes of living tissues which play a vital role in selective permeability of ions. The radiation generates the damage in these membranes so as to change in the selective permeability of ions (Shaheen Atta, 2008). Thus, the electrical conductivities of irradiated samples will be higher than the non-irradiated samples. This tool can be used for the detection of irradiation in vegetable samples.

Materials and Methods

reshly cut locally available rectangular parallelepiped shape (2.3, 2.3, 5 cm^3) and (1, 2.3, 5 cm^3) of vegetable samples, namely, potato, pumpkin, radish, elephant-yam, beetroot and sweet-potato were prepared. They were chosen to be irradiated with low dose gamma radiation from Co-60 source which emits photons at a rate of 294.12 *cGy*/min in air at a distance of 55 cm from head of the source. The samples were exposed to low dose radiation of 0, 1, 3, 5, 9, 12, 15, 20, 25, and 30 *Gy* in air. The vegetable piece (1, 2.3, 5 cm^3) was kept above the experimental sample (2.3, 2.3, 5 cm^3) while irradiating to avoid build up region of the radiation. During the irradiation process the temperature variation was observed and was found that no variation from room temperature. I-V (Current-Voltage) characteristic curves for the rectangular parallelepiped shape (2.3, 2.3, 5 cm) of irradiated samples were obtained within one hour of duration after the irradiation, by Keithley source meter, which is interfaced with computer by the LabVIEW program. The above procedures were repeated for different vegetables such as elephant yam, radish, pumpkin, beetroot, potato and sweet potato.

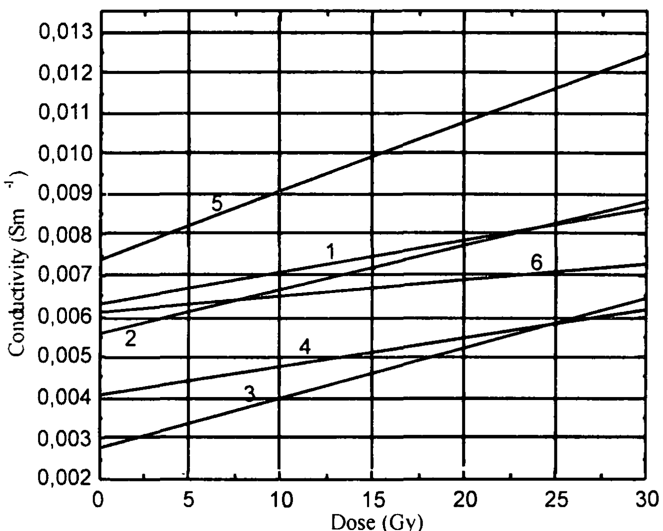

Figure 1:- Electrical conductivity versus dose graph for different vegetables.

1 : potato, Y=(7.85387E-5)X+(0.0063)
2 : pumpkin, Y=(1.08059E-4)X+(0.00552)
3 : elephantyam, Y=(1.21091E-4)X+(0.00281)
4 : radish, Y=(9.6121E-5)X+(0.00405)
5 : sweet potato Y=(1.66033E-4)X+(0.00741)
6 : beetroot Y=(3.95568E-5)X+(0.00612)

The 25 ml empty bottles and home use grinder were cleaned by the hot water then 0.01M NaOH and 0.01M HNO_3 respectively and those were dried. Vegetable samples were grinded by the grinder to get the juices of the samples. Then that juice was filtered by using the filter paper (110 mm diameter Whatman Brand). Then 20 ml of filtered juice was taken into that cleaned bottle and nine bottles were prepared as above one. The samples were irradiated by Co-60 source of 0, 1, 3, 5, 9, 12, 15, 20, 25, and 30 *Gy* in air. Then pH was measured by using JENWAY ion meter (3345 Ion meter) which is used to measure the ion concentration. The above procedures were repeated for different vegetables which are elephant yam, beetroot, radish, pumpkin, and potato.

Results and discussions

The plots of electrical conductivity variation with dose of irradiation in the range from 0 to 30 *Gy* is given in the figure 1 for the vegetables of potato, pumpkin, elephant am, radish, sweet potato, and beetroot.

The electrical conductivities of non-irradiated vegetable samples are in increasing order from elephant yam, radish, pumpkin, beetroot, and potato to sweet potato respectively. The gradient of the conductivity variation against the low dose gamma rays calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato are 0.396, 0.785, 0.961, 1.081, 1.211 and 1.66 $\mu Sm^{-1}GY^{-1}$, respectively. The increasing nature of the conductivity with dose in the irradiated samples is due to the increasing damage of tissue membrane with dose (Shaheen Atta 2008). This effect is different for different samples and very high response to radiation is observed in sweet potato samples lower response in beetroot.

The R^2 values for most vegetables were above 0.8 while the R^2 for beetroot was lowest and below 0.8. It is possible to present the following model to predict the conductivity of solid foods after the dose of irradiation D. $\sigma = \sigma 0\ [1 + k . D]$, where σ is the electrical conductivity where *(Sm^{-1})* after the dose of irradiation D, $\sigma 0$ is the electrical conductivity of the non irradiated sample, and *k* is the radiation compensation constant. The radiation compensation constant calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato are

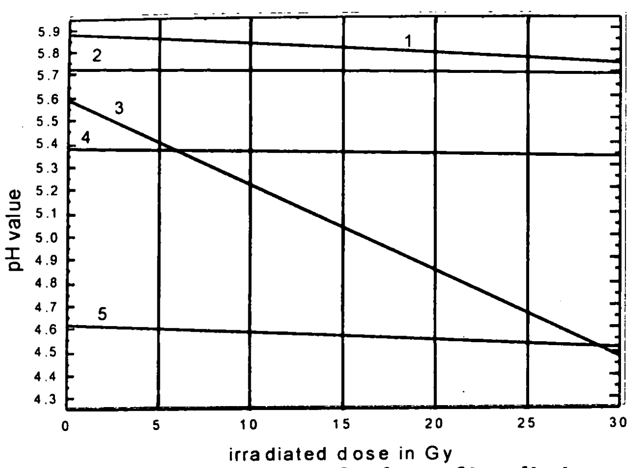

Figure 2: PH variation with the dose of irradiation for different vegetable juice samples.

0.006, 0.012, 0.024, 0.02, 0.043 and 0.022 Gy^{-1}, respectively.

The graph of the pH values variation with dose of irradiation in the range from 0 to 30 *Gy* is given figure 2 for the vegetable`s juice of potato, pumpkin, elephant yam, radish, and beetroot

Figure 2 shows that, the pH values for non-irradiated vegetable samples are in increasing order from pumpkin, elephant yam, potato, radish, and to, beetroot those are 4.621, 5.383, 5.47, 5.731 and 5.92. The gradient of the pH variation against the dose of irradiation was calculated for radish, elephant yam, pumpkin, beetroot, and potato. The gradients are -0.00104, -0.00133, -0.0033, -0.00435 and -0.037 Gy^{-1}, respectively. Acidity is increasing with the increasing dose of irradiation due to the formation of H^+ increasing with dose.

Conclusions

The electrical conductivities of non-irradiated vegetable samples are in increasing order from elephant yam, radish, pumpkin, beetroot, and potato to sweet potato respectively. The gradient of the IV curves at low dose gamma rays calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato were 0.396, 0.785, 0.961, 1.081, 1.211 and 1.66 $\mu Sm^{-1}GY^{1}$, respectively. The radiation compensation constant calculated for beetroot, potato, radish, pumpkin, elephant yam and sweet potato were 0.006, 0.012, 0.024, 0.02, 0.043 and 0.022 Gy^{-1}, respectively. The gradients of the pH-radiation dose curves for radish, elephant yam, pumpkin, beetroot, and potato were - 0.00104, -0.00133, -0.0033, -0.00435 and -0.037 Gy^{-1}, respectively.

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