# Application of Gamma Radiation in Food, Medical Products and Agriculture

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***Abstract*** *Sterilization of health care products, reduction of total microbial load in feed and food samples, extension of shelf-life of fresh vegetables and genetic improvement of some plants are some of applications in the GU-3 gamma irradiation facility. The dosimetric system used is treated in this paper because dose and its uniformity are very important parameters of the radiation processing. They are related with chemical, biological and other physical changes in the irradiated product. To provide good dose uniformity (determined as the ratio of maximal dose to minimal dose) it is applied the radiation technique based on the rotation of the vessel with the material inside it. The dose uniformity was about 105 %. With regard to reducing total microbial load in food and feed samples it was seen that this quantity was reduced from* $(10^{9} + 10^{7}$ *)/g for control, up to >10/g for the irradiated samples. Over analytical control of the irradiated health care products was confirmed their sterility. Irradiated fresh vegetables (tomato and strawberry) had a longer shelf-life than control. We used mutation breeding in pepper through radiation to improve crops quality and in M1 generation photosynthetic pigments were higher in mutant materials than control.*

***Keywords:*** *sterility, microbial reduction, shelf- life, photosynthetic pigments, dose uniformity*

## 1. Introduction

Radiation processing has become today an accepted technology. There are more than 200 high activity gamma irradiation facilities and 1200 electron accelerators with beam energies of 0.1-10 MeV in use. This technology offers various advantages in the field of food treatment, sterilization of medical and pharmaceutical products, treatment of chemical materials and a variety of other products. Today about 60% of disposable medical products are sterilized by irradiation (IAEA, 2005).

Food treatment by irradiation reduce or eliminate the total microbial load, food borne pathogens, making it safer to eat and have a longer shelf- life.

Irradiation of food has been approved in 57 countries for more than 40 products. The largest marketers of irradiated food are Belgium, France and Netherland (Hasa, 2008; IAEA, 2002).

Using radiation technology, many varieties of plants like wheat, barley, carnation etc were developed. Recently a lot of new mutants are generated in many countries (Kume, 2006).

Plant Mutation Breeding is used in Albania to obtain mutants resistant to diseases and environmental stress.

Induced mutations in vegetables and especially in pepper consists in the experimental work intended to improve crops quality and resistance of the fruits for a long period (Maluszynski, 2000).

The absorbed dose is the most important parameter in all radiation processing mentioned above, because it is related directly to the desired effect in a specific material.

For this reason, it is very significant the accurate measurement of dose and its distribution throughout the volume of the irradiated material.

**2. Materials and methods**

The ECB dosimeter system has get a wide spread as a routine system for process control. It is chosen from IAEA such as one of two recommended systems for the dose measurement in the gamma radiation facility (Kovacs, et al, 1997).

In our GU- 3 gamma irradiator calibrated ECB dosimeters are used. They are glass ampoules containing 2.5 ml of dosimetric solution with an outer diameter of 10.80 mm ± 0.01mm and wall thickness of 0.6 mm, enough to fulfil the condition of electron equilibrium.

The ionisation chamber type M 23331 connected with rate meter DI4/DL4 is used as a standard dosimeter. The response of ECB dosimeters was measured by oscillatitrator type OK-302/2.

To study the dose distribution is used a wire copper profile, with ECB dosimeters placed in different location of it (Klemo & Dodbiba, 2011).

Different type of food and feed samples, medical products and seed plants were irradiated to show radiation effect on them.

To measure the absorbed dose a calibrated dosimetric system is used. The calibration procedure of ECB dosimeters is given in (Klemo & Dodbiba, 2011). The plotted calibration curve is presented in fig 1.

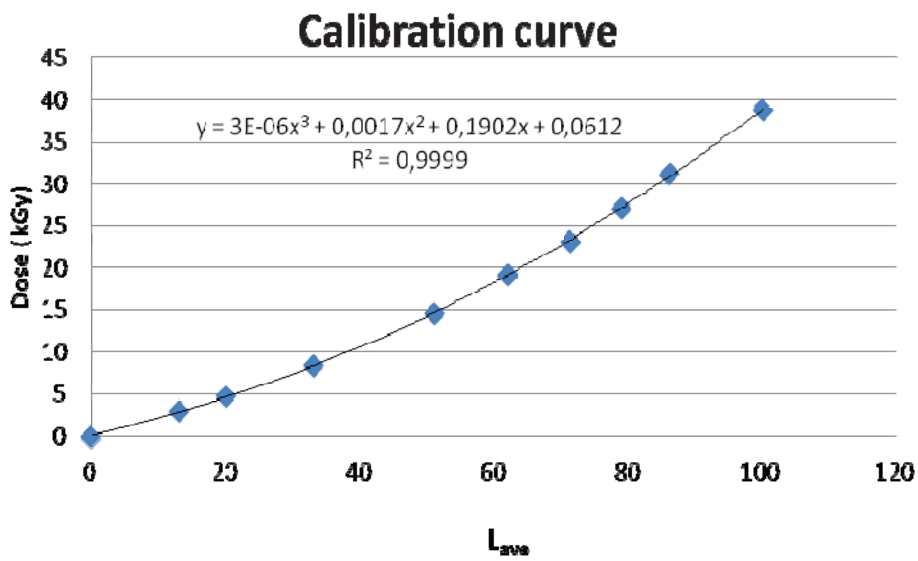


**Fig. 1:** Calibration curve 2011

The distribution of absorbed dose is characterized by the dose uniformity that is the ratio of maximal dose to minimal dose ($D_{max}/D_{min}$), otherwise is called “dose uniformity ratio” (DUR).

It is necessary to have desirable dose uniformity throughout the irradiated material (Mehta & Abdel-Fattah, 2008).

For research application this ratio should be close to unity. It means that the dose should be very uniform in the irradiated material, in order to the experimental results can clearly demonstrate the dose-effect relationship (IAEA, 2002; Mehta, 2008).

In industrial applications wider dose variation is inevitable. The DUR may be more than 1, for example 1.5, 2 or even 3**.** To minimize the DUR are used various radiation techniques (for example multipass, multi-sided irradiation or rotation of the irradiated material (IAEA, 2002).

During irradiation of materials, it is important to choose radiation technique and irradiation geometry which could provide a good dose uniformity.

The radiation techniques used are based in the rotation of the vessel together with the materials inside it. Two of them are given in fig 2 and 3.

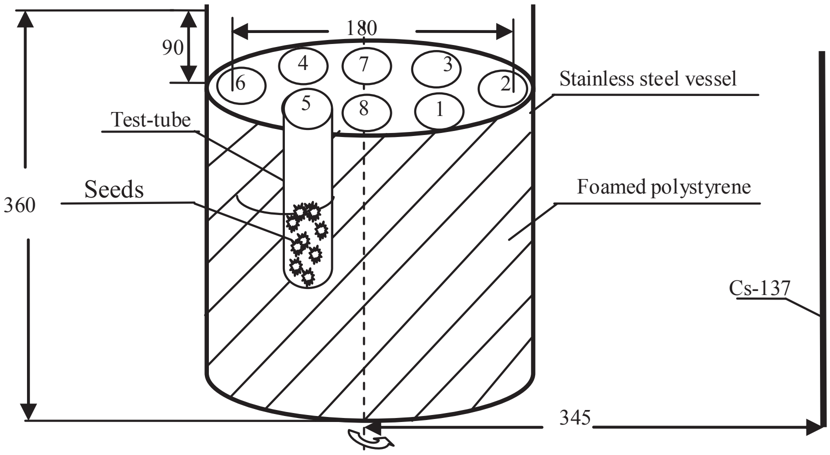


**Fig. 2:** Radiation technique of small seeds

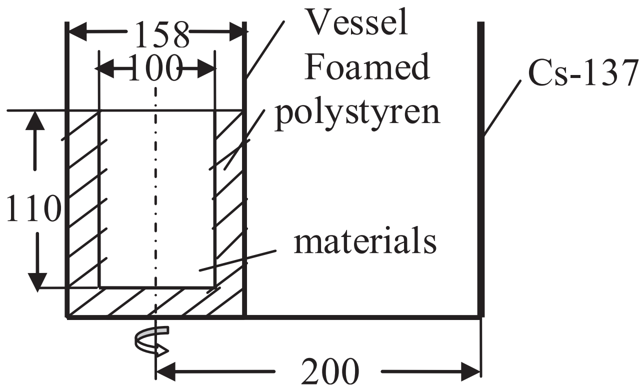


**Fig. 3:** Radiation technique and geometry of different materials

The procedure for dose measurement, was given in (Klemo & Dodbiba, 2011). The result of dose measurement is only an estimation of the dose value and it is complete only when accompanied by a quantitative statement of its uncertainty. For the method used the uncertainty of dose measurement was ≤ ± 6% and the dose uniformity 105%.

### 3. Effects of radiation in food, medical products and agriculture

Using the above irradiation technique (fig.3), different health care products (catheters, vigons, surgical yarn, syringes, needles, Petri dishes, used band, endotracheal tube) were irradiated with doses 25 kGy, 27 kGy and 30 kGy.
As a broth medium was used soybean casein digest broth and resazurin broth. After irradiation process all the medical samples resulted sterilized as seen in the photo 1.

**Photo.1**

Different food and feed samples (wheat, soya meal, animal feed, mixed cereal meal, grind meat, salami) were irradiated to decrease the total microbial load. The doses used were 3 kGy, 4 kGy and 5 kGy.

From the measurements it was seen the reduction of total microbial load from $10^4$-$10^7$ cfu/g (for control) till to 3-$10^2$ cfu/g (for irradiated samples).

All the materials before irradiation were packaged in stomacher bags like in the photo 2.

**Photo. 2**

We have done some experiments, to study the effect of gamma irradiation in the shelf-life of some foods and genetic improvement of pepper plants.

For these purpose tomatoes, strawberries and pepper seeds were irradiated.

The tomatoes were irradiated with the absorbed dose 1 kGy. After irradiation the control and the irradiated product were stored in room temperature ($\geq$ 30⁰C). Also the strawberries were irradiated with 0.5 kGy and stored at 3°C in refrigerator.

In the photos below are given the changes among irradiated samples and control. With number 1 and 2 are denoted respectively the control and the irradiated sample.


**Photo. 3:** 24 June 2011


**Photo. 4:** 19July 2011


**Photo.5:** 24 June 2011


**Photo. 6:** 12 July 2011

It was seen that the irradiated samples had a longer shelf-life than control because the spoilage microorganisms were reduced as a result of irradiated effect.

This experiment is the first one made in our laboratory. Taking into account the positive results achieved, in the future will be realized the experiments with other doses and fruits.

Except tomatoes and strawberries, were irradiated pepper seeds.

One thousand pepper seeds were irradiated with three different doses, respectively 50 Gy, 100 Gy and 150 Gy. The experiment has been carry out during 2011 in the Green House of the Faculty of Natural Sciences in Tirana.

From all measurements during vegetative period, the germination of pepper seeds was decreased significantly with radiation doses, 100 Gy and 150 Gy. For these two doses the germinations were respectively 65 %  and 33 %, compare to control material. These effects are shown in the  photos 7, 8, 9.

Photosynthetic pigments content in different plants treated with 50 Gy was increased up to 50% and in particular plants pigments content was twice compare to the control plants. In leaf materials of pepper plants (M1 generation), treated with 100 Gy, was observed chlorophyll mutations as influence of induced mutation from gamma irradiation.

**Photo .7:** Pepper irradiated with 50 Gy


**Photo. 8:**  Pepper irradiated with 100 Gy

**Photo.9:** Control

**4. Conclusions**

- The uncertainty of the method used for dose measurement was ≤ ± 6%.
- The dose uniformity was 105%.
- The irradiated samples (tomatoes and strawberries) have a longer shelf-life than control.
- The germination of pepper seeds was decreased with doses 100 Gy and 150 Gy respectively 65% and 33% compared with control.
- Photosynthetic pigments content in different plants treated with 50 Gy was increased up to 50 % compared with control.
    - For dose 100Gy was observed chlorophyll mutation.

## References


IAEA. (2005). Status and prospects of radiation processing in Europe. Proceedings of the Coordination Meeting of the TC RER/8/010 project, held at INCT, Warsaw, Poland. Vienna, 1-9.

Hasa, M. (2008). Sterilizimi i paisjeve mjekësore dhe reduktimi i ngarkesës mikrobike në ushqime me anën e rrezatimit gama. Universiteti i Tiranës, FSHN, Tiranë.

IAEA. (2002). Dosimetry for food irradiation.Technical Report Series, ISSN 0074-1914; no.409 STI/DOC/010/409, ISBN 92-0-115502-6,Vienna, 10- 59.

Kume, T. (2006). Application of radiation in agriculture. Takasaki Advanced Radiation Research Instiute, JAEA, 17-19.

Maluszynski M., et al. (2000). Officially released mutant varietys. The FAO/ IAEA data base No 12: 804.

Kovacs, A., et al. (1997). Recent results with ECB dosimeters, E-23.

Klemo, M., & Dodbiba, A. (2011). Recalibration and comparision of dosimetric system. AJTNS, Albanian Academy of Science in Albania, Tirana, V 2, No 30, 37-48.

Mehta, K., & Abdel-Fattah. (2008). Dosimetry and radiation sterilization process.Trends in radiation sterilization of health care products.IAEA, Vienna, 94 - 100.

Mehta, K. (2008). Gamma irradiators for radiation sterilization. Trends in radiation sterilization of health care products.IAEA, Vienna, 12-14.