RECOMMENDED INTERNATIONAL CODE OF PRACTICE FOR THE OPERATION OF IRRADIATION FACILITIES USED FOR THE TREATMENT OF FOODS

CAC/RCP 19-1979 (Rev. 1-1983) [1]

1. INTRODUCTION

This Code refers to the operation of irradiation facilities based on the use of either a radionuclide source (^{60}Co or ^{137}Cs) or X-rays and electrons generated from machine sources. The irradiation facility may be of two designs, either "continuous" or "batch" type. Control of the food irradiation process in all types of facility involves the use of accepted methods of measuring the absorbed radiation dose and of the monitoring of the physical parameters of the process. The operation of these facilities for the irradiation of food must comply with the Codex recommendations on food hygiene.

2. IRRADIATION PLANTS

2.1 Parameters

For all types of facility the doses absorbed by the product depend on the radiation parameter, the dwell time or the transportation speed of the product, and the bulk density of the material to be irradiated. Source-product geometry, especially distance of the product from the source and measures to increase the efficiency of radiation utilization, will influence the absorbed dose and the homogeneity of dose distribution.

2.1.1 Radionuclide sources

Radionuclides used for food irradiation emit photons of characteristic energies. The statement of the source material completely determines the penetration of the emitted radiation. The source activity is measured in Becquerel (Bq) and should be stated by the supplying organization. The actual activity of the source (as well as any return or replenishment of radionuclide material) shall be recorded. The recorded activity should take into account the natural decay rate of the source and should be accompanied by a record of the date of measurement or recalculation. Radionuclide irradiators will usually have a well separated and shielded depository for the source elements and a treatment area which can be entered when the source is in the safe position. There should be a positive indication of the correct operational and of the correct safe position of the source which should be interlocked with the product movement system.

2.1.2 Machine sources

A beam of electrons generated by a suitable accelerator, or after being converted to X-rays, can be used. The penetration of the radiation is governed by the energy of the electrons. Average beam power shall be adequately recorded. There should be a positive indication of the correct setting of all machine parameters which should be interlocked with the product movement system. Usually a beam scanner or a scattering device (e.g., the converting target) is incorporated in a machine source to obtain an even distribution of the radiation over the surface of the product. The product movement, the width and speed of the scan and the beam pulse frequency (if applicable) should be adjusted to ensure a uniform surface dose.

2.2 Dosimetry and process control

Prior to the irradiation of any foodstuff certain dosimetry measurements [2] should be made, which demonstrate that the process will satisfy the regulatory requirements. Various techniques for dosimetry pertinent to radionuclide and machine sources are available for measuring absorbed dose in a quantitative manner. [3]

Dosimetry commissioning measurements should be made for each new food, irradiation process and whenever modifications are made to source strength or type and to the source product geometry.

Routine dosimetry should be made during operation and records kept of such measurement. In addition, regular measurements of facility parameters governing the process, such as transportation speed, dwell time, source exposure time, machine beam parameters, can be made during the facility operation. The records of these measurements can be used as supporting evidence that the process satisfies the regulatory requirements.

3. GOOD RADIATION PROCESSING PRACTICE

Facility design should attempt to optimalize the dose uniformity ratio, to ensure appropriate dose rates and, where necessary, to permit temperature control during irradiation (e.g., for the treatment of frozen food) and also control of the atmosphere. It is also often necessary to minimize mechanical damage to the product during transportation irradiation and storage, and desirable to ensure the maximum efficiency in the use of the irradiator. Where the food to be irradiated is subject to special standards for hygiene or temperature control, the facility must permit compliance with these standards.

4. PRODUCT AND INVENTORY CONTROL

4.1 The incoming product should be physically separated from the outgoing irradiated products.

4.2 Where appropriate, a visual colour change radiation indicator should be affixed to each product pack for ready identification of irradiated and non-irradiated products.

4.3 Records should be kept in the facility record book which show the nature and kind of the product being treated, its identifying marks if packed or, if not, the shipping details, its bulk density, the type of source or electron machine, the dosimetry, the dosimeters used and details of their calibration, and the date of treatment.

4.4 All products shall be handled, before and after irradiation, according to accepted good manufacturing practices taking into account the particular requirements of the technology of the process. [4] Suitable facilities for refrigerated storage may be required.

ANNEX A

DOSIMETRY

1. The overall average absorbed dose

It can be assumed for the purpose of the determination of the wholesomeness of food treated with an overall average dose of 10 kGy or less, that all radiation chemical effects in that particular dose range are proportional to dose.

The overall average dose, D, is defined by the following integral over the total volume of the goods

$$D = \frac{1}{M} \int r \ (x, y, z)\, d\,(x, y, z)\, dV$$

M = the total mass of the treated sample

ρ = the local density at the point (x, y, z)

d = the local absorbed dose at the point (x, y, z)

dV = dx dy dz the infinitesimal volume element which in real cases is represented by the volume fractions

The overall average absorbed dose can be determined directly for homogeneous products or for bulk goods of homogeneous bulk density by distributing an adequate number of dose meters strategically and at random throughout the volume of the goods. From the dose distribution determined in this manner an average can be calculated which is the overall average absorbed dose.

If the shape of the dose distribution curve through the product is well determined the positions of minimum and maximum dose are known. Measurements of the distribution of dose in these two positions in a series of samples of the product can be used to give an estimate of the overall average dose. In some cases the mean value of the average values of the minimum (D_{min}) and maximum (D_{max}) dose will be a good estimate of the overall average dose.

i.e. in these cases:

$$\text{overall average dose} \approx \frac{D_{\max} + D_{\min}}{2}$$

2. Effective and limiting dose values

Some effective treatment, e.g. the elimination of harmful microorganisms, or a particular shelflife extension, or a disinfestation, requires a minimum absorbed dose. For other applications too high an absorbed dose may cause undesirable effects or an impairment of the quality of the product.

The design of the facility and the operational parameters have to take into account minimum and maximum dose values required by the process. In some low dose applications it will be possible within the terms of Section 3 on Good Radiation Processing Practice to allow a ratio of maximum to minimum dose of greater than 3.

With regards to the maximum dose value under acceptable wholesomeness considerations and because of the statistical distribution of the dose a mass fraction of product of at least 97.5% should receive an absorbed dose of less than 15 kGy when the overall average dose is 10 kGy.

3. Routine dosimetry

Measurements of the dose in a reference position can be made occasionally throughout the process. The association between the dose in the reference position and the overall average dose must be known. These measurements should be used to ensure the correct operation of the process. A recognized and calibrated system of dosimetry should be used.

A complete record of all dosimetry measurements including calibration must be kept.

4. Process control

In the case of a continuous radionuclide facility it will be possible to make automatically a record of transportation speed or dwell time together with indications of source and product positioning. These measurements can be used to provide a continuous control of the process in support of routine dosimetry measurements.

In a batch operated radionuclide facility automatic recording of source exposure time can be made and a record of product movement and placement can be kept to provide a control of the process in support of routine dosimetry measurements.

In a machine facility a continuous record of beam parameters, e.g. voltage, current, scan speed, scan width, pulse repetition and a record of transportation speed through the beam can be used to provide a continuous control of the process in support of routine dosimetry measurements.

ANNEX B

EXAMPLES OF TECHNOLOGICAL CONDITIONS FOR THE IRRADIATION OF SOME INDIVIDUAL FOOD ITEMS SPECIFICALLY EXAMINED BY THE JOINT FAO/IAEA/WHO EXPERT COMMITTEE

This information is taken from the Reports of the Joint FAO/IAEA/WHO Expert Committees on Food Irradiation (WHO Technical Report Series, 604, 1977 and 659, 1981) and illustrates the utility of the irradiation process. It also describes the technological conditions for achieving the purpose of the irradiation process safely and economically.

1. CHICKEN (*Gallus domesticus*)

1.1 Purposes of the process

The purposes of irradiating chicken are:

(a) to prolong storage life; and/or

(b) to reduce the number of certain pathogenic microorganisms, such as *Salmonella* from eviscerated chicken.

1.2 Specific requirements

Average dose: for (a) and (b), up to 7 kGy.

2. COCOA BEANS (*Theobroma cacao*)

2.1 Purposes of the process

The purposes of irradiating cocoa beans are:

(a) to control insect infestation in storage;

(b) to reduce microbial load of fermented beans with or without heat treatment.

2.2 Specific requirements

2.2.1 Average dose: for (a) up to 1 kGy
for (b) up to 5 kGy.

2.2.2 ***Prevention of reinfestation***: Cocoa beans whether prepackaged or handled in bulk, should be stored as far as possible, under such conditions as will prevent reinfestation and microbial recontamination and spoilage.

3. DATES (*Phoenix dactylifera*)

3.1 Purpose of the process

The purpose of irradiating prepackaged dried dates is to control insect infestation during storage.

3.2 Specific requirements

3.2.1 Average dose: up to 1 kGy.

3.2.2 ***Prevention of reinfestation***: Prepackaged dried dates should be stored under such conditions as will prevent reinfestation.

4. MANGOES (*Mangifera indica*)

4.1 Purposes of the process

The purposes of irradiating mangoes are:

(a) to control insect infestation;

(b) to improve keeping quality by delaying ripening;

(c) to reduce microbial load by combining irradiation and heat treatment.

4.2 Specific requirements

Average dose: up to 1 kGy.

5. ONIONS (*Allium cepa*)

5.1 Purpose of the process

The purpose of irradiating onions is to inhibit sprouting during storage.

5.2 Specific requirement

Average dose: up to 0.15 kGy.

6. PAPAYA (*Carica papaya* L.)

6.1 Purpose of the process

The purpose of irradiating papaya is to control insect infestation and to improve its keeping quality by delaying ripening.

6.2 Specific requirements

6.2.1 Average dose: up to 1 kGy.

6.2.2 ***Source of radiation***: The source of radiation should be such as will provide adequate penetration.

7. POTATOES (*Solanum tuberosum* L.)

7.1 Purpose of the process

The purpose of irradiating potatoes is to inhibit sprouting during storage.

7.2 Specific requirement

Average dose: up to 0.15 kGy.

8. PULSES

8.1 Purpose of the process

The purpose of irradiating pulses is to control insect infestation in storage.

8.2 Specific requirement

Average dose: up to 1 kGy.

9. RICE (*Oryza* species)

9.1 Purpose of the process

The purpose of irradiating rice is to control insect infestation in storage.

9.2 Specific requirements

9.2.1 Average dose: up to 1 kGy.

9.2.2 ***Prevention of reinfestation***: Rice, whether pre-packaged or handled in bulk, should be stored as far as possible, under such conditions as will prevent reinfestation.

10. SPICES AND CONDIMENTS, DEHYDRATED ONIONS, ONION POWDER

10.1 Purposes of the process

The purposes of irradiating spices, condiments, dehydrated onions and onion powder are:

(a) to control insect infestation;

(b) to reduce microbial load;

(c) to reduce the number of pathogenic microorganisms.

10.2 Specific requirement

Average dose: for (a) up to 1 kGy
for (b) and (c) up to 10 kGy.

11. STRAWBERRY (*Fragaria* species)

11.1 Purpose of the process

The purpose of irradiating fresh strawberries is to prolong the storage life by partial elimination of spoilage organisms.

11.2 Specific requirement

Average dose: up to 3 kGy.

12. TELEOST FISH AND FISH PRODUCTS

12.1 Purposes of the process

The purposes of irradiating teleost fish and fish products are:

(a) to control insect infestation of dried fish during storage and marketing;

(b) to reduce microbial load of the packaged or unpackaged fish and fish products;

(c) to reduce the number of certain pathogenic microorganisms in packaged or unpackaged fish and fish products.

12.2 Specific requirements

12.2.1 Average dose: for (a) up to 1kGy
for (b) and (c) up to 2.2 kGy.

12.2.2 ***Temperature requirement***: During irradiation and storage the fish and fish products referred to in (b) and (c) should be kept at the temperature of melting ice.

13. WHEAT AND GROUND WHEAT PRODUCTS (*Triticum* species)

13.1 Purpose of the process

The purpose of irradiating wheat and ground wheat products is to control insect infestation in the stored product.

13.2 Specific requirements

13.2.1 Average dose: up to 1 kGy.

13.2.2 ***Prevention of reinfestation***: These products, whether prepackaged or handled in bulk, should be stored as far as possible under such conditions as will prevent reinfestation.

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[1] **THE RECOMMENDED INTERNATIONAL CODE OF PRACTICE FOR THE OPERATION OF IRRADIATION FACILITIES USED FOR THE TREATMENT OF FOODS WAS ADOPTED BY THE CODEX ALIMENTARIUS COMMISSION AT ITS 13TH SESSION, 1979 AND SUBSEQUENTLY REVISED IN 1983 BY THE 15TH SESSION. IT HAS BEEN SENT TO ALL MEMBER NATIONS AND ASSOCIATE MEMBERS OF FAO AND WHO AS AN ADVISORY TEXT, AND IT IS FOR INDIVIDUAL GOVERNMENTS TO DECIDE WHAT USE THEY WISH TO MAKE OF THE CODE. THE COMMISSION HAS EXPRESSED THE VIEW THAT CODES OF PRACTICE MIGHT PROVIDE USEFUL CHECKLISTS OF REQUIREMENTS FOR NATIONAL FOOD CONTROL OR ENFORCEMENT AUTHORITIES.**

[2] See Annex A to this Code.

[3] Detailed in the Manual of Food Irradiation Dosimetry, IAEA, Vienna, 1977, Technical Report Series No. 178.

[4] See Annex B to this Code.