MS 1265-2 (2005) (English): CODE OF GOOD IRRADIATION PRACTICE -PART 2: BULB AND TUBER CROPS FOR SPROUT INHIBITION (FIRST REVISION)

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MALAYSIAN STANDARD

MS 1265: PART 2:2005

CODE OF GOOD IRRADIATION PRACTICE - PART 2: BULB AND TUBER CROPS FOR SPROUT INHIBITION (FIRST REVISION)

ICS: 67.020

Descriptors: code of practice, irradiation, ionising, radiation treatment, bulb, tuber, sprout inhibition

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Department of Standards Malaysia

Federal Agricultural Marketing Authority

Federation of Malaysian Manufacturers

Malaysian Agricultural Research and Development Institute

Malaysian Association of Standards Users

Malaysian Palm Oil Association

Ministry of Agriculture and Agro-Based Industry

Ministry of Health Malaysia

Ministry of International Trade and Industry

Universiti Kebangsaan Malaysia

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The Working Group on Food Irradiation which developed this Malaysian Standard consists of representatives from the following organisations:

Department of Fisheries Malaysia

Department of Veterinary Services Malaysia

Federation of Malaysian Consumers Associations

Malaysian Agricultural Research and Development Institute

Malaysian Institute for Nuclear Technology Research

Ministry of Health Malaysia

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FOREWORD

This Malaysian Standard was developed by the Working Group on Food Irradiation under the authority of the Food and Agricultural Industry Standards Committee.

MS 1265 consists of the following parts, under the general title *Code of good irradiation practice*:

- *Part 1: General*

- *Part 2: Bulb and tuber crops for sprout inhibition*

- *Part 3: Fresh fruits and vegetables for insect disinfestations and as quarantine treatment*

- *Part 4: Cereal grains for insect disinfestations*

- *Part 5: Dried fish and dried salted fish for insect disinfestations*

- *Part 6: Bananas, mangoes and papayas for shelf-life extension*

- *Part 7: Fish, frog legs and shrimps for the control of microflora*

- *Part 8: Prepackaged meat and poultry for the control of pathogens and/or to extend shelf-life*

- *Part 9: Spices, herbs and vegetable seasonings for the control of pathogen and microflora*

- *Part 10: Dried meat and dried salted meat of animal origin for insect disinfestations, control of moulds and reduction of pathogenic microorganisms*

This Malaysian Standard is the first revision of MS 1265: Part 2, *Guidelines for irradiation of foods: Part 2: Irradiation of bulb and tuber crops to inhibit sprouting.*

Major modifications in this revision are as follows:

a) the general requirements and guidance for pre-irradiation treatment for tubers have been revised;

b) the requirements and guidance for pre-irradiation storage and transport for tubers have been revised;

c) new radiation source has been added; and

d) the storage life and its requirements for bulbs (onions and garlic) have been inserted.

This Malaysian Standard cancels and replaces MS 1265: Part 2: 1992, *Guidelines for irradiation of foods: Part 2: Irradiation of bulb and tuber crops to inhibit sprouting.*

Compliance with a Malaysian Standard does not of itself confer immunity from legal obligations.

CODE OF GOOD IRRADIATION PRACTICE - PART 2: BULB AND TUBER CROPS FOR SPROUT INHIBITION (FIRST REVISION)

1. Scope

1.1 This Malaysian Standard describes the code of good irradiation practice for bulbs (onions and garlic) and tuber crops (potatoes and yams) for the purpose of sprout inhibition during storage and handling.

1.2 These foods, themselves, are the subject of the radiation treatment and not their contaminating organisms.

2. Normative reference

The following normative reference is indispensable for the application of this standard. For dated reference, only the edition cited applies. For undated reference, the latest edition of the normative reference (including any amendments) applies.

MS 1265: Part 1, *Code of good irradiation practice - Part 1: General*

3. Pre-irradiation treatment

3.1 General

3.1.1 The pre-irradiation treatment needed is an important aspect of the total process of preservation of these foods by irradiation. Each food has its individual requirements and is discussed separately.

3.1.2 The conditions influencing the storability of the bulb and tuber crops will also affect the results of the irradiation treatment. Only varieties of proven storage qualities are suitable for irradiation and long-term storage.

3.1.3 Damage to the commodities begins in the field itself during harvesting and continues to occur during transportation from field to storage or packing house, handling out of storage, grading and marketing. Only products of good initial quality are suitable for irradiation. Irradiation cannot improve the storage properties of bulbs and tubers that are damaged or unhealthy at the time of treatment, which may even be detrimental in such cases.

3.1.4 Mechanical harvesting and grading may accentuate the physical damage, mostly by causing bruising. Although the damage occurring during the above operations cannot altogether be eliminated, the aim should be to minimise the extent and severity of damage by use of proper harvesting and grading and by gentle handling at all stages. Field heat should be removed as soon as possible.

3.1.5 After the crops are harvested, they shall be dried well, cleaned of adhering soil and dust and sorted to remove badly damaged and infected material. Crops should not be harvested when the field is wet in order to avoid soil or mud sticking to them.

3.2 Bulbs

3.2.1 Onions

3.2.1.1 Only onion varieties and strains of proven storage qualities are suitable for irradiation and long-term storage.

3.2.1.2 To obtain good results it is necessary that the onions be grown under the best possible conditions to ensure uniform maturation of the bulbs. Commercial harvesting of onions begins when more than 80 % foliage falls over, or when foliar fall-over is complete when the leaves have senesced and dried. Bulbs should not be topped near to the neck region; it is advisable to cut the bulbs 3 cm to 5 cm above the neck. The bulbs should be fully mature, sound, firm and well covered with dry scales and the fleshy edible scales should not be exposed. Bolted bulbs or bulbs with a thick neck should be avoided.

3.2.1.3 Sprout inhibition caused by irradiation may vary with variety, geographical and climatic conditions during growing and on also bulb size. With some varieties, smaller bulbs may sprout earlier than the larger bulbs but with other varieties the reverse may occur.

3.2.1.4 Proper curing (drying of the outer surface and neck) of the onion prior to irradiation is essential. Drying results in the outer layers of onion scales becoming less permeable to moisture and more resistant to the entry of disease-causing microorganisms. Curing also gives a good scale colour. Curing may be done by field drying or by artificial drying.

3.2.2 Garlic

3.2.2.1 Bulbs should be mature and firm and heavy for their size. Bulbs which are light have either lost moisture or decayed are unsuitable for irradiation.

3.2.2.2 Garlic requires essentially the same curing as onions (see 3.2.1).

3.3 Tubers

3.3.1 General

Potatoes that have been rained on should not be put into storage unless they are first thoroughly dried. Washing of the tuber crops to remove adhering mud or soil prior to storage may not be advisable, as often, if not properly dried and if necessary precautions are not taken to avoid the build-up of microbial contamination in this wash water, washing may lead to increased spoilage in storage. The presence of a water film on potatoes may lead to invasion and rotting by soft-rot bacteria in the course of a few days at temperatures of 10 °C and above, and may lead to a slow development of rot even at 5 °C.

3.3.2 Potatoes

3.2.2.1 The stage of maturity of potatoes affects their susceptibility to damage and their subsequent storage characteristics. Immature potatoes have a weakly developed periderm or an incompletely set skin and are prone to abrasion damage or 'skinning' during harvesting and handling. The rate of water loss from potatoes with such skins is (15 – 100) times greater than that from those with skins that are intact and completely set. Immature potatoes are characteristic of those harvested while the haulm is still green; whereas, potatoes with fully developed periderms or well set skins are from plants whose haulm either has senesced naturally or been destroyed artificially.

3.3.2.2 Different varieties of potatoes have periderms of different thickness. Using varieties with thicker periderm which is of greater resistance to mechanical damage reduces damage during harvesting and handling. Tuber temperature may also influence mechanical damage. Potatoes should be stored protected from light, in order to prevent light-induced greening and production of solanine, a toxic glyco alkaloid.

3.3.2.3 In order to store tubers successfully, they shall be cured properly after harvest; that is, the wounds resulting from harvesting and handling shall be healed. This self-healing shall occur before the tuber is irradiated, since irradiation interferes with the natural healing process. Therefore, after harvesting, potatoes shall be held for a specific period (up to 30 days) prior to irradiation depending on variety and the physiological period. Holding the potatoes at 15 °C to 25 °C and 90 % to 95 % RH maximises healing.

3.3.2.4 After curing potatoes should be handled in a manner so as to minimise damage.

3.3.3 Yams

Yams to be stored should be mature, firm and free of obvious defects. Preferably they should not have been damaged in harvesting and handling. If damaged, self-healing should be allowed on storage prior to irradiation. Different varieties require different temperatures of curing in order to obtain wound healing. Generally, temperatures as high as 35 °C, as soon as possible after harvest, are needed. The optimum temperature should be determined for the species at hand.

4. Packaging

4.1 General

4.1.1 If the irradiation is carried out on the packaged product using doses specified in this standard, the packaging material in contact with the product should not undergo significant alteration of its functional properties nor yield toxic materials which can transfer to the food.

4.1.2 The size and shape of containers which may be used for irradiation are determined in part by certain aspects of the irradiation facility. The critical aspects include the characteristics of product transport systems and of the irradiation source, as they relate to the dose distribution obtained within the container (see Clause 6).

4.1.3 The irradiation procedure will, therefore, be aided if the product packages are geometrically well-defined and uniform. With certain irradiation facilities, it may be necessary to limit the use to certain package shapes and sizes.

4.1.4 Packaging materials used shall comply with the requirements of the legislation currently enforced in the country.

4.2 Bulbs (onions and garlic)

4.2.1 Onions and garlic may be placed in bulk or pallet-sized boxes at the time of harvest and the same containers are used for irradiation and storage to avoid damage to any scales. Bags or sacks made of wide-meshed jute or of synthetic material are satisfactory containers.

4.2.2 In some instances the irradiation facility may have been built so as to require no containers for irradiation and, instead, to enable continuous irradiation of the crops (e.g. onions passing between radiation sources through gravity flow) (see Döllstädt, 1984).

4.3 Tubers (potatoes and yams)

4.3.1 To minimise the handling injuries to the tubers during and following irradiation treatment, the best possible approach is to use pallet boxes or bulk containers in which the product can be stored, dried, cured and irradiated. Under these conditions, the tubers are handled as little as possible and damage is reduced, which is essential for successful long-term storage. Post irradiation storage can be either in the pallet box itself or in bulk, although in the latter case damage, can again occur while unloading. The use of pallet boxes allows rapid mechanised handling and movement of the product with minimal injury. Pallet boxes can be stacked one over the other without increasing the load on tubers in the bottom layers.

4.3.2 Bags or sacks made of wide-meshed jute or of synthetic material may be satisfactory containers for potatoes. The use of such containers, however, may lead to damage to the potatoes unless very careful handling is employed.

4.3.3 The process of filling potatoes into small boxes or containers, in which the potatoes are carried to the source for irradiation and then unloading from these boxes into the final storage container or bin, may result in damage and bruises. Such skin bruises may not heal during subsequent storage and may provide access for rot-causing bacteria and result in increased spoilage during storage. Similarly, the use of conveyors to move loose potatoes in layers past the radiation source also can increase surface injuries when the tubers drop from one belt to another or when they fall into containers or storage bins. This may increase spoilage during storage. However, modern agrotechnical practice of bulk handling and storage of potatoes, has developed suitable 'soft handling' conveying mechanisms and these could be adapted, where necessary.

4.3.4 Although there has been no experience of irradiating yams in bulk containers, these tubers also require essentially the same type of handling during and following irradiation as in the case of potatoes. There is no experimental evidence on the wound-healing capacity of yams after irradiation. However, it can be presumed that irradiation may interfere with the tuber's ability to form a wound periderm. Therefore, it may be important to avoid injuries to the yam tubers during and following irradiation.

5. Pre-irradiation storage and transport

5.1 Precautions (outlined in Clauses 3 and 4), regarding avoidance or minimisation of mechanical damage to bulb and tuber crops, shall be maintained throughout any pre-irradiation storage (whether for curing purposes or for logistical reasons) and transport. As a rule, irradiation of tubers should be made as soon as wound healing process has been completed which, in general, would be within one month after harvesting.

5.2 Onions shall be irradiated to inhibit sprouting before the break of the dormancy period. The length of the dormancy period varies with the variety of onion and the holding temperature after harvest. In general, onions should not be held very long after harvest and before irradiation. Irradiation within one to two months after harvest may result in maximum sprout inhibition.

5.3 Temperatures during storage should be chosen, to prevent development of rot and browning of inner buds. In the case of bulbs, higher temperatures (e.g. 15 °C to 20 °C) at low relative humidities will be satisfactory, at the expense of somewhat increased weight loss.

6. Irradiation

6.1 Facility requirements and operations; process parameters and critical operational control points; ionising radiation sources employed

6.1.1 The requirements and guidance information regarding certain irradiation process parameters and irradiation facilities and their operation should be referred to MS 1265: Part 1.

6.1.2 The ionising radiation which may be employed in irradiating foods is limited to:

a) Gamma rays from the radionuclides Cobalt-60 or Caesium-137;

b) X-rays generated from machine sources operated at or below an energy level of 5 MeV (Million Electron Volts); and

c) Electrons generated from machine sources operated at or below an energy level of 10 MeV.

6.1.3 It should be noted that irradiation by electrons, having limited energy penetration, is not applicable to bulky products such as bulbs and tubers.

6.1.4 It is not possible to distinguish irradiated from non-irradiated product by inspection, therefore, it is important that, in the operation of an irradiation facility appropriate means, such as physical barriers, be employed for keeping the irradiated and non-irradiated product separate.

6.1.5 Indicators which change colour or which otherwise undergo some easily determined and time-stable change when exposed to radiation at the doses required are commercially available. Such devices, common in the radiosterilisation industry, used as a paper sticker, or equivalent, and attached to each product unit, such as a carton, could assist the operator in identifying irradiated product.

6.1.6 It is important that adequate records of the operation of the irradiation facility be kept, and that foods which have been irradiated should be identified by lot number or other suitable means. Such measures to enable verification of the irradiation treatment are likely to be required by the regulatory agencies.

6.2 Amount of radiation used (absorbed dose)

6.2.1 General

6.2.1.1 The most important parameter in the irradiation process is the amount of ionising energy absorbed by the target material. This is termed 'absorbed dose'. The unit of absorbed dose is the Gray (Gy). One Gy is equal to the absorption of one joule per kg. The dose employed is dependent on the purpose of the treatment. It is important that the food should receive the minimum absorbed dose required to achieve the desire effect that the uniformity ratio be maintained at an appropriate level. MS 1265: Part 1 describes that overall average dose (OAAD) should not exceed 10 kGy for whole food.

6.2.1.2 The control of the irradiation procedure so as to deliver a prescribed dose entails a number of considerations, important among which is the technology for measuring dose, which is termed 'dosimetry'. It is recommended that manuals on dosimetry procedures be consulted. Refer to bibliography for list of references on dosimetry procedures.

6.2.2 Dose for bulbs (onions and garlic)

6.2.2.1 The absorbed dose required to prevent onions from sprouting is highly dependent on growing conditions, varietal differences, dormancy state of bulbs, curing conditions, and post-irradiation storage temperature. Generally, the absorbed dose needed for satisfactory sprout inhibition may range from 20 Gy to 150 Gy depending on the above factors and the influence brought about by the interaction among these factors. Absorbed doses of 20 Gy to 70 Gy are effective if the irradiation is carried within one month to two months after harvest. If irradiation is carried out at periods greater than that period (i.e. when the bulbs are no longer dormant) more sprouting would occur, especially if doses applied is above 80 kGy. The sprouts produced grow for a time, but later die and wither off.

6.2.2.2 The dormancy period of some varieties of onions may be extended by storing them at higher temperatures such as 26 °C – 30 °C. With other varieties, low temperature storage, such as 3 °C to 5 °C extends the dormancy period. Therefore, the optimum storage temperature before irradiation shall be determined for any given variety. Smaller bulbs may require larger doses.

6.2.2.3 As with onions, the absorbed dose required for satisfactory sprout inhibition of garlic is dependent upon the time of irradiation after harvest. Absorbed doses in the range of 20 Gy to 60 Gy, if applied shortly after harvest, are effective. If the garlic is irradiated at later periods after harvest, absorbed doses of 100 Gy to 150 Gy may be needed.

6.2.3 Dose for tubers (potatoes and yams)

6.2.3.1 The optimum absorbed dose for sprout inhibition of potatoes varies with the varieties, time of irradiation after harvest and post irradiation storage temperature. For many varieties a dose of 70 Gy to 100 Gy is effective. However, it is necessary to determine the exact absorbed dose needed for a particular variety. Processing of bulk quantities in large containers will result in considerable wide dose distribution. Attention should be paid to the effects of the resulting maximum dose.

6.2.3.2 Sprout inhibition is secured most effectively by irradiation soon after harvest when the potatoes are dormant. If irradiated after the dormant period, larger absorbed doses may be needed.

6.2.3.3 With some varieties a larger absorbed dose is needed if storage at higher temperatures (e.g. 13 °C) is used. It is necessary to determine the proper absorbed dose for the particular variety and also the intended storage temperature.

6.2.3.4 Yams which are dormant require an absorbed dose of 75 Gy for sprout inhibition. If the yams are in the post-dormancy state, an absorbed dose of 200 Gy may be needed for complete sprout inhibition. Too little irradiation applied at the post-dormancy state results in some sprouting, but such sprouts later die.

6.3 Irradiation conditions

Procedures usually employed for the irradiation of materials at ambient temperatures may be employed. The irradiation area should be ventilated to minimise ozone build-up.

7. Post-irradiation handling and storage

7.1 Bulbs (onions and garlic)

7.1.1 For long-term storage of onions, temperatures near 0 °C and RH's of 65 % to 70 % are optimal. Bulbs irradiated within the dormancy period at absorbed doses of 20 Gy to 70 Gy can be stored at temperatures of 5 °C to 20 °C. Storage of irradiated onions at 0 °C to 3 °C prevent discolouration of inner bud in some varieties, is not considered important for practical purposes. Air movement within storage bins or stacks is needed to remove respiration heat. Onions stored in open mesh bags or in slatted crates or pallet bins also require air circulation. Humidity levels below 50 % cause faster desiccation; levels above 85 % cause rotting. Onions can be stored for up to eight months to nine months at ambient temperature in moderate climatic conditions.

7.1.2 In tropical countries storage at ambient temperatures for four months to five months may be suitable provided the RH is 75 % to 85 %. Adequate ventilation shall be provided.

7.1.3 Garlic can be stored for eight months to nine months, at approximately 0 °C and 80 % to 85 % RH. Storage can be achieved for only one month at temperature between 25 °C to 33 °C . At intermediate temperatures (10 °C to 11 °C) and 85 % to 90 % RH, storage may be achieved for six months to seven months. The losses occur during storage are due to microbial spoilage and desiccation.

7.2 Tubers (potatoes and yams)

7.2.1 Potatoes should be stored in the absence of light in order to prevent production of solanine, a toxic glyco-alkaloid. Since the wound healing process of potatoes is inactivated by irradiation, it is necessary to minimise handling injuries subsequent to irradiation. Such injuries is best minimised by using pallet boxes or bulk containers in which the potatoes can be stored, dried, cured, irradiated and again stored.

7.2.2 Although irradiation inhibits sprouting, it is important to store tubers under controlled temperature conditions to delay the growth of fungi and bacteria.

7.2.3 Potatoes stored to be sold as fresh table-stock may be stored at 3 °C to 5 °C and 90 % RH. Potatoes stored to be used in preparing chips and "French fries" may be stored at 8 °C to 10 °C and 90 % RH. The higher temperature in the latter use is for the purpose of minimising sugar build-up in the potato.

7.2.4 In temperate climates proper storage temperatures may be secured by ventilation with cold outside air. In tropical climates, long-term storage of potatoes at ambient temperatures is not possible. For storage up to 4 months a temperature of 15 °C may be employed. For longer storage periods a temperature of 10 °C or lower is needed.

7.2.5 If possible, potatoes are best cured, irradiated and stored in the same bulk container. This minimises losses due to tuber damage resulting from handling. Air circulation within the container may be needed. Potatoes stored in bulk to heights of 4.5 m require good aeration to prevent rotting.

7.2.6 Yams may be stored for four months to five months at temperatures of 25 °C to 37 °C and at 50 % to 85 % RH, in yam barns. In yam barns a vertical, or nearly vertical, wooden frame-work is used. The yams are tied to this frame-work individually with strings or ropes.

7.2.7 Yams stored at 12 °C or lower undergo physiological breakdown. The optimum conditions for long term storage of yams are at 16 °C and 70 % RH.

8. Labelling

8.1 Foods that have been irradiated shall be labelled and labelling shall be in accordance with the current national legislation requirements.

8.2 Labelling should not only identify the food as irradiated, but also serve to inform the purchaser as to the purpose and benefits of the treatment.

8.3 Each package containing the food treated by ionising radiation may bear on it the international food irradiation symbol given in MS 1265: Part 1.

9. Re-irradiation

Irradiation of the same product more than once is not recommended. Re-irradiation of bulbs and tubers after effective sprout inhibition serves no useful purpose. MS 1265: Part 1 provides provisions for re-irradiation of foods.

10. Quality of irradiated bulb and tuber crops

10.1 General

In general, irradiation at the dose levels required for sprout inhibition of the bulbs and tubers covered in this guideline does not change their texture and their external appearance. However, some changes do occur which may affect the acceptability of these foods. The variety of the particular food plays a very significant role in the occurrence of such changes. This indicates that it may be necessary to limit irradiation to only certain varieties.

10.2 Bulbs

10.2.1 Onions

Irradiation may cause a brownish discolouration or darkening in the inner buds or growth centre. The affected area is a small fraction of the bulb and is located near the basal disc or stem end. The smallest discolouration is found in bulbs irradiated in the deepest state of dormancy. Storage at 0 °C to 3 °C has been shown to prevent discolouration of the inner buds in some varieties. Generally, discolouration of the inner bud does not affect most uses of onions, including the manufacture of dehydrated slices. However, some results contradicting this view have been obtained.

10.2.2 Garlic

The sensory qualities of garlic bulbs are not adversely affected by irradiation. A pale yellow discolouration of the inner sprouts may occur after storage, but this does not affect the acceptability of garlic. Limited information indicates that dehydrated garlic made from stored irradiated bulbs is lighter in colour and more pungent than that made from non-irradiated bulbs.

10.3 Tubers

10.3.1 Potatoes

10.3.1.1 The sugar content of irradiated potatoes, when stored at 14 °C to 15 °C is generally lower than that of non-irradiated potatoes which have to be stored at 2 °C to 4 °C for the same period. Vitamin C, on the other hand generally is not lower in the irradiated potatoes.

10.3.1.2 A sweet taste may be observed soon after irradiation in certain varieties of potatoes. This is due to a temporary increase in sugar content, which may return to a normal level in time. Storage temperature affects this phenomenon. A permanent increase in sugar content can occur on prolonged storage. This makes the potato unsuitable for processing into chips, crisps and “French fries”.

10.3.1.3 In certain varieties a bluish green discolouration occurs in irradiated potatoes when they are boiled or french fried. Generally this occurs after two months to three months of storage. This 'after-cooking' darkening in irradiated potatoes is similar to what occurs in certain varieties of non-irradiated potatoes. The irradiation which induced darkening may be prevented or reduced by any of the methods described as follows:

a) removal of peel prior to boiling in water;

b) adding small amounts of citric acid to the cook water; or

c) holding the potatoes for a few days at 34 °C to 35 °C.

NOTE. Removal of the peel, however, does not reduce the darkening in baked potatoes.

10.3.1.4 After prolonged storage, especially at 10 °C to 15 °C, with certain potato varieties which normally have a yellow or cream colour of the flesh, irradiation may cause the colour to be paler or whiter. Storage of the potatoes a few days at a higher temperature restores the normal colour.

10.3.1.5 In certain varieties of potatoes internal black spot and tissue and vascular browning may occur. Cultural practices and storage conditions affect this phenomenon.

10.3.1.6 Irradiation inhibits light-induced greening, but findings on its effect on light-induced formation of solanine, a toxic glyco-alkaloid, have been contradictory.

10.3.1.7 In general, consumer acceptance of irradiated potatoes, as determined by tests, equals that of non-irradiated or chemically sprout inhibited potatoes, but is favoured in comparison to cold stored potatoes.

10.3.2 Yams

The sensory qualities of yams irradiated with doses up to 150 Gy are unaffected. However, with doses of 200 Gy and higher will cause damage to internal tissue occurs in storage. The irradiation treatment does not significantly alter the starch and sugar levels.

Bibliography

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MS ISO ASTM 51261: 2005, *Guide for selection and calibration of dosimetry systems for radiation*

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Acknowledgements

Dr Muhamad Lebai Juri (Chairman)	Malaysian Institute for Nuclear Technology Research
Puan Seri Azalina Mohd Ghazalli (Secretary)	SIRIM Berhad
Encik Ahmad Hazizi Aziz	Department of Fisheries Malaysia
Dr Maznah Ahmad	Department of Veterinary Services Malaysia
Dr Noraini Mohd Khalid	Malaysian Agricultural Research and Development Institute
Encik Mohd Sidek Othman	Malaysian Institute for Nuclear Technology Research
Puan Shamsinar bt Abdul Talib	Ministry of Health Malaysia
Prof Madya Dr Russly Abdul Rahman	Universiti Putra Malaysia

Printed by: SSP, SIRIM Berhad (001/2005)