EVALUATION OF A DOSE LEVEL INDICATOR TO BE USED FOR BRAZILIAN IRRADIATED FRUITS

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ABSTRACT

Among several applications of food irradiation, its use as an alternative to fumigation of food is gaining increasing recognition and utilization. Irradiation can be used as a single treatment, part of a multiple treatment or combined with other mitigation measures for treatment of plant pests of quarantine significance. The aim of this work was to evaluate Sterin labels indicators to be used for Brazilian irradiated fresh fruits. ^{60}Co-gamma irradiation was performed with doses ranging from 5 to 175Gy (Sterin-125) and from 100 to 500Gy (Sterin-300) using whether a Gammacell 220 or a panoramic irradiator. The devices showed to be suitable for the purpose and the subjective judgment whether the threshold dose was surpassed was possible in a reliable manner.

Key Words: ionizing radiation, dose level indicator, fresh fruit irradiation.

I. INTRODUCTION

Radiation processing is a rapidly developing technology with several applications in the field of food preservation. Among several applications of food irradiation [1], its use as an alternative to fumigation of food is gaining increasing recognition and utilization [2][3]. Major importing countries have shown increasing concerns on imported food and agricultural commodities, which may harbor foreign pests. They have introduced strict measures to prevent entry/establishment of such pests in their countries. In addition, there are increasing concerns among consumers of pesticide residues in food. Fumigation of food and food ingredients for insects control by various chemicals, such as ethylene dibromide (EDB), methyl bromide (MB) and ethylene oxide (ETO), either has been prohibited or is being increasingly restricted in most advanced countries for health, environmental or occupational safety reasons.

Irradiation has been demonstrated as an effective method to replace the fumigants mentioned above [4]. Unlike fumigation, irradiation does not leave any residues in or on the products. Irradiation can be a single treatment, part of a multiple treatment or combined with other mitigation measures for treatment of plant pests of quarantine significance. For reliable disinfestations the insects may survive a radiation treatment and may even be able to fly but must not be capable of proliferation. The necessary radiation dose for fruit fly (tephritidae family) eradication, for example, is about 150Gy. A minimum dose of 300Gy is effective against other species. However, to prevent adult emergence, including the emergence of normal-like, sterile adult insects capable of fly, the generic minimum radiation dose should be about 250Gy for any species of fruit flies. Unlike other competing techniques, irradiation is a broad spectrum quarantine treatment, not specific to insect species or host commodities.

Although for any kind of industrial irradiation, determining the absorbed dose involves a dosimetry system that covers the absorbed-dose range of interest and shall be calibrated before use, the availability of commercial dose level indicators make possible the visual verification of radiation absorbed dose on items under quarantine control.

Sterin labels were designed as new threshold indicators, where a visual message changes after exposure at or above the threshold indication dose (e.g. 125Gy, 300Gy). They were reported to maintain stability under several use conditions [5]. The aim of this work was to evaluate Sterin label indicators to be used in the dose range appropriate to fresh fruit disinfestations.

II. METHODOLOGY

Radiation-Sensitive Indicators. Sterin irradiation indicators are products of the International Specialty Products (ISP) of Wayne, New Jersey, USA. These indicators were designed to provide visual verification of irradiation treatment at 50-500Gy dose levels and can be used as quality devices for irradiation disinfestations. Sterin labels were designed as threshold indicators, where a visual message changes from "NOT IRRADIATED" before exposure to IRRADIATED" after exposure at or above the threshold indication dose (e.g. 125Gy, 300Gy).

Tests of Label Dose Indicators Using a ^{60}Co Gammacell 220 (AECL). The indicators were peeled and removed from the release sheet and attached on wooden supports. In Experiment A dose rate of about 400Gy/h, dose of 5, 10, 50, 70, 125 and 200Gy for Sterin-125 and 5, 10, 50, 200, 300 and 500Gy for Sterin-300 were employed. In Experiment B, another set of doses were used: 50, 100, 125, 150 and 200Gy for Sterin-125 and 100, 200, 300, 400 and 500Gy for Sterin-300, when the dose rate was 8.5 kGy/h.
After irradiation, the sensitive plastics were detached from the label and cleaned with ethyl acetate mixed with ricinus oil to remove adhesive glue. Spectrophotometric measurements were performed using a Pharmacia LKB Novaspec II spectrophotometer. Thickness measurements were performed using a Peacock micrometer and values of 0.5733+/- 0.002mm and 0.370 +/- 0.002 were found.

Tests of Label Dose Indicators Using a ^{60}Co Panoramic Source. Another kind of gamma source, a Panoramic Irradiator from Yoshisawa Kiko Ltd. was also employed, dose rate between 600 and 800 Gy/h. The source itself is a ^{60}Co pencil of about 20cm height and 1.25cm diameter which arise by remote control in the middle of a circular table. The dose distribution was previously mapped by Fricke dosimetry according to standard procedures [6] at established distances from the source. The radiation doses were: 0, 61, 84, 124 and 197Gy for Sterin-125 and 0, 124, 197, 354 and 656Gy for Sterin-300 indicators.

III. RESULTS AND DISCUSSION

Irradiation treatment must be carried out to ensure that the minimum absorbed dose required to assure quarantine security is fully attained throughout the commodity. Dose and dose distribution are determined by product parameters and by source parameters. Product parameters are primarily the density of the food itself and the density of packing in which irradiation take place [7].

In this work, the tests with the dose level indicators were performed using two types of ^{60}Co gamma irradiation sources available at the Institute. Tables 1 and 2 show the results of the irradiation of Sterin labels in a ^{60}Co Gammacell 220 for experiment A (dose rate 400Gy/h) and B (dose rate 8,5kGy/h) respectively. In all the assays, the indicator windows appeared completely dark, because the radiation-sensitive film was opaque covering the word "NOT" displaying the visual message "IRRADIATED", when the irradiation dose was 125Gy and 300Gy for Sterin-125 and Sterin-300 respectively. Nevertheless, they are not precise enough, as even smaller doses than the theoretical thresholds gave also the same indication.

Table 1 – Experiment A. Visual evaluation of Sterin-125 and Sterin-300 indicators irradiated (dose rate: 0.4kGy/h) in a Gammacell220. (-) "NOT" could be seen clearly; (+) "NOT" could hardly be seen; (++)"NOT"was completely covered (2 sets of experiments).

Dose (Gy)	Sterin-125		Sterin-300	
0	-	-	-	-
5	-	-	-	-
10	-	-	-	-
50	+	+	-	-
70	+	+		
125	++	++		
200	++	++	++	++
300	++	++	++	++
500			++	++

Table 2 – Experiment B. Visual evaluation of Sterin-125 and Sterin-300 indicators irradiated (dose rate: 8.5kGy/h) in a Gammacell220. (-) "NOT" could be seen clearly; (+) "NOT" could hardly be seen; (++) "NOT" was completely covered (2 sets of experiments).

Dose (Gy)	Sterin-125		Sterin-300	
0	-	-	-	-
50	+	+		
100	++	++	+	+
125	++	++		
150	++	++		
200	++	++	++	++
300			++	++
400			++	++
500			++	++

Table 3 and 4 present the readings of absorbance at 665nm of detached label indicators as a function of

Table 3. Spectrophotometric measurements at 665nm for Sterin-125 irradiated with different doses of ^{60}Co radiation.

Dose (Gy)	$Absorbance_{665nm}$
0	0.0
5	0.06
10	0.09
30	0.18
50	0.28
80	0.38
100	0.43
125	0.42

Table 4. Spectrophotometric measurements at 665nm for Sterin-300 irradiated with different doses of ^{60}Co radiation.

Dose (Gy)	$Absorbance_{665nm}$
0	0.0
10	0.15
75	0.24
100	0.35
200	0.54
250	0.64
300	0.64

absorbed dose for 125Gy and 300Gy indicators. As can be seen, in both cases, near the threshold for each one of the indicators there is no longer increase in the absorbance with the dose.

Table 5 shows the readings of the two kinds of indicators labels that were irradiated at the panoramic source. Similarly as before, the radiation sensitive films were fully opaque covering the word "NOT" displaying the visual message "IRRADIATED" when the irradiation dose was 125Gy and 300Gy for Sterin-125 and Sterin-300 respectively.

Table 5. Visual evaluation of Sterin-125 and Sterin-300 indicators irradiated in a Panoramic gamma source. (-) "NOT" could be seen clearly; (+) "NOT" could hardly be seen; (++) "NOT" was completely covered (2 sets of experiments).

Dose (Gy)	Sterin-125		Sterin-300	
0	-	-	-	-
61	+	+		
84	++	++		
124	++	++	+	+
197	++	++	++	++
354			++	++
656			++	++

To ensure suitable quality control at food irradiation technologies and for quarantine authorities simple, routine dosimetry methods as well as dose level indicators are needed for absorbed dose control.

From the present results is possible to conclude that the devices are not highly precise but are suitable for the purpose and the subjective judgment whether the threshold dose was surpassed was possible in a reliable manner.

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