Extension of Storage Life of Papayas Grown in Puerto Rico by Gamma Radiation Treatments[1]

Vachira Jiravatana, José Cuevas-Ruiz, and Horace D. Graham[2]

INTRODUCTION

Several methods of food preservation are employed to reduce deterioration in food quality. These include among others, canning, cold storage, freezing, fumigation and drying. However, great losses still occur, particularly in fresh fruits. Huge amounts of food are lost annually because of microbial spoilage, insect infestation and physiological changes. Microorganisms can be destroyed throughout fruit by penetrating ionizing radiation. In this respect, gamma rays from cobalt-60 have shown great potential use in the preservation of fresh fruits (*2,9*).[3]

In preservation of foods by radiation pasteurization, the product is exposed to relatively low doses of ionizing radiation to reduce the number of spoilage microorganisms, retard the ripening process, or other physiological processes such as sprouting in onions and potatoes and therefore extend shelf-life. Post-irradiation refrigeration usually is needed in some cases to achieve fullest benefits.

Puerto Rico produces large quantities of nutritious fruits, vegetables and other foodstuffs. Many of these products, the papaya for example, are relished by many people because of characteristic fresh flavors and aromas. However, microbial decay and physiological breakdown, limit storage life. Conventional methods of preservation result in drastic reduction of fresh flavor and aroma as well as nutritional value. Preservation by radiation, therefore, has potential value for this tropical fruit in commerce.

The literature is replete with information on preservation of fruits and vegetables with radiation (*8,9*). Some reports are available on the use of

[1] The research reported herewith was performed during 1968–69 while the senior author held an International Atomic Energy Fellowship. Present address: Nuclear Center, Srirubsook Road, Bangkhen, Bangkok, Thailand.

[2] Research Associate and Chief Scientist, respectively, Agricultural Bio-Sciences Division, Puerto Rico Nuclear Center, operated by the University of Puerto Rico under Contract No. AT-(40-1)-1833 for the U. S. Atomic Energy Commission. The authors wish to thank Mr. A. J. Rodríguez, Chemical Engineer, Food Technology Laboratory, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico for his kindness in providing papaya fruits for this study. Thanks also are due to Miss Carmen Asencio, Puerto Rico Nuclear Center, for technical assistance.

[3] Italic numbers in parentheses refer to Literature Cited, pp. 318–19.

irradiation in prolonging shelf-life of papayas (*1*). No information is available, however, on the effect of irradiation on papaya varieties grown in Puerto Rico. Extension of storage life of papaya fruit would extend the availability period of this fruit, and a larger fresh fruit papaya market thus would result.

The present research was designed to: 1, Determine the dosage of gamma radiation needed to extend the shelf-life of selected papaya fruits grown in Puerto Rico, and 2, determine the changes which occur in the carbohydrates and the levels of ascorbic acid and carotenoids when such papayas are treated with gamma radiation.

MATERIALS AND METHODS

Papaya fruits (*Carica papaya*) of the variety P. R. 965 in the mature-green stage were used exclusively in these studies. They were picked from the Puerto Rico Agricultural Experiment Station farm and brought to the food science laboratory the day before irradiation. Fruits were selected for soundness, uniformity in size, shape and surface color. Bruised or otherwise defective fruit were excluded. Fruits selected were randomized into five groups of five papayas each. They were irradiated in the Puerto Rico Nuclear Center's cobalt-60 gamma irradiation source at a dose rate of 1.5 Krad/min. The samples were gamma irradiated at 25, 50, 75 and 100 Krads. The irradiated and non-irradiated control fruits were stored in a constant temperature room at 68° F. and 80-percent relative humidity. At appropriate intervals, depending on how the ripening of the papayas progressed, individual fruits were withdrawn and assayed for total carbohydrates, ascorbic acid, total carotenoids and titratable acidity. The carbohydrate content was determined by the anthrone method (*5*). Ascorbic acid was determined by the reduction of 2,6-dichlorobenzenoneindophenol, following the titration method (*4*) described in Methods of Vitamin Assay (*4*); total carotenoids content by the method described in the A.O.A.C. (*6*); and total titratable acidity by titration with standard 0.1N NaOH (*7*). The progress of ripening was noted by daily observation. The sugar to acid ratio determination also served as an index of the progress of ripening.

Shelf-life extension was judged by retardation of ripening as indicated by visual observations and by changes in the sugar to acid ratio of the irradiated fruits during storage. The experiment was replicated 4 times during the course of this study.

RESULTS AND DISCUSSION

Visual and tactual examination of papayas showed a delay in ripening of 7 days in fruits irradiated from 25 to 100 Krads as compared with the

non-irradiated controls (table 1). Maximum extension of shelf-life (measured by delay in ripening) was achieved at the 25 to 50 Krads levels. At the same time, no difference in shelf-life extension was observed in the 75 and 100 Krads treatment after the 12th day of storage. The chemical analyses, especially sugar to acid ratio, confirmed that there was a delay in ripening irradiated fruits (table 2). No difference in ripening delay (visual observation) was noted among the 25 and 50 Krad levels of irradiation. The 100 Krads treatment, however, showed a slight stimulation of ripening on the 12th day of storage, as shown in table 1.

The results obtained on the effect of gamma radiation on the nutrients of papaya fruits are presented in table 2. The content of ascorbic acid was slightly higher in non-irradiated controls than in irradiated fruits. This

TABLE 1.—*Effect of different dosage levels of gamma radiation on ripening of P. R. 965 papayas*

Radiation dose (Krads)	Days in storage			
	5	12	20	27
	Number of papayas ripened (out of 4)			
0	1	2	3	4
25	0	1	2	4
50	0	1	2	4
75	0	1	3	4
100	0	2	3	4

effect might have been due to partial destruction of this vitamin in irradiated fruits. The ascorbic acid content in fruits treated with different levels of radiation, however, were in the same range, although varying slightly, probably due to storage time.

Irradiation *per se* seemed to have little effect on total carotenoid content. As the storage time increased, the total carotenoid content increased. This is consistent with the knowledge that the carotenoid content increases as fruit ripens (*3*).

The total carbohydrate content (expressed as anthrone positive) decreased as the radiation doses increased, because of delay in ripening due to gamma radiation. However, it increased with storage time and as the ripening process of the fruit progressed. This effect was reflected in the acid content of the fruit. The acidity of the fruit decreased as the sugar content increased, thus giving a higher sugar to acid ratio (table 2).

No adverse effects were observed, such as skin discoloration of the fruits, at the levels of radiation used in this experiment (25 to 100 Krads). Both

control and irradiated papayas developed their characteristic yellow color when ripe.

Fungus growth apparently was controlled effectively by even the lowest dose of radiation used in this study. The non-irradiated controls had to be discarded due to fungus proliferation. These results are consistent with findings of other investigators that gamma radiation is an effective method to reduce fungus proliferation in fresh fruit and therefore extend the shelf-life in these commodities (*2*).

TABLE 2.—*Effect of gamma radiation on the ascorbic acid content, total carotenoids, total carbohydrates, titratable acidity and sugar to acid ratio in P.R. 965 papayas*[1]

Radiation dose (Krads)	Days in storage at time of assay	Ascorbic acid mg/100 g.	Total carotenoids μg/g.	Total carbohydrates (percent)	Titratable acidity ml. NaOH/ 100g.	Sugar to acid ratio	Stage of papaya assayed[2]
0	0	35.45	22.60	4.7	0.26	18.1	Mature green
	10	68.66	258.66	7.3	0.22	33.2	Yellowing
	20	64.73	197.66	8.4	0.12	70.0	Ripe
25	0	29.74	13.66	4.1	0.19	22.5	Mature green
	10	50.50	139.66	5.2	0.24	21.1	Yellowing
	20	53.20	164.66	6.5	0.19	42.4	Ripe
50	0	32.95	13.33	3.9	0.22	20.5	Mature green
	10	61.33	183.33	5.7	0.22	27.6	Yellowing
	20	51.00	158.33	6.5	0.22	35.1	Ripe
75	0	32.38	9.00	3.8	0.24	15.9	Mature green
	10	63.06	136.66	5.1	0.22	22.7	Yellowing
	20	59.06	294.00	6.4	0.20	38.2	Ripe
100	0	37.42	11.00	4.0	0.25	18.9	Mature green
	10	66.66	201.33	6.2	0.23	32.0	Yellowing
	20	60.23	204.33	7.2	0.18	42.8	Ripe

[1] Each figure represents mean of 4 replicates.

[2] Visual observation.

SUMMARY

Shelf-life extension (measured as ripening delay) and the retention of nutrients in irradiated P. R. 965 papayas have been investigated at constant storage temperature and relative humidity.

The major findings were:

1. The ripening process in irradiated papayas was delayed up to 7 days by the use of gamma radiation treatments. The maximum delay in ripening was achieved by 25 to 50 Krads treatments, while the 100 Krad treatment showed a slight stimulation of ripening in storage.

2. Some destruction of vitamin C (ascorbic acid) seemed to have been effected by the gamma irradiation, although there were only slight differences between dose levels.

3. The level of total carotenoids was not affected by gamma radiation. During storage, there was a marked increase in these pigments as the papayas ripened.

4. Gamma irradiation inhibited fungal proliferation on papaya fruit even at dosages of 25 Krad.

5. There was no effect observed at the dosages studied on the skin of the fruit which developed its characteristic bright yellow color when ripe.

RESUMEN

La duración en almacén (medida en términos de retardación en la maduración) y la retención de nutrimentos en papayas de la variedad P. R. 965 irradiadas, se estudiaron controlando la temperatura y la humedad relativa.

Los resultados más importantes fueron los siguientes:

1. El proceso de maduración en las papayas irradiadas se demoró hasta un máximo de 7 días como resultado de los tratamientos con radiación gamma. La retardación máxima de la madurez se logró con los tratamientos de 25 a 50 Krads, mientras que a 100 Krads se encontró un ligero estímulo a favor de la maduración en el almacén.

2. Aparentemente, hubo alguna destrucción de la vitamina C (ácido ascórbico) debido a la radiación gamma, a pesar de encontrarse sólo ligeras diferencias entre los diferentes niveles de dosis.

3. El contenido total de carotenoides no fue afectado por la radiación gamma. Durante el almacenamiento, hubo un incremento marcado de estos pigmentos, según las papayas maduraban.

4. Definitivamente, la radiación gamma inhibió la proliferación de hongos en la fruta de papaya, aun sometida a una dosis de 25 Krad.

5. En las dosis estudiadas no se observó efecto alguno en la corteza de las frutas, pues éstas desarrollaron su color amarillo brillante característico de la madurez.

LITERATURE CITED

1. Akamine, E. K., and Wong, Roland T. F., Extending the shelf life of papayas with gamma irradiation, *Hawaii Farm Sci. 15:* 4–6, 1966.
2. Beraha, L., Smith, M. A., and Wright, W. R., Gamma radiation dose-response of some decay pathogens, *Phytopathology 50:* 474–76, 1960.
3. Goodwin, T. W., The Carotenoids, Chemical Publishing Co., New York, N. Y., 1954.
4. Gyorgy, P., Vitamin Methods, Vol. 1, Academic Press, Inc., New York, N. Y., pp. 266–67, 1950.
5. Morris, D. L., The quantitative determination of carbohydrates with Dreywood's anthrone reagent, *Science 107:* 254, 1948.

6. Official Methods of Analyses of the Association of Official Agricultural Chemists, 10th ed., Washington, D. C., 1965.
7. Quantitative Inorganic Analysis, The Macmillan Co., New York, N. Y., 1946.
8. Radiation Preservation of Foods, U. S. Quartermaster Corps, U. S. Government Printing Office, Washington 25, D. C., 1957.
9. Salunkhe, D. K., Gamma radiation effects on fruits and vegetables, *Econ. Bot. 15:* 128-56, 1961.