EFFECTS OF GAMMA IRRADIATION ON BANANA *(Musa sinensis* Sw.*)*

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Abstract

This research deals with the study on the effect of γ-irradiation on shelf-life extension and quality of banana by using Co-60 source. A bunch of mature green banana sample (Thi-hmwe-nget-pyaw) was harvested from Yay Thoe Kone Village (Hlapa Garden),Kangyi Daunt Township, Ayeyarwady Region. This sample was divided into three groups; control (non-irradiated) and irradiated with two doses of gamma radiation (0.25 kGy and 0.35 kGy). Induced radio activities of two types of the γ-irradiated banana were monitored by using NaI (Tl) Scintillation Detector. The shelf-life of each γ-irradiated banana sample was studied by assessing postharvest changes such as colour, ripening at room temperature. Effect of γ-irradiation on nutritional qualities (moisture, ash, protein, fiber, fat, carbohydrates contents and energy value) and trace elements (K, Mg, Ca, Mn and Fe) was studied by AOAC methods and AAS method respectively. Effect of γ-irradiation on some important physicochemical parameters of banana such as vitamin C, total acidity and pH was studied by using iodometric and acid-base titration method and pH meter respectively. From these studies, it was observed that the two types of γ-irradiated samples (0.25 and 0.35 kGy) have no induced activity. The shelf-life of γ-irradiated banana samples (0.25 and 0.35 kGy) ripened within 13 and 15 days at room temperature, respectively. Therefore, the shelf-life of banana was extended 6 to 8 days by γ-irradiation. It was also found that nutritional qualities of banana are not effected by γ-irradiation except a minor decrease in vitamin C content. The results suggest that γ-irradiation can be extended the shelf life of banana without harmful for consumption.

Keywords: banana, γ-irradiation, shelf-life, Co-60, nutritional qualities

Introduction

Banana is one of the most important commercial fruits in the global markets. Most of the exported banana worldwide is from commercial producers in South-East Asia. The banana can be cultivated in tropical and subtropical regions which grow under warm conditions (Hailu, *et al.*, 2013). With around 1000 types of bananas, which can be sub-divided into 50 groups

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of varieties, there really are a great many different bananas in the world. They are eaten raw, or cooked, and there are bananas to satisfy all kinds of tastes and consumers (Fuller and Madella, 2009). The banana is widely cultivated in Myanmar because of its usefulness and being an integral part of Myanmar culture. There are about 150 species in the banana family, and at least 25 species are grown in Myanmar. Bananas and plantains are today grown in every humid tropical region and constitute the fourth largest fruit crop of the world, following the grape, citrus fruits and the apple. Banana is unique due to its high calories and nutritive values. Furthermore, banana is a very digestible fruit. However, banana being a fragile, perishable fruit, short shelf life, so it cannot be preserved for longer time after harvesting. Food irradiation is a promising new food safety technology that can destroy or inactivate organisms that cause spoilage, thereby extending the shelf life of foods. World Health Organization (WHO) has been expressed the approval in principle of irradiated fruits up to 1.0 kGy for delaying ripening. The foods are not changed in nutritional value and they do not become dangerous as a result of irradiation (FDA, 1997). Other benefits of food irradiation include extending shelf life of certain food, and controlling insect infection in grain products, fruits and vegetables. The food irradiation process uses three types of ionizing radiation sources (cobalt-60 gamma source, electron beam generator, x-ray accelerator). The radiation dose, the quantity of radiation energy absorbed by the food, is the most critical factor in food irradiation. Often, for each different kind of food, a specific dose has to be delivered to achieve a desired result. If the amount of radiation delivered is less than the appropriate dose, the intended effect may not be achieved. Conversely, if the dose is excessive, the food product may be so damaged as to be rendered unacceptable (WHO, 1988).The effects of irradiation on food vary very much depending on the type of food and on the dosage level. Not all fresh produce is suitable for irradiation (IAEA, 2003). Therefore, this research work was studied to explore shelf life extension of banana by using food irradiation technique. For this purpose, a bunch of mature green banana sample was harvested from Yay Thoe Kone Village (Hlapa Garden), Kangyi Daunt Township, Ayeyarwady Region. This sample was irradiated with different doses of (0.25 and 0.35 kGy) γ-radiation. Then, the shelf life and quality

(nutritional values, elemental contents, vitamin C, total acidity and pH) of each irradiated samples were studied.

Materials and Methods

Firstly, a bunch of mature green banana was harvested from Yay ThoeKone Village (Hlapa Garden), Kangyi Daunt Township, Ayeyarwady Region. Then, this sample was transported to the Department of Atomic Energy, Ministry of Education for irradiation. The period between the harvesting and irradiation was approximately 7 hours. This sample was divided into three groups. Each group contains twenty bananas. First and second groups were placed in polyethylene bag and treated with 0.25 kGy and 0.35 kGy dose of gamma radiation respectively from Co-60 source (Co-60 gamma chamber 5000) which has dose rate of 1.59 kGy/h. Third group involved non-irradiated bananas (0 kGy)was used as comparative study.

For study on safety consumption of γ-irradiated samples (BG 0.35, BG 0.25) and non-irradiated (BG 0), the induced activity was monitored by NaI (Tl) Scintillation Detector (LUDLUM MODEL 730) at Nuclear Chemistry Laboratory, University of Yangon at day 1.

For study on postharvest storage time, the shelf-life of two types of γ-irradiated (BG 0.35, BG 0.25) and non-irradiated (BG 0) samples was studied by assessing postharvest changes (colour and ripening) at room temperature.

For study on nutritional qualities, the contents of moisture, ash, protein, fiber and fat in these γ-irradiated(BG 0.35, BG 0.25) and non-irradiated (BG 0) samples were determined by air oven method, muffle furnace method, Kjeldahl distillation method, fiber cap method and Soxhlet extraction method respectively at day 7. The carbohydrate contents and energy value in these samples were calculated by using formula. The elemental contents (K, Mg, Ca, Mn and Fe) of samples (BG 0.35, BG 0.25, BG 0) were determined by using atomic absorption spectrophotometer (Perkin Elmer Analyst 800) at day 7.

Study on the ripening stage during storage, contents of vitamin C, total acidity and pH of γ-irradiated banana samples were determined by iodometric and acid-base titration method and pH meter at day 7.

Results and Discussion

Safety Consumption of the γ-Irradiated Mature Green Bananas at Day 1

Although gamma radiation used by Co-60 source is not strong enough to decay the nucleus of even one atom of a food molecule, the induced radioactivity of each irradiated sample was monitored for safety consumption at day 1. This monitoring indicated that all of the γ-irradiated samples have no distinct activity above the background activity and no induced activity was observed (Table 1). Thus, the γ-irradiated banana can be handled, stored and consumed safely.

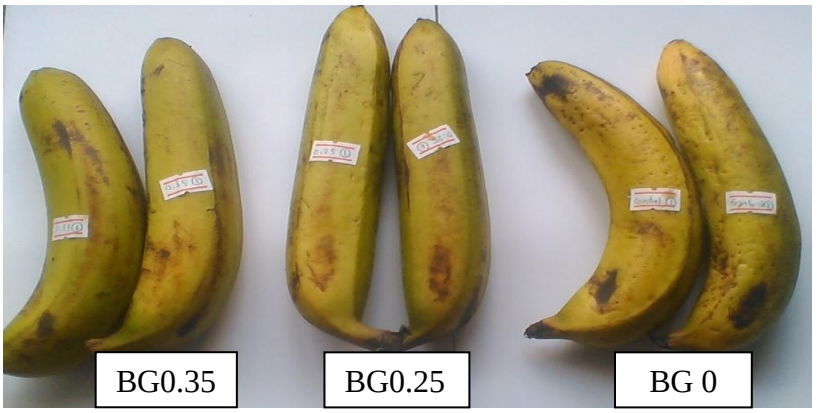
Table 1: Monitoring of Induced Activity in the γ -Irradiated Bananas at Day 1

No.	Samples	Induced activity relative to background (±%) (cp 300s)
1	BG 0	3.20
2	BG 0.25	2.61
3	BG 0.35	3.45

± = due to fluctuation Note: activity no distinct above background
BG 0 = Gamma dose of 0 kGy of banana
BG 0.25 = Gamma dose of 0.25 kGy of banana
BG 0.35 = Gamma dose of 0.35 kGy of banana

Effect of Gamma Irradiation on Shelf-life of Postharvest Mature Green Bananas

From this study (Table 2), it was found that the shelf-life of non-irradiated banana ripened within 7 days whereas the 0.25 and 0.35 kGy dose of γ-irradiated bananas ripened within 13 and 15 days at room temperature under same condition. Therefore, the shelf-life of banana was extended 6 to 8 days by γ-irradiation. Thus, gamma radiation treatment delayed ripening of banana. It can be seen in Figure 1.



(a) (b) (c)

Figure 1: Observation of the change of the γ-irradiated and non-irradiated mature green bananas of different doses during storage at day 4
(a) 0.35 kGy dose (b) 0.25 kGy dose (c) 0 kGy

Table 2: Shelf-Life of γ-Irradiated and Non-irradiated Mature Green Banana Samples at Room Temperature

Storage period (days)	Banana ripening (%)		
	BG 0	BG 0.25	BG 0.35
1	0	0	0
3	0	0	0
5	23.08	0	0
7	100	18.75	0
9	ND	37.50	0
11	ND	50	50
13	ND	100	50
15	ND	ND	100

ND = not detected as samples were spoiled
BG 0 = Gamma dose of 0 kGy of banana
BG 0.25 = Gamma dose of 0.25 kGy of banana
BG 0.35 = Gamma dose of 0.35 kGy of banana

Effect of Gamma Irradiation on some Elemental Contents of Postharvest Mature Green Bananas by AAS at Day 7

From this study (Table 3), it was found that elemental contents (K, Ca, Mg, Mn, Fe) in the two types of γ- irradiated mature green banana samples (BG 0.25 and BG 0.35) were not different significantly from those of non-irradiated sample (BG 0) at day 7. Thus, it can be inferred that 0.25 kGy and 0.35 kGy doses of gamma irradiation have no detrimental effect on elemental contents of banana.

Table 3: Some Elemental Contents in γ-Irradiated and Non-irradiated Mature Green Bananas by AAS at Day 7

No.	Samples	Elemental content (%)				
		K	Ca	Mg	Mn	Fe
1	BG 0	0.062	0.007	0.027	0.002	0.006
2	BG 0.25	0.074	0.006	0.032	0.002	0.005
3	BG 0.35	0.063	0.007	0.023	0.002	0.004

BG 0 = Gamma dose of 0 kGy of banana
BG 0.25 = Gamma dose of 0.25 kGy of banana
BG 0.35 = Gamma dose of 0.35 kGy of banana

Effect of Gamma Irradiation on some Nutritional Values of Postharvest Mature Green Bananas at Day 7

From study the nutritional values of two types of γ-irradiated and non-irradiated samples at day 7 (Table 4), it was found that moisture contents of two types of γ-irradiated samples (BG 0.25 and BG 0.35) were lower (8.35% and 9.70%) than that of control (BG 0) (12.03%). This is due to the absorption of energy when gamma ray passes through the banana. The carbohydrate contents of these γ-irradiated samples (BG 0.25 and BG 0.35) were higher (84.31% and 82.61%) than that of control (80.68%). In the case of 0.35 kGy dose, ash content was higher (3.35%) and fiber content of this sample (BG 0.35) was lower (0.75%) than that of control (2.84% ash and 0.90% fiber). In the case of 0.25 kGy dose, ash and protein contents of this sample (BG 0.25) (2.81% and 3.46%) were not different from that of control(2.84% and 3.43%) .However, fiber content of this sample was higher(0.96%) and fat content of this sample was lower (0.11%) than that of control (0.90% fiber

and 0.12% fat). Therefore, γ-irradiated samples do not badly suffer on macronutrients (proteins, fats, carbohydrates) within banana and energy value increase due to higher carbohydrates. Thus, gamma irradiation does not significantly change in nutritional value of banana. According to the nutritional point of view, 0.25 kGy dose of gamma irradiation is more effective due to higher fiber, carbohydrates and energy value and lower fat content of banana than that of control.

Table 4: Nutritional Values of γ-Irradiated and Non-irradiated Mature Green Bananas at Day 7

No.	Nutritional parameters	*Nutritional values (%) of different samples (based on dry weight)*		
		BG 0	**BG 0.25**	**BG 0.35**
1	Moisture	12.03	8.35	9.70
2	Ash	2.84	2.81	3.35
3	Protein	3.43	3.46	3.46
4	Fiber	0.90	0.96	0.75
5	Fat	0.12	0.11	0.13
6	Carbohydrate	80.68	84.31	82.61
7	Energy Value (kcal/100g)	337	349	345

BG 0 = Gamma dose of 0 kGy of banana
BG 0.25 = Gamma dose of 0.25 kGy of banana
BG 0.35 = Gamma dose of 0.35 kGy of banana

Effect of Gamma Irradiation on some Physicochemical Parameters of Mature Green Bananas at Day 7

According to the literature, vitamin C, total acidity and pH are physiological parameters of ripening banana (Zaman, *et al*., 2007). From this study at day 7, (Table 5), it was found that vitamin C contents of two types of γ-irradiated banana samples (BG 0.25 and BG 0.35) were lower (31.68 and 26.40 mg/100 mL) than that of control (BG 0) (33.79 mg/ mL) but not enough to results for vitamin C deficiency. It was also found that higher the dose, more reduce the light sensitive vitamin C. It was found that total acidity contents of these samples (BG 0.25 and BG 0.35) (1.7 % and 1.4 %) were increased, thus pH values of these samples (BG 0.25 and BG 0.35) (4.1 and 4.5) were decreased compared to that of the control (1.0% total acidity and

5.5 of pH) . According to the literature, the amount of organic acid in fruits decreases as a result of their consumption in the process of respiration or changed into sugars at ripening (Marriot,1980). That is why, total acidity contents of two types of γ-irradiated banana samples were higher than that of control at day 7. Because these γ-irradiated banana samples were delayed ripening time due to the effect of gamma irradiation.

Table 5: Some Important Physicochemical Parameters of γ-Iirradiated Mature Green Banana Samples at Day 7

No.	Physiochemical parameters	Values of parameters in different samples (base on dry weight)		
		BG 0	**BG 0.25**	**BG 0.35**
1	Vitamin C (mg/100 mL)	33.79	31.68	26.40
2	Total acidity (%)	1.0	1.7	1.4
3	pH	5.5	4.1	4.5

Conclusion

In this work, effects of gamma irradiation on mature green banana samples were studied by treatment with 0.25 and 0.35 kGy doses of Co-60 gamma source. From overall results, all of the γ-irradiated mature green bananas have no induced activity. The nutritional qualities in γ-irradiated banana samples are essentially unchanged. The shelf-life of γ-irradiated banana samples can be extended 6 to 8 days at room temperature. All γ-irradiated banana samples occurred less spotting during the storage period. This benefit can be achieved to distribute as fresh product without harmful effect on consumption.

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