Nigerian Journal of Physics (NJP)
ISSN online: 3027-0936
ISSN print: 1595-0611
DOI: https://doi.org/10.62292/njp.v34i4.2025.381
Volume 34(4), December 2025

Effect of Gamma Irradiation on Shelf-Life and Quality of *Musa paradisiaca and Musa acuminata* Locally grown in Benue State Nigeria

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ABSTRACT

Banana (Musa Spp.) is a unique fruit due to its high calories and nutritive value. Being a good source of carbohydrate, minerals and vitamins, it leads all other fruits in food value. However, banana is being fragile, perishable fruit and cannot be preserved for longer time after harvesting. As a result, significant portion of the fruits harvested are lost every year due to shorter postharvest life. This research investigated the effect of Co-60 gamma irradiation on shelf life and Quality of two banana species (*Musa paradisiacal and Musa accuminata AAA group)* locally grown in Benue State, Nigeria. Banana fruits were irradiated at doses of 100*Gy*, 200*Gy* and 300*Gy* and stored at room temperature for shelf-life study. Proximate analysis was done when the fruits have fully ripened. For plantain, 100*Gy* dose extended the shelf life by 2-days, 200*Gy* extended the shelf life by 5-days while 300*Gy* dose extended the shelf life by 7-days. For Cavendish banana, 100*Gy* extended the shelf life by 3-days, 200*Gy* dose extended the shelf life by 5-days while 300*Gy* extended the shelf life by 6-days. Irradiated samples proximate composition was compared to the controls. For plantain, 100*Gy* dose had significant effect on Ash and pH composition, 200*Gy* had no significant effect on proximate composition while 300*Gy* dose affected the protein composition. For Cavendish banana, 100*Gy* dose impacted on Ash, Crude Fibre and Carbohydrates. 200*Gy* dose affected Ash and Crude Fibre while 300*Gy* dose showed no significant effect. Comparing the effect of irradiation on shelf life and proximate composition, the optimal dose of gamma irradiation for Plantain and Cavendish banana were found to be 200*Gy* and 300*Gy* respectively for shelf-life extension without statistically affecting the samples proximate composition.

Keywords:
Banana,
Dose,
Irradiation,
Proximate,
Shelf life.

INTRODUCTION

Musa species commonly known as banana and plantain are giant humid tropical and subtropical giant perennial herbs of the Eumusa section, Order Zingiberales, family Musaceae and genus Musa (Christenhusz and Byng, 2016). Banana and plantain are highly valued commodity due to their social, cultural and economic importance. In 2013, banana ranked 4th among the main world fruit crops in financial values (Holmes, 2013). Bananas are used in many aspects of human life. Bananas are used as food, fibres and ornamentals. The leaves, fruit and stems are used in herbal medicine for treating ailments such as dysentery, diarrhoea and digestive disorders (Morton, 1987). Rubbing of banana peels on mosquito bites has a good effect of stopping the stinging sensations (Morton, 1987). It is a unique fruit due to its high calories and nutritive value. Being a good source of carbohydrates, minerals and vitamins it leads all other fruits in food value (Qaiser e*t al.,* 2017). Banana is an essential source of instant energy that can be considered an ideal supply of potassium intake (Al-Dairi *et al*., 2021). Banana is consumed fresh or processed into several products at small or industrial scales, like a chip, dried fruit, bread, ice cream, smoothe, flour, and as an ingredient for functional food. Due to their nutritive elements, processed bananas can be used as an excellent food for babies and as a snack food, particularly, when it is mixed with some legumes-based product (Debabandya *et al*., 2010). However, the bananas are perishable that metabolically active, undergoing ripening and

senescence processes that must be controlled to delay ripening (Mahajan *et al*., 2014). The fresh banana produce is potentially contaminated by microbes and pathogens during cultivation, harvesting, transporting, packaging, storage and selling to the consumers which manifests a severe risk in food safety and decreases the shelf life of bananas (Abdullah *et al*., 2017). Therefore, it cannot be preserved for a long time after harvesting which contributes to the limitation in exporting bananas (Abdullah *et al*., 2017).

Since there is an increasing demand for fresh and nutritious food products with high organoleptic attributes, improved safety and prolonged shelf life, various non-thermal processes like high hydrostatic pressure, pulsed electrical field, and irradiation technologies have been investigated (Junqueira *et al.,* 2011). Food irradiation can provide a promising alternative treatment to increase the shelf life of banana as it is better in terms of cost, efficacy and resulting negative impact compared to the other technologies. Gamma radiations have proved to be more effective than an x-ray, as it is non-thermal technology, legal, low cost, maintaining freshness, quality, nutrition and leaves no harmful residue (Handayani & Permawati, 2017). The advantages of gamma irradiation compared to the other methods is it provides more efficient and homogenous penetration power in the tissue, short radiation time and does not increase the fruit temperature (Abdullah *et al*., 2017). It can increase the shelf life of a banana by eliminating pathogenic bacteria, disinfect fresh fruits and vegetables as a postharvest quarantine treatment and reduce or eliminate micro organisms (Abdullah *et al*., 2017). This study aims to investigate the application of gamma irradiation as the preservation method and its effect on shelf life and quality of two banana species locally grown in Benue State, Nigeria.

MATERIALS AND METHODS

The materials used for this research are: Cobalt – 60 gamma Irradiator, Oven, Desiccators, Crucibles, Muffle furnance, Weighing balance, pH meter, Refractometer, Burette, Pipette, Sodium hydroxide, Hydrochloric acid, Suphuric acid, Petri dish, Sample holder and Round bottom flask.

Sample Preparation and Irradiation

Freshly banana fruits (Plantain and Cavendish) were harvested from banana Orchard located in Ohimini local Government Area of Benue State. After proper selection was done, the fruits were taken to the Ahmadu Bello University Centre for Energy Research and Training (CERT) Zaria and exposed to 100 Gy, 200 Gy and 300 Gy of gamma irradiation using cobalt - 60 as a source at the dose rate of 1.5 Gy/hr.

Determination of Proximate Composition of Samples

Official methods of AOAC manual (2005) were used for proximate analysis of irradiated and non-irradiated samples.

Percentage of moisture was calculated by:

M.C (%) = $(W_w-W_d)/W_w) \times 100$

W_w is the weight of moisture sample

W_d is the weight of demoisture sample

To determine the ash content, sample was first ignited and then placed in Muffle furnace at 500 °C–550 °C temperature for 4 to 6 hrs till the sample become ash. Weight of ash was calculated by:

Weight of ash = weight of crucible + ash – weight of crucible

% of ash was calculated as:

Ash (%) = wt. of ash (g)/wt. of sample × 100

For the determination of crude fat, Soxhlet apparatus was used. In a Soxhlet apparatus the extraction was carried out for 6 hrs with 500 ml of ethanol.

Loss of weight was being calculated as:

Loss in weight = wt. of thimbles + demoisture sample – (weight of thimbles – fat free sample)

Fat (%) = loss in weight (g)/wt. of sample × 100

% of fibre was calculated by:

Fibre (%) = wt. of sample (g) - loss in weight (g)/wt. of sample × 100

Kjeldahl method was used for estimation of protein content and carbohydrate content was determined by the differential method.

Carbohydrate (%) =100 - (% Moisture + % Ash + % Fat+ % Crude protein + % Crude fiber)

Ascorbic acid content was determined as per standard AOAC method using 2, 6-dichlorophenol indophenols dye.

$$\text{Ascorbic acid (mg/100g)} = \frac{T \times D.F \times V}{A \times W} \times 100$$

*Dye factor = 0.5/T.V

Where T is the Titre Value

D.F is the Die Factor

V is the Volume made up

A is the Aliquot of extract taken

W is the Weight of sample taken

For determination of total soluble solid, titratable acidity, and pH for non – irradiated and irradiated (100 Gy, 200 Gy, and 300 Gy) samples, total soluble solid (TSS) content were determined by a digital refractometer, pH of the samples was calculated by a digital pH meter, and titratable acidity was calculated by titrating 10 ml of clear juice of banana samples diluted in 100 ml of deionise water against 0.1 N NaOH solution at pH 8.1 (AOAC, 1995). All evaluations were carried out three times and expressed as percentage.

Determination of Shelf Life

Shelf life of fruits was calculated from daily estimation of disease severity on the same fruits from each replication and considered as ended when the fruits had little or no commercial viability (disease severity more than 25%) as estimated by Rashid et al. (2015).

Statistical analysis

The quality composition of banana samples were determined in triplicate and the mean value were evaluated ± the standard error. Data obtained from the quality composition were subjected to analysis of variance (ANOVA) using SPSS 23. The significance level was set at 0.05.

RESULTS AND DISCUSSION

Table 1: Percentage Quality Composition of Plantain

Quality parameters	Control 0*Gy*	Dose 100*Gy*	Dose 200*Gy*	Dose 300*Gy*
Moisture	61.93±1.963	59.146±1.905	57.391±1.8	57.033±1.207
Fibre	0.805±0.068	0.881±0.012	0.800±0.028	0.958±0.031
Protein	3.837±0.23	3.576±0.175	4.401±0.104	4.761±0.219
Oil	0.861±0.017	0.872±0.007	0.866±0.009	0.894±0.006
Ash	1.982±0.033	1.025±0.091	1.753±0.151	1.939±0.089
Carbohydrate	30.593±1.847	34.501±1.762	34.789±1.859	33.044±0.895
pH	4.317±0.017	3.500±0.258	4.127±0.19	4.17± 0.139
Acid	0.177±0.015	0.19±0.010	0.173±0.009	0.157±0.007
TSS	16.653±0.308	17.13±0.513	15.667±0.403	16.527±0.504
AS	0.063±0.024	0.067±0.011	0.06±0.006	0.063±0.013

Table 2: Percentage Quality Composition of Cavendish Banana

Quality Parameters	Control 0 *Gy*	Dose 100 *Gy*	Dose 200 *Gy*	Dose 300 *Gy*
Moisture	72.95 ± 0.56	76.3 ± 1.002	71.74 ±0.52	72.71 ± 0.056
Ash	0.95 ± 0.015	2.33 ± 0.566	3.03 ± 0.003	0.64 ± 0.035
Fibre	0.572 ± 0.058	0.919 ± 0.006	0.143 ± 0.006	0.512 ± 0.006
Protein	3.293 ± 0.583	3.5 ± 0.491	3.124 ± 0.006	3.971 ± 0.572
Oil	0.862 ± 0.058	0.882 ± 0.006	0.851 ± 0.064	0.885 ± 0.005
Carbohydrates	21.374 ± 0.52	16.070 ± 0.94	21.112 ± 0.949	21.283 ± 0.058
pH	5.661 ± 0.052	6 ± 0.577	5.371 ± 0.104	5.27 ± 0.514
Acid	0.175 ± 0.005	0.185 ± 0.051	0.174 ± 0.006	0.15 ± 0.052
TSS	16.810 ± 0.577	16.901 ± 0.578	16.695 ± 0.096	16.473 ± 0.047
AA	0.064 ± 0.001	0.068 ± 0.001	0.0614 ± 0.001	0.0635 ± 0.002

Effect of Gamma Irradiation on Quality composition of plantain

Table 3: Levene's Test of Homogeneity for Plantain Quality Composition at 0.05 level of significance

	Test of Homogeneity of Variances			
	Levene Statistic	df1	df2	Sig.
Moisture	0.346	3	8	0.793
Ash	0.994	3	8	0.443
Crude_fibre	3.754	3	8	0.060
Protein	0.633	3	8	0.614
Oil	1.407	3	8	0.310
Carbohydrate	0.491	3	8	0.698
pH	3.635	3	8	0.064
Acid	1.082	3	8	0.410
TSS	0.969	3	8	0.453
AA	2.307	3	8	0.153

Levene's Test for Homogeneity of Variance for Plantain was conducted and the result was recorded in Table 3. All P values (Sig.) are greater than 0.05 which shows that there is homogenous variation in all aspects of the quality composition. Hence, ANOVA test was used to determine if the variations across the aspects of the quality compositions is significant or not.

From ANOVA test, analysis revealed that Sig (moisture = 0.256, crude fibre = 0.072, oil = 0.206, carbohydrates = 0.321, acid = 0.185, TSS = 0.164 and AA = 0.258) > 0.05, variation between irradiated groups and the control not significant. However, Sig (ash = 0.000, protein = 0.008, and pH = 0.044) < 0.05, irradiated groups varied significantly as compared to the control.

Turkey's HSD posthoc test was used determine the aspects that varies in relation to control. Analysis revealed that ash and pH composition in the 100 Gy irradiated sample varied significantly from the control. However, the variation was insignificant in the 200 Gy and 300 Gy irradiated samples. The protein content in 300 Gy irradiated sample varied significantly from the control while the 200 Gy and 100 Gy samples showed no significant.

Table 4: Summary of Significance of Variation in Mean quality Composition of Plantain

Proximate Composition	Dose 100	Dose 200	Dose 300
Moisture	NS	NS	NS
Ash	Sig	NS	NS
Crude Fibre	NS	NS	NS
Protein	NS	NS	Sig
Oil	NS	NS	NS
Carbohydrate	NS	NS	NS
pH	Sig	NS	NS
Acid	NS	NS	NS
TSS	NS	NS	NS
AA	NS	NS	NS

Key: NS = Not Significant
Sig = Significant

Effect of Gamma Irradiation on Quality Composition of Cavendish Banana

Table 5: Levene's Test of Homogeneity for Cavendish Banana Quality Composition at 0.05 level Significance

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Moisture	3.488	3	8	0.070
Ash	3.938	3	8	0.054
Crude_fibre	3.146	3	8	0.087
Protein	1.329	3	8	0.331
Oil	2.179	3	8	0.168
Carbohydrate	1.075	3	8	0.413
pH	2.120	3	8	0.176
Acid	2.079	3	8	0.181
TSS	2.168	3	8	0.170
AA	1.872	3	8	0.213

Levene's Test of homogeneity of variance was conducted for the quality composition of Cavendish banana. The result is presented in Table 5. All aspects of the quality compositions varied homogenously (Sig>0.05). Hence the ANOVA test was carried out to assess the significance of variation in the quality compositions of the irradiated samples and the control.

Moisture (Sig = 0.052), protein (Sig = 0.638), oil (Sig = 0.935), pH (Sig = 0.572), acid (Sig = 0.919), TSS (Sig =0.889), and AA (Sig = 0.27) Sig > 0.05, had no significant difference in variation between the control and irradiated samples while ash (Sig = 0.001), crude fibre (Sig = 0.000), and carbohydrate (Sig =0.000) Sig < 0.05 varied significantly. Turkey HSD test was used to determine the irradiation groups with significant variation of ash, crude fibre and carbohydrates from the control.

Ash and crude fibre content in the 100 Gy and 200 Gy samples varied significantly from the control while the 300 Gy sample variation was insignificant. The carbohydrates content in the 100 Gy dose varied significantly from the control while the 200 Gy and 300 Gy samples had no significant variation.

Table 6: Summary of significance of Variation in Mean Quality Composition of Cavendish banana

Proximate Composition	Dose 100 Gy	Dose 200 Gy	Dose 300
Moisture	NS	NS	NS
Ash	Sig	Sig	NS
Crude Fibre	Sig	Sig	NS
Protein	NS	NS	NS
Oil	NS	NS	NS
Carbohydrate	Sig	NS	NS
pH	NS	NS	NS
Acid	NS	NS	NS
TSS	NS	NS	NS
AA	NS	NS	NS

Key: NS = Not Significant
Sig = Significant

Effect of gamma irradiation on the Shelf Life of plantain

The maximum shelf life of 27 days was observed for plantain exposed to 300*Gy* dose, followed by 25 days which was observed for plantain exposed to 200*Gy*, followed by 22 days which was observed for plantain exposed to 100*Gy* dose and the minimum shelf life of 20 days was observed for the control (non-irradiated). Hence, the shelf life was extended by 2, 5 and 7 days respectively. The higher shelf life in the irradiated Plantain samples might be due to delayed ripening as a result of inhibition of enzymatic activities, reducing respiration and ethylene production. Same findings were noted by Zaman *et al*., (2007) in banana and Adeniyi (2021), In Plantain.

Table 7: Observed Shelf Life for Plantain

S/No	Dose (Gy)	Shelf Life (Days)	Extended Shelf Life (Days)
1	0	20	
2	100	22	2
3	200	25	5
4	300	27	7

Effect of gamma irradiation on the Shelf Life of Cavendish banana

The maximum shelf life of 22 days was observed for Cavendish banana exposed to 300 *Gy* of gamma irradiation, followed by 21 days which was observed for 200 *Gy* dose, followed by 19 days which was observed for 100 *Gy* dose and the minimum of 16 days which was observed for the control (non - irradiated). Hence, the shelf life was extended by 3, 5 and 6 days respectively. The higher shelf life in irradiated fruits might be due to delayed ripening as a result of inhibition of enzymatic activities, reducing respiration and ethylene production. Same findings were noted by Moreno *et al*. (2006) and Dhaker *et al*. (1966) in mango; Zaman*et al*. (2007) in banana; Sing *et al*. (2008) in guava, and Adeniyi (2021) In Plantain.

Table 8: Observed Shelf Life for Cavendish banana

S/No	Dose (Gy)	Shelf Life (Days)	Extended Shelf Life (Days)
1	0	16	
2	100	19	3
3	200	21	5
4	300	22	6

CONCLUSION

In this study, Gamma radiation from Co-60 source was successfully used to extend the shelf life of Plantain and Cavendish Banana. The effect of gamma irradiation on shelf life and quality composition of the fruits were found to be dose dependent. The optimal gamma irradiation dose for shelf-life extension were found to be 200 *Gy* for Plantain and 300 *Gy* for Cavendish Banana. These doses extended the shelf life of Plantain and Cavendish banana by 5 and 6 days respectively without significantly affecting the quality composition of these fruits.

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