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Shelf Life and Proximate Analysis of Gamma Irradiated Tomatoes (Lycopersicon Esculentum) Locally Grown in Benue State, Nigeria

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ABSTRACT

In order to address the postharvest losses associated with the production of tomatoes locally grown in Gboko local Government Area of Benue state,the effect of Gamma irradiation on the shelf life and proximate composition of gamma irradiated Lycopersicon esculentum tomatoes locally grown in Gboko local Government Area of Benue State was investigated using the following gamma irradiation doses: 0.25 kGy, 0.50 kGy, 1.00 kGy and 2.00 kGy respectively from Gamma Irradiator (GS 1000) located at Nuclear Technology Centre, Abuja. The analysis of the investigation revealed that the dose range of 0.50 kGy to 1.00 kGy is effective for extension of shelf life of Lycopersicon esculentum tomatoes by 9 to 10 days respectively. Kjedal and iodometric methods were employed to determine the carbohydrate, crude fibre, ascorbic acid, moisture content, percentage ash, percentage protein and fat contents of non-irradiated and irradiated tomatoes. Results of the analysis revealed that the mentioned parameters decreased with increasing gamma irradiation doses except carbohydrate which increased with increasing gamma irradiation doses. The dose range of 0.5 kGy to 1.00 kGy is recommended for the extension of shelf life of Lycopersicon esculentum tomatoes locally grown in Benue State.

Keywords:
Shelf life,
Food irradiation,
Gamma rays,
Ionization,
Free radicals.

INTRODUCTION

Tomatoes constitute an excellent food for those who want to adopt a natural diet. They present in their composition a series of elements very appropriate to detoxify the organism and to prevent the appearance of many illnesses. Tomatoes rank 16th among all fruits and vegetables as a source of vitamin A; 13th in vitamin C and contain significant amount of Lycopene, magnesium, niacin, potassium and calcium (Durrant, 2001). Lycopene found in tomatoes is being studied as a potent carotenoid, a molecule which protects people against cancer causing-free radicals.

The abundance of fruits like tomatoes, oranges, mangoes, pears, pepper, etc.; vegetables and tubers has earned Benue State the title "Food Basket of the Nation". Regrettably, due to poor storage and lack of effective preservation techniques, farmers loss most of their profit due to decay and poor post-harvest handling of their farm produce. Some commonly used methods of food preservation include; heat treatment, modified atmosphere, chemical treatment, cold treatment and food irradiation (either high-energy electrons or x-rays from accelerators or by gamma rays emitted from radioactive sources such as cobalt-60 or caesium-137), but the most versatile treatment amongst them is food irradiation method (Farkas, 1998 and Dhall, 2013). Ultraviolet radiation, x-rays, and microwave heating have been utilized for treatment of fruits and vegetables with varying results (Agba et al., 2023; Akaagerger et al., 2024; Lawal et al., 2023). Radiation treatment has a range of effects such as killing bacteria, molds and insect pests reducing the ripening and spoilage of fruits and at higher doses induces sterility in food-borne pathogens (Kader, 1986; Asli *et al.*, 2012).

During ionization resulting from treating foods with ionizing energy, free radicals are produced. These free radicals react with various food constituents and may cause injury to the cells. Since fresh fruits contain 80 – 90% of water and their intercellular spaces (about 20% of total volume) contain oxygen, the most common free radicals are those of water and oxygen. Consequently, treating fresh fruits with ionizing energy in nitrogen atmosphere can reduce the quantity of free radicals and possible injuries to the fruits (Kader, 1986; Prakash *et al.*, 2000; Abo *et al.*, 2016). This paper seeks to investigate the effect of gamma irradiation on ripening, shelf life and

the possible changes in the nutritional value of the gamma irradiated foods using *lycopersicum esculentum* tomato fruits locally grown in Benue State, Nigeria.

MATERIALS AND METHODS

Materials

Fresh *lycopersicum esculentum* tomatoes fruits were obtained from experimental farm in Makurdi town, Benue State. The tomatoes samples were packed in five (5) different baskets and subjected to gamma irradiation at different doses of 0.25 kGy, 0.50 kGy, 1.00 kGy, 1.50 kGy and 2.00 kGy respectively, using gamma irradiation facility at Nuclear Technology Centre, Abuja. Chemical analysis for determination of Carbohydrate, Crude Fibre, Ascorbic acid, Moisture content Percentage Ash, Percentage Protein and Fats was carried out using the following methods and apparatus; kjeldahl procedure, Tilman Hirsch method, incinerator, Soxhlet apparatus, Hexane, Sodium Hydroxide, and Sulphuric acid.

Chemical Analysis

Determination of Crude Protein

Protein content was determined using kjeldahl method, according to the procedure of Association of Official Analytical Chemists (AOAC). Concentrated H_2SO_4 (12 ml) and two tablets of selenium catalyst were dropped into a kjeldahl digestion flask containing one 1 g of the sample. The flask was placed in a digester fume cupboard, switched on and allowed to digest for 45 minutes to obtain a clear colourless solution. The digest was distilled with 4% of boric acid, and 20 % sodium hydroxide solution until distillation was completed. The distillate was then titrated with 0.1 mol/l of HCl until a violet colour was formed, indicating the end point. A blank was run under the same condition as with the sample. Total protein was then calculated using equation 1 (Awolu *et al.*, 2017).

$$Protein\ (\%) = \frac{[titre\ value\ of\ sample - blank] \times 0.01 \times 14.007 \times 6.25}{1000 \times weight\ of\ sample} \times 100 \quad (1)$$

Determination of Ash Content

Five grams (5 g) of sample was weighed in incinerated crucibles and then ashed in a muffle furnace at 600 ℃ for 4 hours. The ash content was then calculated using equation 2 (AOAC, 2005).

$$Ash\ content\ (\%) = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

Where w_1 is the weight of empty crucible
W_2 is the weight of crucible + food before drying
W_3 is the weight of crucible + ash

Determination of Moisture Content

Five grams (5 g) of sample were weighed in petri dish of known weight. It was then dried in the oven at 104 ±1℃ for 4 hours and later cooled in a desiccator and weighed. The moisture content was calculated using equation 3 (AOAC, 2005).

$$Moisture\ content\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (3)$$

Where W_1=Weight of empty crucible
W_2=Weight of crucible + food before drying
W_3=Weight of crucible + sample after drying

Determination of Crude Fibre

Five grams (5 g) of sample was weighed into a 500 mL Erlenmeyer flask and 100 mL trichloroacetic acid digestion reagent shall be added. It was brought to boiling and refluxed for exactly 40 minutes. The flask was removed from the heater, cooled and filtered through a 15.0 cm whatman paper. The residue was washed with hot water, stirred once with a spatula and transferred to a desiccator and weighed (W_1) when cool. It was then ashed in a muffle furnace at 500 ℃ for 6 h ours, allowed to cool, and reweighed (W_2).

The percentage crude fibre was calculated by applying equation 4.

$$Crude\ fibre\ (\%) = \frac{(W_1 - W_2)}{W_0} \times 100 \quad (4)$$

Where W_1=Weight of crucible + fiber + ash
W_2=Weight of crucible + ash
W_0 = Dry weight of food sample.

Determination of Fat Content

Two grams (2 g) of sample was weighed on a chemical balance and wrapped in a filter paper and placed in an extraction thimble. 25 mL of N-hexane was measured into the round bottom flask for fat extraction. After extraction, the flask and its contents were cooled in a desiccator and weighed for fat content. The percentage fat content was calculated using equation 5 (Alozie *et al.*, 2009).

$$Fat\ content\ (\%) = \frac{weight\ of\ fat\ extracted}{weight\ of\ food\ sample} \times 100 \quad (5)$$

Determination of Carbohydrate Content

Carbohydrate content was determined using equation 6 (Alozie *et al.*, 2009).

$$\%\ Carbohydrates = 100 - \%(protein + fat + fibre + ash + moisture\ content) \quad (6)$$

Ascorbic Acid Determination

Iodine solution of 0.0898 mol/dm^3 was used to determine ascorbic acid via Iodometric method.

RESULTS AND DISCUSSION

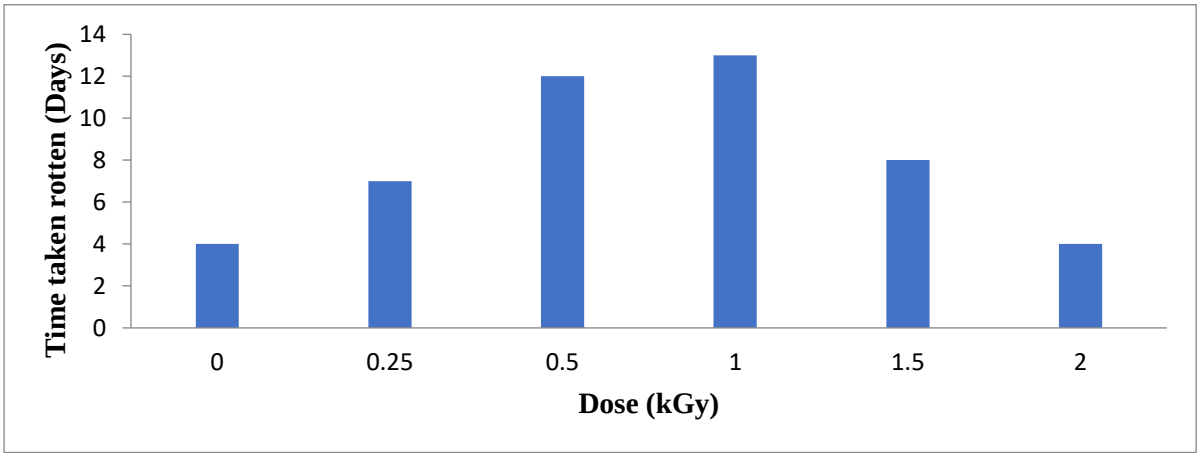

Figure 1: Graph of time for the irradiated and non-irradiated fully ripe tomatoes to get rotten

Table 1: Percentage loss of crude fibre in gamma irradiated tomatoes

Dose (kGy)	Crude Fibre (%)	Loss (%)
0.00	7.24	0.00
0.25	6.83	0.41
0.50	6.78	0.46
1.00	6.72	0.52
1.50	6.69	0.55
2.00	6.57	0.67

Table 2: Percentage loss of carbohydrate in gamma irradiated tomatoes

Dose (kGy)	Carbohydrate	Loss (%)	Gain (%)
0.00	63.42	Nil	0.00
0.25	64.42	Nil	1.00
0.50	64.86	Nil	1.44
1.00	64.94	Nil	1.52
1.50	65.19	Nil	1.77
2.00	65.18	Nil	1.76

Table 3: Percentage loss of Ascorbic acid in gamma irradiated tomatoes

Dose (kGy)	Ascorbic acid (%)	Loss (%)
0.00 (Control)	0.151	0.000
0.25	0.145	0.006
0.50	0.148	0.003
1.00	0.122	0.029
1.50	0.146	0.005
2.00	0.136	0.015

Table 4: Percentage loss of Moisture in gamma irradiated tomatoes

Dose (kGy)	Moisture (%)	Loss (%)
0.00	7.82	0.00
0.25	7.68	0.13
0.50	7.53	0.29
1.00	7.64	0.18
1.50	7.48	0.34
2.00	7.58	0.24

Table 5: Percentage loss of Ash in gamma irradiated tomatoes

Dose (kGy)	Ash (%)	Loss (%)
0.00	4.15	0.00
0.25	4.10	0.05
0.50	4.08	0.07
1.00	3.98	0.17
1.50	3.97	0.18
2.00	3.89	0.26

Table 6: Percentage loss of Protein in gamma irradiated tomatoes

Dose (kGy)	Protein (%)	Loss (%)
0.00	13.50	0.00
0.25	13.30	0.20
0.50	13.29	0.21
1.00	13.32	0.18
1.50	13.25	0.25
2.00	13.23	0.22

Table 7: Percentage loss of fats in gamma irradiated tomatoes

Dose (kGy)	Crude Fibre (%)	Loss (%)
0.00	3.87	0.00
0.25	3.54	0.33
0.50	3.46	0.41
1.00	3.40	0.47
1.50	3.42	0.45
2.00	3.50	0.37

Results of the investigation revealed that γ-irradiated doses of 0kGy (control), 0.25kGy, 0.5 kGy, 1.0 kGy, 1.5 kGy, and 2.0 kGy took 4, 7, 12, 13, 5 and 4 day respectively to get rotten (Figure 1). This implies that gamma irradiation doses within the dose range of 0.5 kGy, and 1.0 kGy, is effective for extension of shelf life of *Lycopersicom esculentum* tomatoes. Rottening with black spots of the fully ripe tomatoes was observed on the fifth day for tomatoes sample irradiated with gamma does of 0.25 kGy, and 2.00 kGy. This may be as a result of damage caused by slightly higher ionization produced by gamma radiation in the irradiated tomato samples.

The percentage loss of crude fibre in γ-irradiated tomato fruits at different doses increase with γ-irradiation doses, likewise percentage loss in ash and protein; there was no percentage loss in carbohydrate content. The percentage gain was observed to increase with increasing γ-irradiation doses. The analysis of experimental result also revealed that the percentage loss in ascorbic acid was more pronounced in samples irradiated with γ-dose of 1.0kGy (0.029) followed by 2.0kGy (0.015) and least at 0.5kGy (0.003). The percentage loss in moisture content dropped from its peak value for samples irradiated with γ-dose of 1.5kGy (0.34) to samples irradiated with 0.5kGy (0.29) and rose sharply in samples irradiated with γ–dose of 2.0kGy (0.24) and again dropped to 0.13 for samples irradiated with γ–dose of 0.25kGy. Percentage loss in fats had its peak value in samples irradiated with γ-dose of 0.25kGy (0.33). The changes in the percentage of the constituent nutrients as seen in Tables 1 to 7 may be as a result of the interaction between the radicals (complex ions) produced during food treatment with gamma radiation. These complex ions may react with various food constituents and may even cause injury to the cells of the exposed food stuff (Kader, 1986).

CONCLUSION

This research work has shown that gamma irradiation with Cobalt-60 source within a dose range of 0.50 kGy to 1.00 kGy proves adequate for extension of shelf-life of tomatoes by 9 to 10 days. Chemical analysis of the γ-irradiated and non-irradiated tomatoes for the crude fibre, carbohydrate, ascorbic acid, moisture content, ash, protein and fats shows insignificant changes in their nutritional values. Hence, the gamma irradiation dose ranges of 0.25 kGy – 0.50 kGy and 0.50 kGy – 1.00 kGy are recommended for delay in ripening and extension of shelf-life of *Lycopersicom esculentum* tomatoes locally grown in Gboko Local Government Area of Benue State, Nigeria.

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