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Determination of the Optimum Dosage of Gamma Irradiation on Tomatoes for Effective Shelf-Life Extension in Benue State

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Abstract
In this study, the determination of tomato shelf life under agroclimatic condition using gamma radiation was undertaken. The AOAC method was employed to determine the nutritional profiles of freshly harvested matured unripe tomatoes (Roma VFN and UTC) free of mechanical injury or physiological disorder packaged inside an envelope and irradiated using gamma irradiation (Co-60 irradiator, 220 Gamma cell Excel) and statistical analysis carried out. Results of the study indicate that irradiation of tomatoes with gamma irradiation doses of 0.4kGy, 0.7kGy and 1.0kGy had no significant effect on the nutritional content of the tomato varieties irradiated. The study showed that gamma irradiation at 0.40kGy to 1.0kGy was effective in reducing rotting and enhancing the extension of the shelf life of the tomatoes with the optimum dose for shelf life extension being determined to be 1.0kGy.

Keywords: *Tomato, Shelf life, Agroclimatic condition, Gamma, Irradiation.*

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Introduction

Tomato is one of the most important fruits and has significant popularity in today's market both as a processed ingredient and as a fresh fruit. It contributes to a well-balanced and healthy diet. Tomatoes are rich in vitamin, essential amino acids, minerals and dietary fibres. It contains vitamin B and C, phosphorus andiron. They are consumed freshly in salads or cooked in sauces, stew and animal dishes. They can be processed into ketchup, juices and purées. Also, dried and canned ones are economically important processed products.

Tomato is a climacteric and short seasoned fruit. Short shelf life of tomatoes is due to its active metabolism, high respiration rate and rapid ripening behaviour at optimal temperatures. This represents a serious constraint for its efficient handling and transportation. Tomatoes are usually harvested over a limited period of time; it is thereforenecessary to provide storage for the fruits to regulatemarketing and preserve high quality. Softening after harvest and subsequent microbial infestation poses major constraints in the marketing chain of the produce.In turn, longer shelf lives will enhance trade opportunities between nations by extending time constraints under which fresh produce must be delivered to more distant geographic markets or by allowing the use of slower and less expensive modes of transportation [2].

Gamma radiation has been used as a post-harvest food preservation process for many years and it has proven to be effective for controlling post-harvest losses and extending the shelf life by delaying the ripening and senescence of climacteric fruits [3]. The process is gaining much importance as it can be performed at room temperature and has high efficiency for inactivation of food borne pathogens and parasites [4]. Moreover, climacteric fruits submitted to gamma irradiation exhibit a delay of ripening [2]. This study aims to irradiate tomato fruits with gamma radiation doses, ascertain the shelf-life extension and determine the nutritional content.

Materials and Method

Materials

Tomato fruits**,** envelopes**,** Gamma irradiator (2.5MeV)**,** sample holder**,** digital weighing balance.

Samples Selection

Matured but unripe tomatoes, freshly harvested, sound, clean and free of any mechanical injury or physiological disorder, and without indication of microbial spoilage or insect infestation were selected and used to test for the delay ripening of tomatoes using gamma irradiation. The tomatoes to be irradiated were harvested at the hard mature green state and before starting their climacteric changes, this is because, irradiation conducted after the climacteric stage has begun will not delay the ripening period of the fruit but may even accelerate it. Also, irradiation at a too early stage may prevent normal ripening from occurring. There are different species of tomato in Nigeria (Tomato Jos, Tropical, Roma VF, UTC, Leventis, Panchy and Ronita).

Irradiation Procedure

The samples were exposed to gamma irradiation (Co-60 irradiator, 220 Gamma cell Excel) using doses: 0.40kGy, 0.70kGy and 1.00kGy. The procedure was performed at the Gamma Irradiation Facility, Ghana Atomic Energy Commission, Accra Ghana. The samples were four, one for controlled (not irradiated) and 3 were irradiated. Each of the tomatoes samples for the irradiation were placed in envelopes and labeled according to the doses they were

exposed to. The samples were irradiated with calculated doses of 0.40kGy, 0.70kGy and 1.00kGy.

Samples Preparation for Analysis of Bio-Chemical Effect of Gamma irradiation

The fresh tomato was cleaned and divided into two parts. One part, on which moisture is to be determined, was blended into a paste. While the other part on which proximate, elemental and vitamins analysis is to be carried out was sliced using a sharp knife and was then put under the sun to dry. After drying, the dried tomato was crushed into a powder using a clean mortar and pestle. The powdered sample was then stored at room temperature for the duration of the research. For the irradiated tomato; the tomato paste was also divided into two parts, one part was used for moisture determination while the other part was dried under sun to dry for proximate elemental and vitamin determination.

Proximate Analysis

The proximate composition (crude protein content, ash content, fat content, crude fibre content, Moisture content and carbohydrate content) of the tomatoes was determined using the standard methods of the Association of Official Analytical Chemists (AOAC). This was carried out in the Chemistry Advanced Laboratory, Benue State University, Makurdi, Nigeria.

Determination of Crude Protein

Protein content was determine using Kjeldal method, concentrated H_2SO_4 (12mL) and two tablets of selenium catalysts were placed into a Kjeldahl digestion flask containing 1g of the sample. The flask was placed in the digester in a fume cupboard, switched on and digested for 45 min to obtain a clear colorless solution. The digest was distilled with 4% boric acid and 20% sodium hydroxide solution was automatically metered into it in the distillation equipment until distillation was completed. The distillate was then titrated with 0.1mol/L HCl until a violet color was formed indicating the endpoint. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated using the equation (1):

$$\text{Protein\%} = \frac{(titre value\ \ of sample\ -blank\ )\times 0.1\times 14.007\times 6.25}{1000\times weig\ ht\ of\ \ sample} \quad (1)$$

Determination of Ash Content

Five grams of samples was weighed and placed into well incinerated crucibles and then ashed in a muffle furnace at 600^{o}C for 3h. The ash content was calculated using equation (2):

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

where, W_1=Weight of empty crucible,W_2=Weight of crucible +food before drying,W_3=Weight of crucible +ash.

Determination of Crude Fibre

Each sample of two grams was weighed into 500mL Erlenmeyer flask and 100mL of tricholoroacetic acid digestion reagent was added. It was brought to boiling and refluxed for exactly 40 min counting from the start of boiling. The flask was then removed from the

heater, cooled a little and filtered through a 15.0cm Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105^{o}C. After drying the sample was transferred to a dessicator and weighed (W_1) when cool. It was then ashed in muffle furnace at 500^{o}C for 6hours and allowed to cool and then reweighed (W_2). The percentage crude fibre content was calculated as shown in equation (3):

$$\text{Crude Fiber \%} = \frac{W_1 - W_2}{W_3} \times 100 \quad (3)$$

where, W_1=Weight of crucible + fiber + ash, W_2=Weight of crucible + ash, W_3= Weight of food sample.

Determination of Fat Content

Each sample of two grams was weighed on a chemical balance and wrapped in a filter paper. It was then placed in an extraction thimble. The Extractor was cleaned, dried in an oven and cooled in the dessicators before weighing. Then 25mL of N-hexane was measured and placed into the round bottom, the fat content was then extracted with a solvent. After the extraction, the solvent evaporated by drying in the oven. The flask and its contents were then cooled in a dessicator and weighed to obtain the fat content. The percentage fat content was calculated as shown in equation (5):

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

Determination of Carbohydrate Content

Carbohydrate content was determined using the equation (6):

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

Statistical Analysis

Analyses were performed in replicate of two (2). Results were expressed by means of standard deviation. Statistical significance was established using Analysis of Variance (ANOVA) and correlation analyses to estimate the effect of gamma irradiation on proximate composition of local yam tubers. Means were separated according to Duncan Multiple range analysis at $P \leq 0.05$ with the help of software SPSS version 23.

Results and Discussion

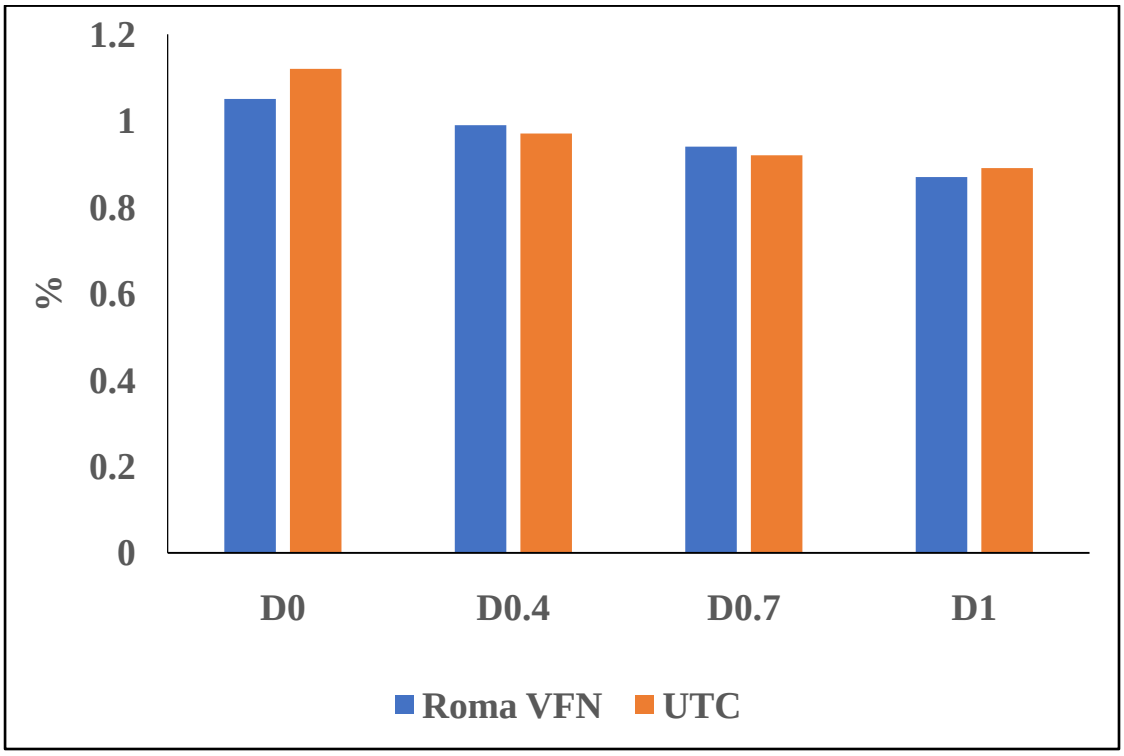


Figure 1. Ash content of irradiated and unirradiated tomatoes

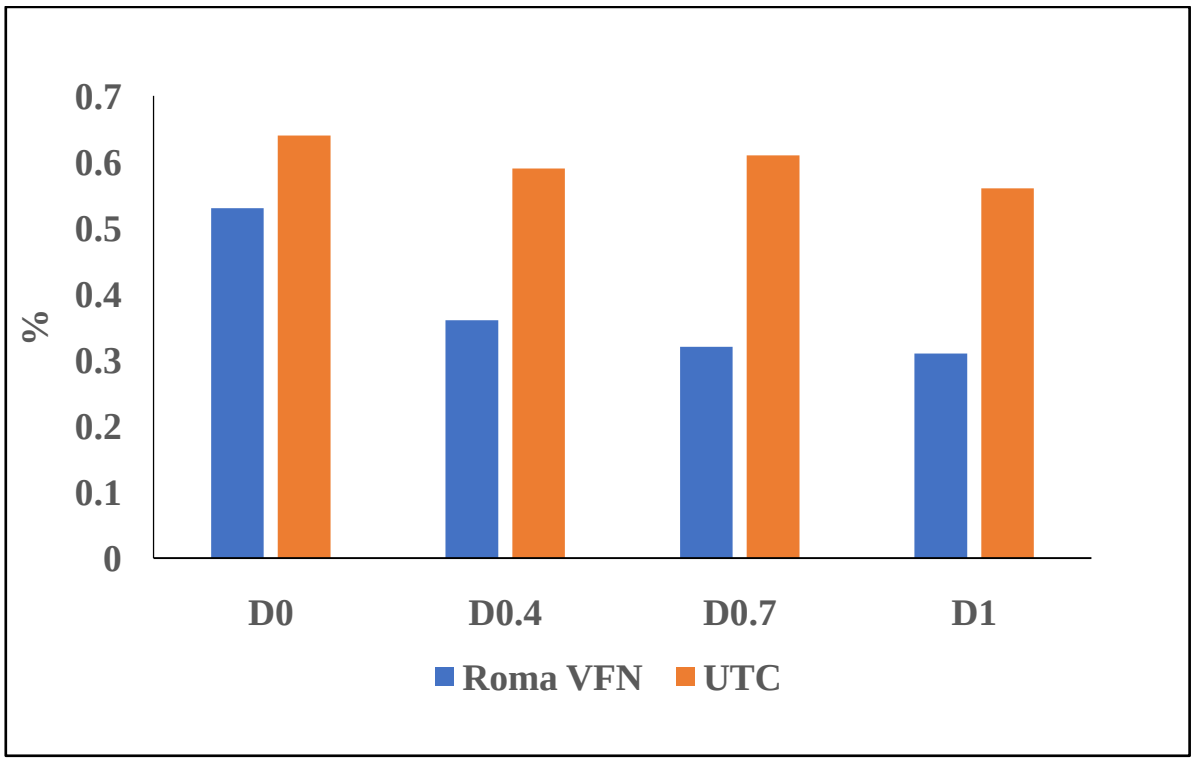


Figure 2. Fat content of irradiated and unirradiated tomatoes

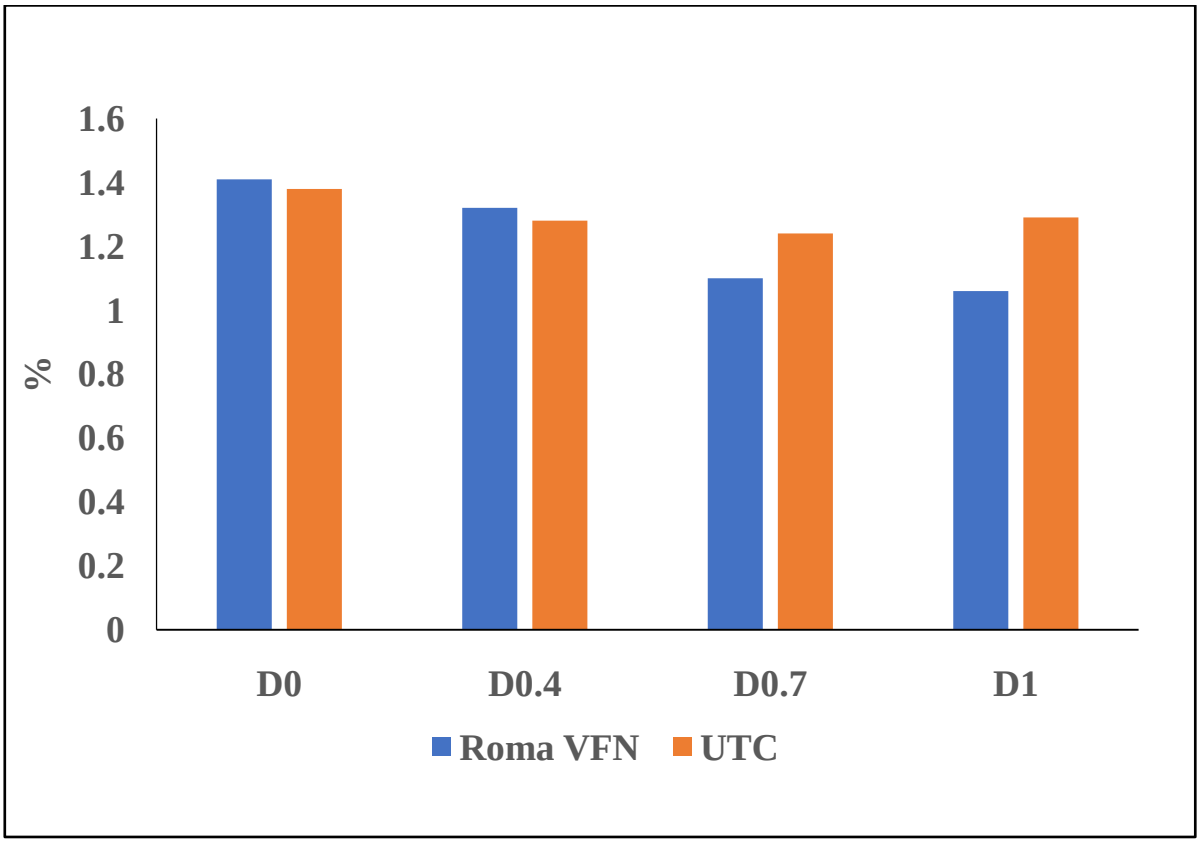


Figure 3. Fibre content of irradiated and unirradiated tomatoes

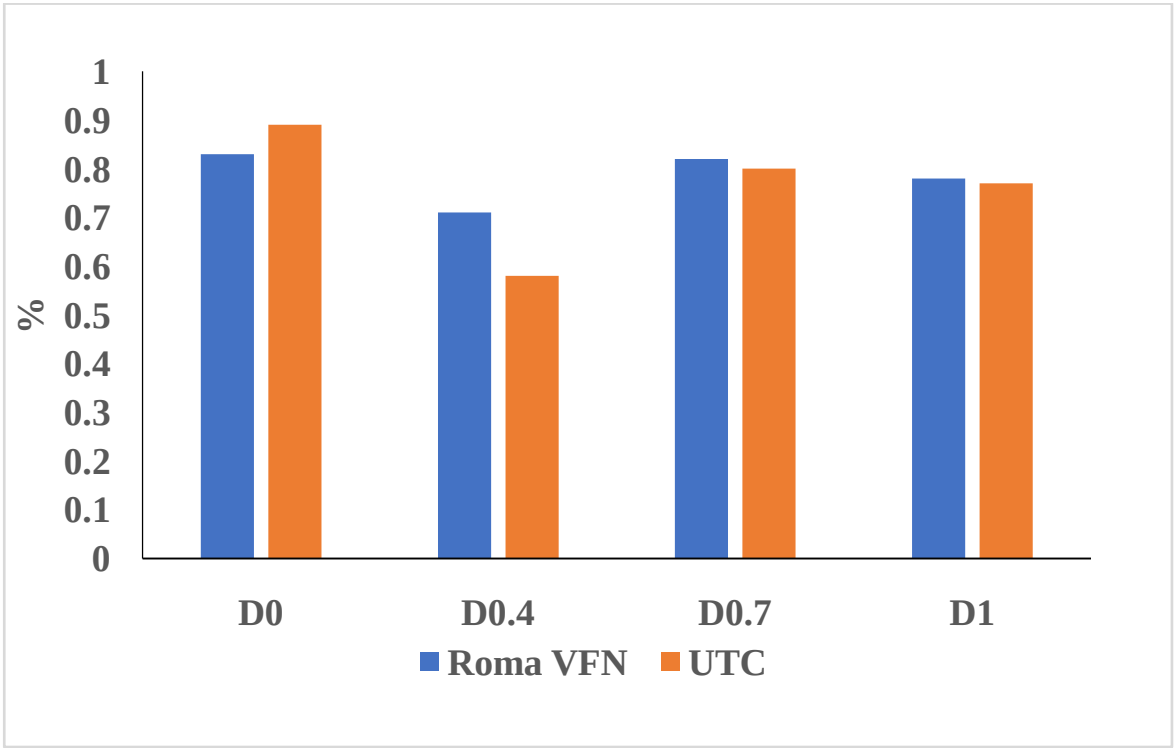


Figure 4. Protein content of irradiated and unirradiated tomatoes

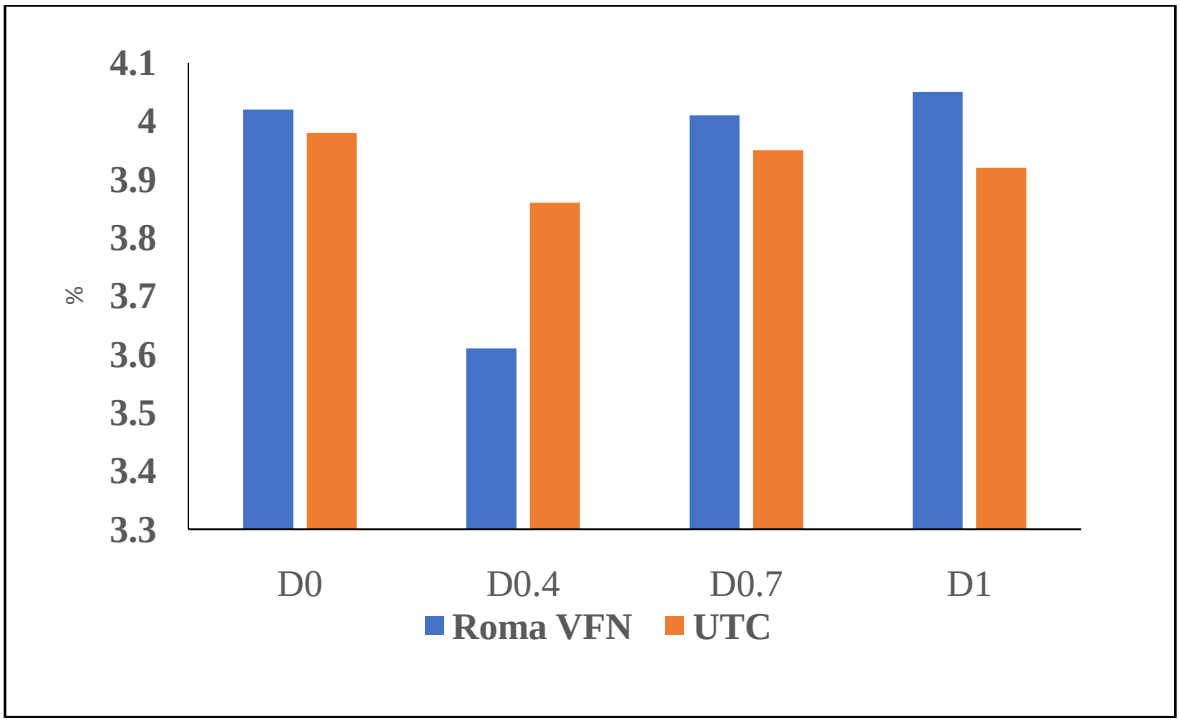


Figure 5. Carbohydrate content of irradiated and unirradiated tomatoes

The ash content as denoted in Figure 1 is a reflection of the mineral content of the tomatoes which remain unaffected by radiation processing. There was a continuous reduction in the ash content in both varieties as the doses increases. In the first varieties (*Round tomato: Roma VFN)* , the ash percent was 1.05% in control, 0.99 in 0.40kGy, 0.94 in 0.70kGy and 0.87 in 1.00kGy. This implies that gamma irradiation dose range used has a positive effect on the ash content. Same variation could be observed in the elongated tomato. Plants accumulate these nutrients through absorption by roots in the medium of water, thus this action decreases especially in water-stressed plants [5]. The highest ash content in Roma VF may be as a result of its ability to absorb minerals from the soil [5]. The crude mineral concentrations in fruits are unchanged during the storage except when there are leakages from the fruits and also when they are not metabolized. The variances in ash content in each variety may be as a result of storage methods coupled with the influence of irradiation. It was reported that with increase in dose the ash content of sample increased and with increase in storage duration the ash content of the sample decreased.

In Figure 2, the Fat content tends to increase at 0.70kGy for both cultivars. In elongated tomato, the fat percent was 0.64 in control, 0.59 in 0.40kGy, 0.61 in 0.70kGy and 0.56 in 1.00kGy.

In Figure 3, the fiber content of the tomatoes was decreased in experimental samples when compared to the control. In cultivar 1, the fiber percent was 1.41 in control, 1.32 in 0.40kGy, 1.10 in 0.70kGy and 1.06 in 1.00kGy. The author in [5] revealed that the percentage crude fiber in Yoruba variety of tomato was 2.50%, comparatively higher than the two varieties considered in this current study. The principal components of dietary fibers are lignin, cellulose, hemicelluloses, pectins, resistant starch and non-digestible oligosaccharides. The cell wall makes up to 1% to 2% of the fresh weight of fruits and cellulose constitutes about 33% of that amount [6]. Dietary fibre is an indigestible component of food that enhances

peristaltic movement of bowels. It prevents constipation as well as colon cancer [6]. It modulates the function of the intestinal tractand is characterized by low calories [6].

The protein percent in tomatoes as showed in Figure 4 was decreased at 0.40kGy when compared to control, whereas in 0.70kGy only a slight variation was observed. In Round tomato: Roma VFN, the protein percent in control was 0.83, 0.71 in 0.40kGy, 0.82 in 0.70kGy and 0.78 in 1.00kGy. The values were lower than 1.0% - 1.1% as reported by [7]. The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production [5]. The differences in protein content can also be attributed to irradiation which may have differential effects on the activities of cell wall enzymes such as α-galactosidase, β-galactosidase, β-mannosidase and β-glucosidase. These are also responsible for the rotting and softening of the fruit [5]. Fruits contain a low amount of protein but aged tissues such as overripe fruits usually have a higher amount of non-protein nitrogen [6]. The amounts of protein continually decreased from day 1 to day 16. Murr and Morris had pointed that protein degradation, as indicated by protease activity and the level of free amino acid in the tissue.

In Figure 5, the carbohydrate percent in tomatoes was decreased in 0.40kGy when compared to control, but in 0.70kGy only a slight variation was observed. The carbohydrate percent in control was 4.02, 3.61 in 0.40kGy, 4.01 in 0.70kGy and 4.05 in 1.00kGy. Carbohydrate is an essential nutrient in the body as it is the major energy source in the body. The amount of carbohydrate is second to moisture in all the varieties. It was observed that there is an interplay between the moisture and carbohydrate contents without the influence dosage. This assertion was supported by [8] that the percentages moisture and carbohydrate are increasing and decreasing respectively as the storage period increasing. This study shows that moisture and carbohydrate content of the tomatoes constitute the highest of food contents, while protein is the lowest. The variation in the nutritive values of the tomato used in this study might be due to the environmental effect in which they are grown. The recorded nutritional values in this study are in conformity with the findings of [5] for the stated irradiated doses.

Conclusion

The determination of tomato shelf life under agroclimatic condition using gamma radiation is presented. Gamma irradiation at 0.40 to 1.0kGy was effective in reducing rotting and enhancing the shelf life of tomatoes. The treatment resulted in significant decrease in decay of tomatoesand microbial load. The unirradiated tomatoes were fully decayed in 12 days, while the irradiation at 0.70kGy extended the storage life of tomatoes by 7 days and 1.00kGy for 11 days under ambient conditions. The results of study also show that no huge nutrient losses were observed by radiation processing. Additionally, gamma irradiation treatments were found suitable for delay of ripening and extension of shelf life of tomato fruits. Based on these findings, the study recommends that tomatoes should be irradiated at matured but unripe stage with an optimum dosage of gamma irradiation of 1.00KGy to extend shelf life and reduce post-harvest losses.

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