DETERMINATION OF TOMATO SHELF LIFE UNDER AGROCLIMATIC CONDITION USING GAMMA RADIATION

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Abstract
In this study, the determination of tomato shelf life under agroclimatic condition using gamma radiation was undertaken. The Association of Official Agricultural Chemists (AOAC) method was employed to determine the nutritional profiles of freshly harvested matured unripe tomatoes (Roma VFN and UTC species) free of mechanical injury or physiological disorder packaged inside an envelope and irradiated using gamma irradiation of doses 0.40kGy, 0.70kGy and 1.00kGy. Analyses were performed in replicates and 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 the tomatoes variety used. Means were separated according to Duncan Multiple range analysis at P d" 0.05 with the help of software SPSS version 23. 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 for 11 days with the optimum dose for shelf life extension being determined to be 1.0kGy.

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

Introduction

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 therefore necessary to provide storage for the fruits to regulate marketing and preserve high quality. Quick softening after harvest and subsequent microbial infestation are the major constraints in the marketing chain of the produce. Environmental conditions have strong impact on most of the quality traits of tomato such as colour and firmness of fruits (Causse *et al*., 2002). A lot of problems related to post-harvest life of tomato are associated with microbial and fungal deterioration of fruit. A number of fungal species have been described as contributory agents of tomato decay during storage. Tomatoes are a seasonal fruit and reducing post-harvest losses is very important.

Post-harvest fruit losses are serious worldwide problem. Reducing post-harvest losses is very important; ensuring that sufficient tomatoes, both in quantity and in quality is available to every inhabitant in our planet. Reduction of post - harvest losses reduce cost of production, trade and distribution, lowers the price for the consumer and increases the farmer's income. According to the United States Agency for International Development (USAID), about 50% of fresh agricultural produce in Nigeria is lost at post-harvest stage. From the prevailing condition it seems that the lack of suitable preservation methods is a major factor that contribute to the primary limitation to production and consumption of increased amount of fruit.

Nigeria is a country endowed with variety of fruit, but most of our agricultural products are lost to insect attack, rodents, micro-organisms and poor postharvest handling. Losses also occur during harvesting handling; packaging, processing and storage of these agricultural produce. To keep the quality of tomato from harvest to the consumers, conservative techniques are often used, and among them is the irradiation techniques.

The Food and Drug Administration (FDA) has announced the approval in principle of irradiated fruits up to 1.0 kGy for delaying ripening. Irradiation can delay ripening of some tropical fruits, resulting in an extended shelf life. 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 (Kadar A. A., 1986).

Gamma radiation has been used as a post-harvest food preservation process for many years and it has proved to be effective for controlling post-harvest losses and extending the shelf life by delaying the ripening and senescence of climacteric fruits (Mostafavi *et al*., 2010). However, there is no data bank for the exact amount of gamma irradiation for a particular fruit neither is there available information for a given amount of gamma irradiation for a given mass of a specific fruit. However, the difference in densities of these fruits suggest different amount of gamma irradiation. Today, there is a growing interest to apply radiation for the treatment of fruits instead of using fumigation. 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 (Bidawid *et al*., 2000). Moreover, climacteric fruits exposed to gamma irradiation exhibit a delay of ripening (Kadar A. A., 1986). In Benue state of Nigeria, where farming is a major occupation, tomato fruits are produced in large quantity especially during its season but mostly lost to spoilage due to ineffective preservative techniques. To prevent the post-harvest losses of tomato fruits and knowing the importance of consuming fruits with quality, it is of great value to extend the shelf life span of tomato fruits using gamma irradiation. To prolong its shelf life, an optimum dose of irradiation is required, inappropriate dosage, even at low dose may not be suitable, as it can result in undesirable odour and flavor and even tissue damage in tomato fruits. For this reason, this study aims to examines the possibility of extending the shelf-life span of tomato under agroclimatic condition using gamma radiation.

Materials and Method

Materials

Elongated tomatoes (UTC) and Round tomatoes (Roma VFN) fruits, envelopes, Gamma irradiator (2.5MeV), sample holder, digital weighing balance.

Samples Selection

Freshly harvested matured but unripe Elongated tomatoes (UTC) and Round tomatoes (Roma VFN) varieties commonly grown in Benue State were used in this research. 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 delay ripening using gamma irradiation. The tomatoes irradiated were harvested at the hard mature green state and before starting their climacteric changes. There are different species of tomato in Nigeria (Tomato Jos, Tropical, Roma VF, UTC, Leventis, Panchy and Ronita) but the elongated tomatoes (UTC) and round tomatoes (Roma VFN) varieties obtained from farmers in Makurdi Local Government Area of Benue State were used.

Irradiation Procedure

The samples (Elongated tomatoes and round tomatoes) 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 in 2018. 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 tomatoes were 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, Rev. Fr. Moses Orshio Adasu University, Makurdi, Nigeria in 2018.

Determination of Crude Protein

Protein content was determined 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 colourless 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 colour 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):

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

Determination of Ash Content

Five grams of samples were weighed and placed into well incinerated crucibles and then ashed in a muffle furnace at 600°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 of tomatoes were 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°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°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 of tomatoes were weighed on a chemical balance and wrapped in a filter paper. This 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):

%Carbohydrates = 100 - % (*protein+ fat+ fibre +ash +moisture content*) (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 d" 0.05 with the help of software SPSS version 23.

Results and Discussion

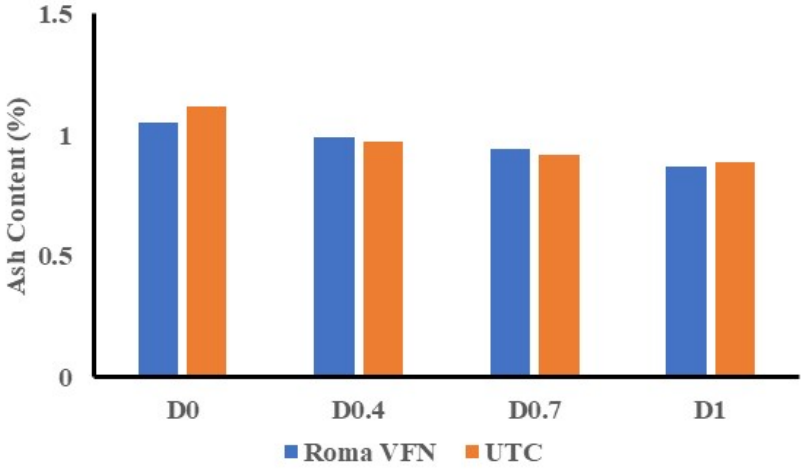

Figure 1: Ash content of irradiated and unirradiated tomatoes

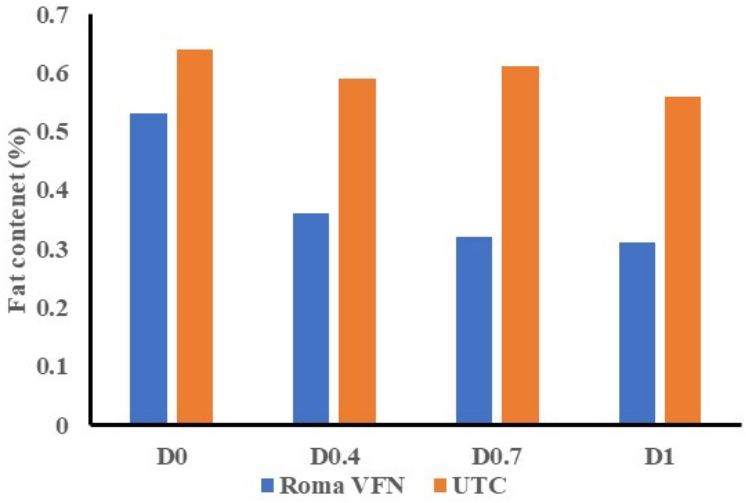

Figure 2: Fat content of irradiated and unirradiated tomatoes

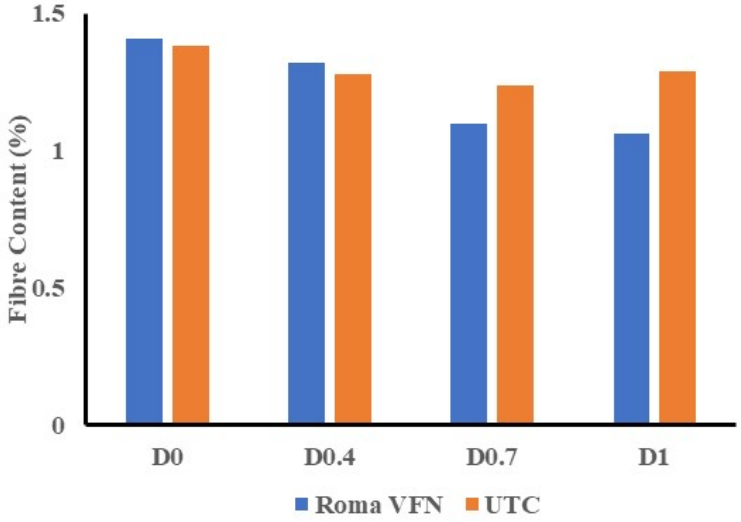

Figure 3: Fibre content of irradiated and unirradiated tomatoes

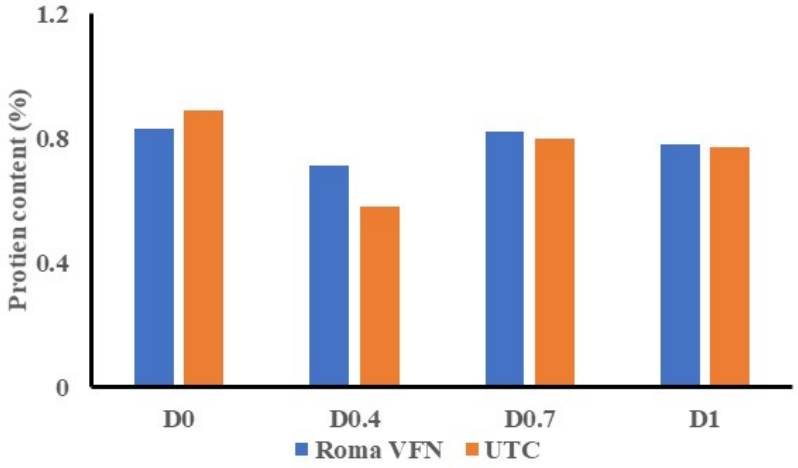

Figure 4: Protein content of irradiated and unirradiated tomatoes

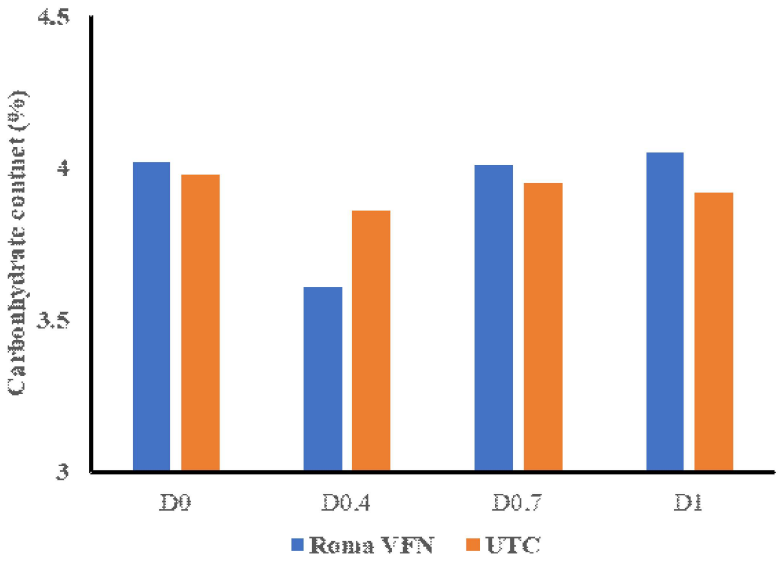

Figure 5: Carbohydrate content of irradiated and unirradiated tomatoes

The ash content is a reflection of the mineral content of the tomatoes which remain un-affected 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 (Olanyi *et al*., 2010). The highest ash content in Roma VF may be as a result of its ability to absorb minerals from the soil (Olanyi *et al*., 2010). 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 metabolised. 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.

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.

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. (Olanyi *et al*., 2010) 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 (Masefield J., 2004). Dietary fibre is an indigestible component of food that enhances peristaltic movement of bowels. It prevents constipation as well as colon cancer (Masefield *et al*., 2004). It modulates the function of the intestinal tract and is characterized by low calories (Masefield *et al*., 2004).

The protein percent in tomatoes was decreased in 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 International Commission on Radiation Units and Measurements Report 60, USA. 1998. The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production (Olanyi *et al*., 2010). 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 á-galactosidase, â-galactosidase, â-mannosidase and â-glucosidase. These are also responsible for the rotting and softening of the fruit (Olanyi *et*

al., 2010). Fruits contain a low amount of protein but aged tissues such as overripe fruits usually have a higher amount of non-protein nitrogen (Masefield J., 2004). 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.

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 (Olanyi *et al*., 2010) 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 (Olanyi *et al*., 2010) for the stated irradiated doses.

Conclusion

Gamma irradiation at 0.40 kGy to 1.0 kGy was effective in reducing rotting and enhancing the shelf life of tomatoes. The treatment resulted in significant decrease in microbial load and decay of tomatoes. The unirradiated tomatoes were fully decayed in 12 days, while the irradiation at 0.70 kGy extended the storage life of tomatoes by 7 days and 1.00 kGy for 11 days under ambient conditions. The results of study also show that no huge nutrient losses were observed by radiation processing. Gamma irradiation treatments were found suitable for delay of ripening and extension of shelf life of tomato fruits.

Radiation dose of 1.0 KGy was determined as the optimum dosage for effective shelf extension of the studied tomatoes. This has also shown that gamma irradiation has no adverse changes on the physiological properties of tomatoes kept for 23 days under ambient conditions.

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