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Effects of Gamma Irradiation on the Shelf Life and Physicochemical Properties of Fresh Cherry Tomatoes

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Abstract— *The Effects of Gamma Irradiation on the Shelf Life and Physicochemical Properties of Fresh Cherry Tomatoes was determined. Gamma irradiation of fresh tomato is a modern practice of prolonging the shelf life of the fresh tomato after harvest which minimizes economic losses associated with short time decay and maximizes profit of the product. It reduces scarcity of fresh tomatoes and increases availability even out of harvest season. It also reduces losses during the period of transportation and storage. Local variety of fresh harvested tomatoes (cherry) were exposed to cobalt 60 gamma irradiation of doses 0.5KGy, 1KGy, 1.5KGy, 2.0KGy, 2.5KGy, 3.0KGy, 3.5KGy and 4.0KGy at ambient temperature (28±1°C) lower temperature (20± 1°C). The physicochemical properties and the shelf life were examined during the period of irradiation treatments increased the shelf – life of fresh tomato. Gamma radiation treatment decreased significantly (P≤ 0.04) the weight loss, respiration rate and delay in the softening of fresh tomato fruit compared to the un-irradiated one. No significant difference was observed in terms of color, texture, taste and flavor and all other physical parameters.*

Keyword— *Fresh Tomato, Irradiation, Post-harvest, Shelf Life, Storage.*

I. INTRODUCTION

Cherry tomato is a small climacteric fruit with a short shelf life ranging from seven to fourteen weeks depending on the climactic condition of the environment due to post harvest diseases, accelerated ripening and senescence, all of which causes loses in quality and quantity.(Sumonsiri, N., 2022).

Tomato is a warm-season plant reasonably resistant to heat and drought, and grows under a wide range of climatic condition and soil conditions. It is not sensitive to day length, and sets fruit in day lengths varying from Seven (7) to Nineteen (19) hours. It requires Three (3) to Four (4) month from time of seeding producing the first ripe fruit. The tomato thrives best when the weather is clear and rather dry and the temperatures are uniformly moderate, 65°+ 85°F (18°C to 30°C).

Numerous pests and diseases can affect tomato plants. Tomato hornworms, blossom end rot, and fungi infections are typical issues. (http://www.housegardenhome.com) Tomatoes are the major dietary sources of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart diseases and cancer. (Bjarnadottir, A. 2023).

As many other crop commodities, tomato is also subject to postharvest losses. These post significant difficulties to farmers, processors, and retailers as well as hindering the producer country's exportation (Mazumder MNN. 2022)

Tomatoes have become a staple commodity to human kind because they are rich in carotenoids, polyphenols, and vitamin C. moreover, tomatoes are also consumed for their high lycopene content (17.6%), pro-vitamin A carotenoids (14.6%), beta-beta-carotene (17.2%), vitamin E (6.0%), and lastly as a corucial source of vitamin C. (Razal Z. et al 2021).

Today tomato have becomes prominent in food processing industry as well as in household gardens, even though their cultivation needs close, careful attention. Tomatoes are delicious both raw and as varied byproducts. It is one of the veggies that is grown and eaten the most on the earth. The queen of the vegetable patch is how people refer to them. http://www.alimentarium.org/en/fact-sheet/tomato Retrieved on 16 July 2023.

High temperature accompanied by high humidity favor the development of foliage diseases. Hot, drying winds causes the flower to drop (Wilbur, A. 1992).

Although they are regarded a consumed as vegetables, tomatoes are botanically classified as a fruit. Whether sliced for a simple salad, diced to make a tasty salsa dip or juiced for drinking, tomatoes have established themselves as essential ingredient in cooking. Their unique, juicy sweetness is unrivalled and they maintain versatility when used. (Marshall, C. 2008).

Global tomato production (fresh and processed) has strongly increased in the past five decades. In 1961, production was 27.6 million tonnes, in 2002 this was 116.5 million tonnes and in 2014 it was estimated at 171 million tonnes. China, the European Union (EU), India, the USA and Turkey accounted for almost 70% of global production in 2014. Asia leads with about 60% of the world production, America and Europe account for about 15% and 13% respectively. (Heuvelinic, E.P. 2018).

Currently, producers and exporters seek technologies such as food irradiation technique for sanitary purposes and to increase the shelf-life of vegetable products, with a view to expanding foreign markets by meeting international requirements concerning the environment and food security. (Ana, C.L. 2018).

Microbial spoilage of fruit and vegetable is known as rot, which exhibits as change in texture, colour, and most the time off odour hence there is a dire need to develop method to overcome the postharvest losses of fruits. (Munir N. et al 2018)

Irradiation is a processing and preservation method that produces outcomes comparable to pasteurization or freezing. During this procedure, the tomato is exposed to doses of ionizing energy, or radiation. At low doses, irradiation extends a tomato shelf life. Insects, mold, bacteria, and other potentially dangerous microorganisms are killed during this process at greater dosages. Considerable scientific research over the past five decades indicates that tomato irradiation is a safe and effective form of processing. (http://www.betterhealth.vic.gov.au) Irradiation caused a decreased in firmness compared with un-irradiated fruits, although it was verified a similar acceptability among fruits un-irradiated and radiated at 4.0KGy. Therefore, this result suggest that the irradiation treatment could be advantageous in improving microbial safety of cherry tomatoes and shelf life extension without affecting significantly its quality attribute. (Guerreiro, N.D. et al 2016).

Irradiation is effective in maintaining the quality and extending the shelf life of cherry tomatoes (kotepong P. 2021).

Irradiation greatly inhibited the activity of ethylene forming enzymes. Irradiation boosted fruit respiration right away following treatment, but it took longer to reach the climacteric respiratory peak and had a smaller peak rate. (Adams M. Y. et al, 2014)

For this reason, scientist have the responsibility to help the consumer understand the radiation process and it's potential to improve life and protect health. (Ferreira, K.M. et al, 2020).

Gamma Irradiation is a safe and effective emerging technology for food preservations. It can penetrate into the food and interact with micro–organism, disrupting its genetic material. The use of irradiation was proposed as a safest method for reducing the risk of food borne pathogens, such as E-coli in fresh fruits and vegetables. However, the interaction between irradiation and food components directly could cause the development of undesirable sensory and chemical changes in some foods, (Khalid, A.A. et al, 2000).

Irradiation induced changes in tomato fruits and pericarp firmness, electrolyte efflux, and cell wall enzymes activity as influenced by ripening stage. (El-Assi N. 1997)

The safety and benefit of tomato preservation by ionizing radiation has being studied extensively world-wide. The microbial safety of can be improve and its shelf life prolong without substantially changing its nutritional, chemical, and physical properties using irradiation. (Singh A. et al 2016).

II. MATERIAL AND METHOD

Fig. 1.1: Post-harvest Fresh Cherry Tomato

Fig. 1.2: Post-harvest Fresh Cherry Tomato

Local Variety of fresh harvested tomatoes (Cherry Tomato) was obtained from Neighborhood market, Kawo Area of Kaduna State. Some fresh tomatoes of uniform size and maturity without wounds or blemishes were selected for study. After collections, tomatoes were divided into different groups for irradiation treatment.

The samples were exposed to gamma – radiation doses of 0.5KGy, 0.75KGy, 1.0KGy, 1.5KGy, 2.0KGy, 3.0KGy and 4.0KGy. And the dose rates were 2.0KGy/h.

Chemical dosimeter ceric–cerous was used for dose measurements. After irradiation, the samples were kept separately under ambient temperature (temp 28$\pm$ 1^{O}C) and refrigerated (temp 4$\pm$ 1^{O}C) storage conditions.

All irradiated and non – irradiated samples were evaluated for microbial/test, sensory evaluation and physicochemical parameters, loss in weight decay percentage, titratable acidity, PH was determined

Weight loss: Weight loss of irradiated and un-irradiated tomatoes was evaluated during the storage until complete spoilage. Weight loss percentage in tomatoes was determine according

$$W_L = \frac{(W_o - W_t)}{W_o} \times 100\% \text{-----------------(i)}$$

Where

W_L = % weight loss

W_o = initial weight of tomato

W_t = weight of tomato at the testing time

Microbial Analysis: Irradiated and un-irradiated sample of tomatoes were analyzed for the bacteria fungal and coliform colony forming unit (C F U) by standard plate count methodology. Analysis was also carried out after 12 days of storage at room temperature 28^{o}C and under refrigerated condition 4^{o}C. Serial dilutions were prepared using sterile phosphate buffer solution Plate Count Agar (PCA) for bacterial plate count, potato dextrose agar (PDA) for fungal count and violent red bile against (VRBA).

Sensory valuation: Sensory attributes namely color, texture and overall accessibility were evaluated on a nine point scale. Sensory testing was performed by finalist and numerical values were assigned to each attribute on a nine point scale, where 9 = excellent, 8 = very good 6 = acceptable 4 = poor.

Titratable Acidity: was determined and expressed as % citric acid homogenate obtained un-irradiated and radiated tomatoes were prepared and the PH determined.

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Decay Percentage: shelf – life of irradiated and un-irradiated tomatoes kept at room temperature and under refrigerated condition was evaluated during storage at every 3 days interval until complete spoilage. Any fruit showing sign of soft rot or mold was considered as decayed. The % of spoilage was calculated for each dose.

$$\frac{Num\ of\ decay\ fruits}{Num\ of\ tested\ fruits} x\ 100\% = Decay\ \%$$ ----------------(ii)

Increase in weight loss in case of tomatoes irradiated to 4 KGy is attributed to the severe membrane degradation at higher irradiation dose.

Effect of gamma radiation on the shelf life extension of cherry tomatoes at room temperature (28 ± 2ºC) was studied. The physical conditions of the radiation treated and control tomatoes were observed at every 3 day interval and were fully decayed within 15 days of storage at ambient temp.

III. Result and Discussion

Weight Loss: Compared to the un–irradiated tomato fruit, irradiation has significantly (P≤ 0.04) reduced weight loss in all the irradiated samples. After 24 day of exposure to radiation, all the irradiated samples were kept well throughout the period of exposure (24 days). There were no significant differences in loss of weight among fruits irradiated using the four (4) doses of 0.5 KGy, 1.0 KGy, 1.5 KGy, 2.0 KGy, weight loss in tomato decreased with increasing irradiation dose as was found by Sparks and Iritain (1964).

TABLE I

S. No.	Percentage Loss in Weight for Three Days Exposure	
	Dose (KGy)	**(%) Loss in Weight**
1	0.0	1.20±0.5
2	0.5	1.16±0.1
3	1.0	1.14±0.2
4	1.5	1.11±0.3
5	2.0	0.88±0.4
6	2.5	0.72±0.2
7	3.0	0.64±0.2
8	3.5	0.56±0.3
9	4.0	0.51±0.2

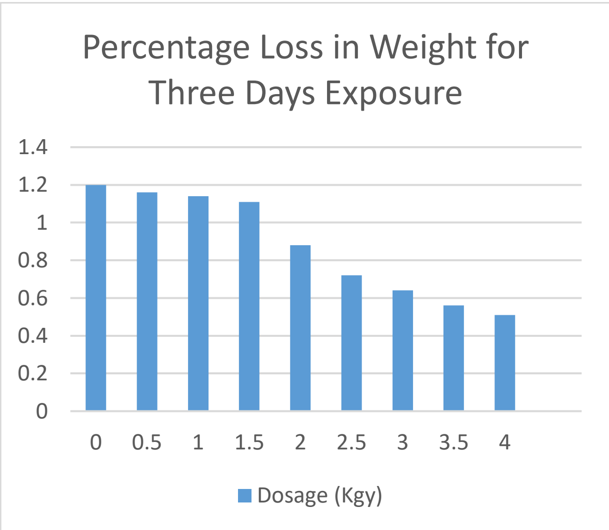

Fig. 2: Percentage Loss in Weight for Three Days Exposure

TABLE II

S. No.	Percentage Loss in weight for six days exposure	
	Dose (KGy)	**(%) Loss in Weight**
1	0.0	4.40±1.3
2	0.5	4.01±0.9
3	1.0	3.90±1.2
4	1.5	3.61±0.1
5	2.0	3.57±0.6
6	2.5	3.21±0.3
7	3.0	3.09±0.1
8	3.5	2.91±0.5
9	4.0	2.75±0.2

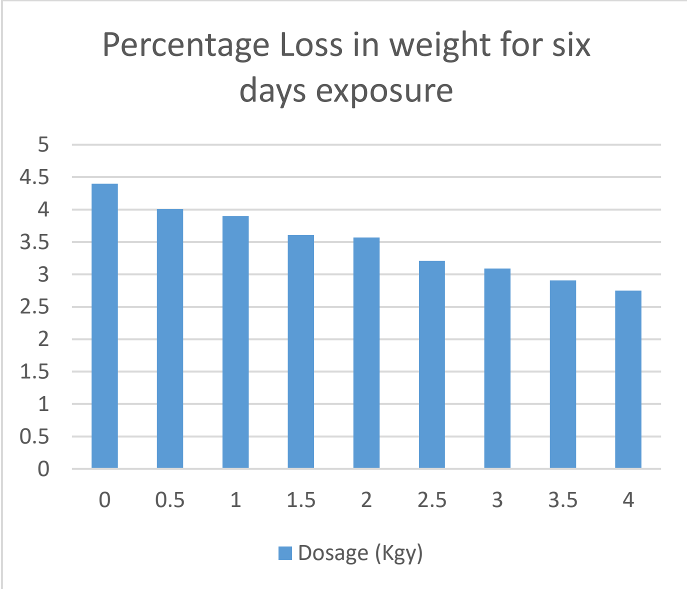

Fig. 3: Percentage Loss in weight for Six Days Exposure

TABLE III

S. No.	Percentage Loss in Weight for Nine Days Exposure	
	Dose (KGy)	**(%) Loss in Weight**
1	0.0	5.96±1.7
2	0.5	5.75±1.1
3	1.0	5.51±3.0
4	1.5	5.35±1.2
5	2.0	4.91±6.2
6	2.5	4.61±2.4
7	3.0	4.40±1.3
8	3.5	4.00±2.1
9	4.0	3.89±2.6

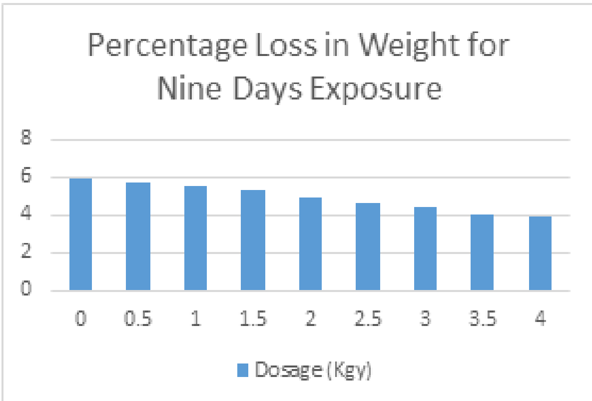

Fig. 4: Percentage Loss in Weight for Nine Days Exposure

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TABLE IV

S. No.	Percentage Loss in Weight for Twelve Days Exposure	
	Dose (KGy)	(%) Loss in Weight
1	0.0	7.78±1.7
2	0.5	7.65±1.2
3	1.0	7.45±3.6
4	1.5	7.41±1.2
5	2.0	7.31±1.5
6	2.5	7.12±2.2
7	3.0	7.02±3.1
8	3.5	6.97±3.1
9	4.0	6.20±1.0

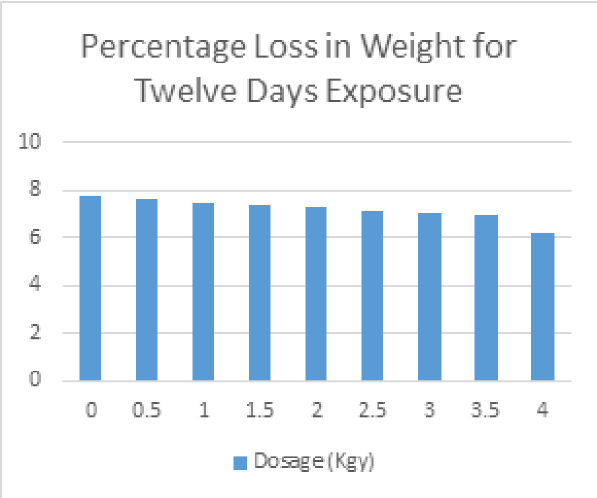

Fig. 5: Percentage Loss in Weight for Twelve Days Exposure

TABLE V

S. No.	Percentage Loss in Weight for Fifteen Days Exposure	
	Dose (KGy)	(%) Loss in Weight
1	0.0	8.93±0.1
2	0.5	8.81±0.6
3	1.0	8.41±0.5
4	1.5	8.39±3.8
5	2.0	8.27±0.7
6	2.5	8.13±0.8
7	3.0	8.01±0.7
8	3.5	7.90±3.1
9	4.0	7.71±1.2

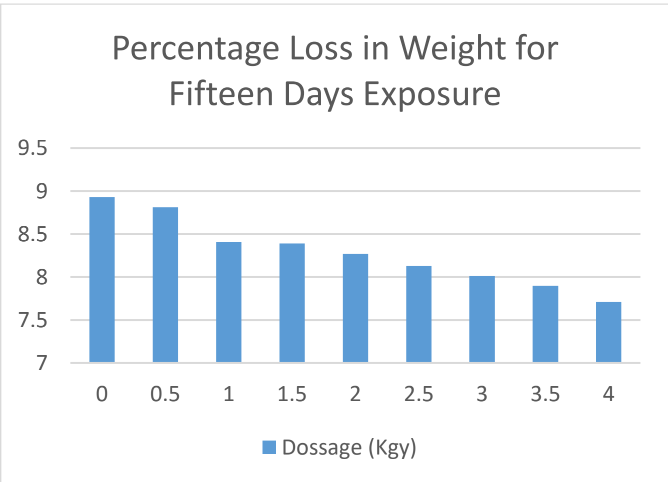

Fig. 6: Percentage Loss in Weight for Fifteen Days Exposure

TABLE VI

S. No.	Percentage Loss in Weight for Eighteen Days Exposure	
	Dose (KGy)	(%) Loss in Weight
1	0.0	11.80±1.8
2	0.5	11.13±2.7
3	1.0	11.01±2.1
4	1.5	10.90±1.3
5	2.0	10.71±2.1
6	2.5	10.18±4.1
7	3.0	10.08±5.2
8	3.5	10.00±2.4
9	4.0	9.87±3.4

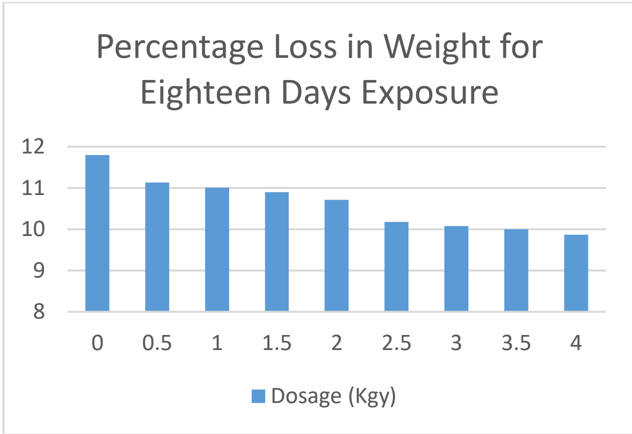

Fig. 7: Percentage Loss in Weight for Eighteen Days Exposure

TABLE VII

S. No.	Percentage Loss in Weight for Twenty One Days Exposure	
	Dose (KGy)	(%) Loss in Weight
1	0.0	14.81±6.4
2	0.5	14.68±2.8
3	1.0	14.41±3.4
4	1.5	14.38±1.7
5	2.0	14.21±8.0
6	2.5	14.00±1.7
7	3.0	13.90±3.2
8	3.5	13.80±1.8
9	4.0	13.60±8.9

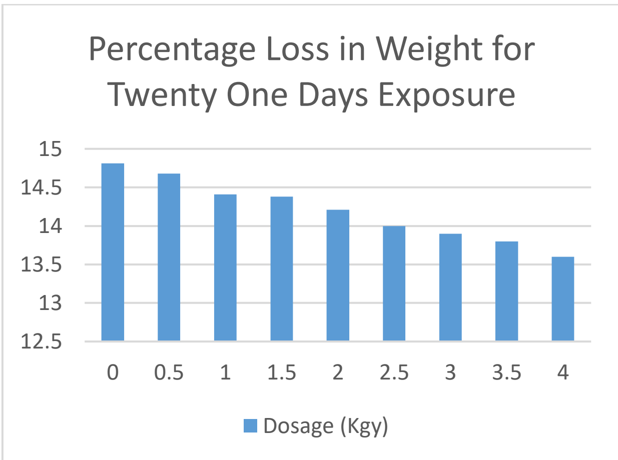

Fig. 8: Percentage Loss in Weight for Twenty One Days Exposure

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TABLE VIII

S. No.	Percentage Loss in Weight for Twenty Four Days Exposure	
	Dose (KGy)	**(%) Loss in Weight**
1	0.0	17.59±3.6
2	0.5	17.41±6.4
3	1.0	17.31±7.9
4	1.5	17.24±3.2
5	2.0	17.06±1.7
6	2.5	16.84±3.2
7	3.0	16.60±2.2
8	3.5	16.52±3.1
9	4.0	16.43±2.1

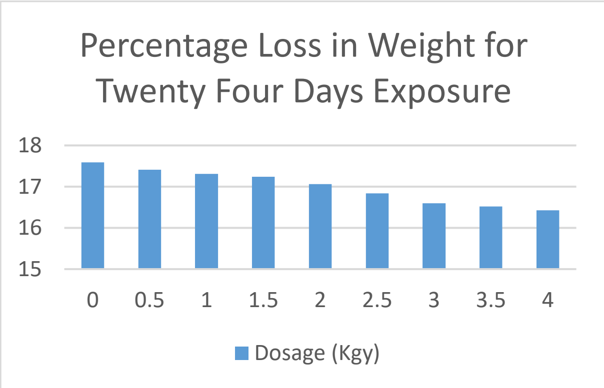

Fig. 9: Percentage Loss in Weight for Twenty Four Days Exposure

Weight loss in tomatoes treated with 0.5, 1.0, and 1.5 KGy was lower than that of the control during 24 days of storage. There were no significant differences (P>0.004) in loss of weight among fruits irradiated using the doses of 0.5, to 1.5 KGy. However, increase in weight loss in tomatoes irradiated at higher doses of 2.0 to 4.0 KGy as compared to the un-irradiated tomatoes was observed. Tomatoes treated with 4.0 KGy were almost decayed, indicating that the irradiation treatment with 0.5 – 1.5 KGy could prolong the shelf – life of tomatoes, and the high dose would cause damage to fruit. After 15 days storage period significant number of the control fruits were discarded due to complete rotting whereas irradiated fruits (0.5 – 1.5 KGy) continued to keep good condition up to 24 days. The shelf – life of tomatoes could be prolonged by treatment with doses of 0.5 – 1.5 KGy. The dose range of 0.5 – 1.5 KGy recorded lower weight loss in tomatoes as compared to un–irradiated tomatoes over the storage period of 24 days at ambient temperature. The reduced weight loss observed is due to the effect of gamma–irradiation on the respiration rate and in delaying the onset on climacteric, ripening process and sense science.

TABLE IX

S. No.	pH Values of Irradiated and Un–irradiated Fresh Cherry Tomatoes	
	Dose (KGy)	**pH**
1	0.0	5.20±0.20
2	0.5	4.72±0.21
3	1.0	4.64±0.52
4	1.5	4.31±2.10
5	2.0	4.22±0.10
6	2.5	4.13±3.20
7	3.0	4.03±2.40
8	3.5	4.07±1.40
9	4.0	4.00±3.10

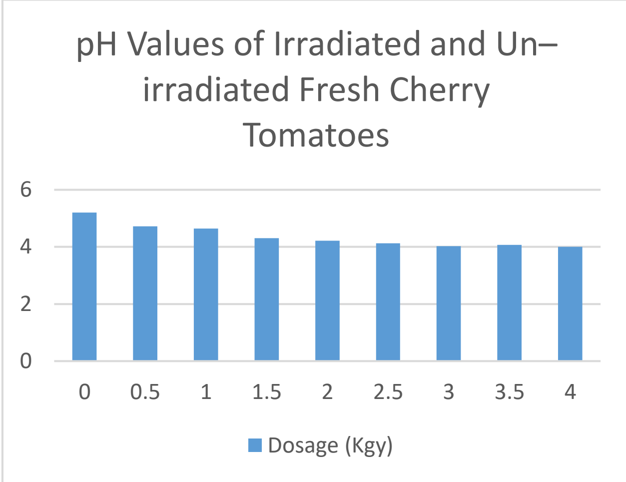

Fig. 10: pH Values of Irradiated and Un–irradiated Fresh Cherry Tomatoes

TABLE X

S. No.	Titratable Acidity of Irradiated and Un–irradiated Fresh Cherry Tomatoes	
	Dose (KGy)	**Titratable Acidity**
1	0.0	3.05±0.06
2	0.5	2.84±0.21
3	1.0	2.61±0.09
4	1.5	2.47±0.03
5	2.0	2.30±0.02
6	2.5	2.25±0.05
7	3.0	2.14±0.07
8	3.5	2.10±0.09
9	4.0	2.01±0.08

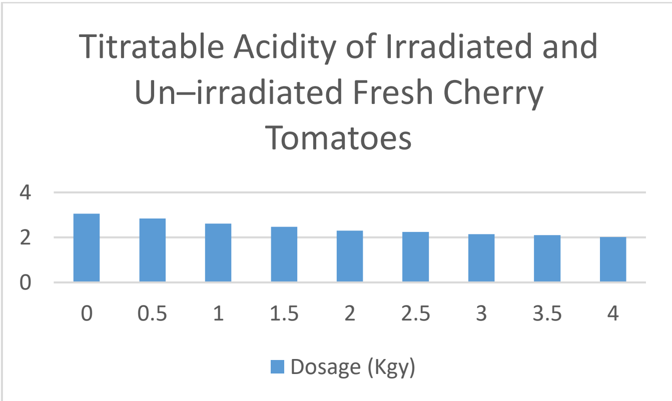

Fig 11: Titratable Acidity of Irradiated and Un–irradiated Fresh Cherry Tomatoes

TABLE XI

S. No.	Anthocyamin/cont of Irradiated and Un–irradiated Fresh Cherry Tomatoes	
	Dose (KGy)	**Anthocyamin/cont**
1	0.0	3.05±0.06
2	0.5	2.84±0.21
3	1.0	2.61±0.09
4	1.5	2.47±0.03
5	2.0	2.51±0.02
6	2.5	2.39±0.05
7	3.0	2.14±0.07
8	3.5	2.13±0.09
9	4.0	2.01±0.08

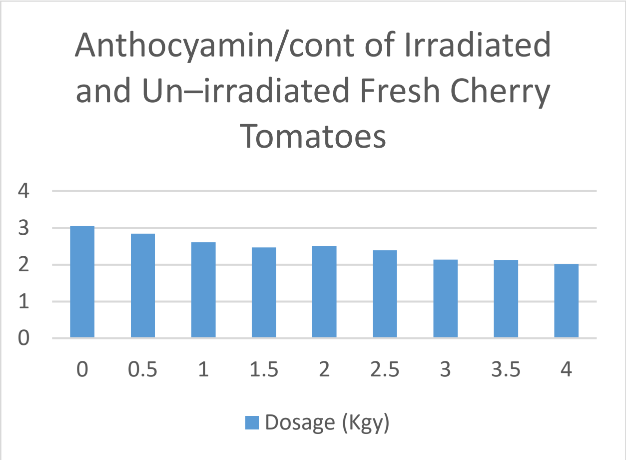

Fig. 12: Anthocyamin/cont of Irradiated and Un–irradiated Fresh Cherry Tomatoes

The above table indicates that no significant differences in the Anthocyamin content between irradiated fruit and the un–irradiated ones the Anthocyamin content of tomatoes on irradiation up to 2.0 KGy decreases with increasing radiation dose. This decrease may be due to delay in ripening, which has to do with the higher firmness of irradiated fruit.

The effect of gamma irradiation on pectin content at different doses was evaluated. The result showed that the soluble pectin content decreased with the increase of radiation dose. There were no significant differences (P>0.04) between the fruits exposed to 0.5, 1.0, 1.5 KGy and the control group in the content of pectin. Radiation dose above 1.5 KGy caused significant reduction in pectin content softening of fruits induced by irradiation physiological weight loss of tomato fruits stored at ambient temperature (28 $\pm$ 1°C) after 24 days of exposure to gamma irradiation has showed to be less than the weight loss of the un–irradiated sample throughout the study period.

The difference in weight loss was higher at higher temperature (28 $\pm$ 1°C) and lower temperature (15 $\pm$ 1°C)

The PH range increase in irradiated sample in all doses throughout the storage period. Titratable acidity was higher in irradiated sample.

IV. Conclusion

Physiological weight loss of tomato fruits stored at ambient temperature (28±1°C) after 24 days of exposure to gamma irradiation has showed to be less than the weight loss of the un-irradiated sample throughout the period of study.

The difference in weight loss was higher at higher temperature (28±1°C) and lower at lower temperature (15±1°C).

The P_H range increased in irradiated sample in all doses throughout the storage period. Titratable acidity was higher in irradiated samples.

The shelf life of the irradiated samples were found to be prolong for an average period of four weeks with minimum exposure of 0.5 KGy, exposure above 0.5 kGy increases the shelf life of the samples. No significant effect in physical properties of the sample is observed throughout the period of exposure.

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