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COMPARATIVE STUDY OF GAMMA IRRADIATION OF DIFFERENT DOSES IN GRAPES, TOMATO, GUAVA, LITCHI, STRAWBERRY AND KINNOW

Kuminder Kaur[1] and R. K. Gupta[2]*

[1]Ph.D Research Scholar, Department of Physics, Guru Kashi University, Talwandi Sabo, India.

[2]Professor in Physics, Department of Physics, Guru Kashi University, Talwandi Sabo, India.

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***Corresponding Author**
R. K. Gupta
Professor in Physics,
Department of Physics,
Guru Kashi University,
TalwandiSabo, India.

ABSTRACT

The current study was conducted to investigate the effects of gamma irradiation of different doses on various fruits and vegetables. Gamma irradiation has been proved to inhibit microbial growth, delay ripening and extend shelf life of fruits and vegetables. In productivity of plants low temperature during germination and early seedling growth is one of the most significant limiting factors. Radiation doses of 0.75 to 1.0 kGy did not affect the quality parameters of tomatoes like titratable acidity, pH, anthocyanin content.

KEYWORDS: Shelf life of fruits and vegetables, effect of gamma irradiation on fruits and vegetables, limitations of food irradiation.

INTRODUCTION

The gamma irradiators are powered by Co^{60}, which effectively killed microorganisms. The amount of radiation received depends on the type of product and its dose requirements. The gamma irradiation is used routinely to sterilize medical, dental and household products and for the radiation treatment of cancer. Gamma irradiations have been used for several decades to decontaminate various items-including food, cosmetic raw materials and medical supplies with great efficiency. For achieving a specific effect that reduces the levels of microorganisms, this process involves exposing the item to ionizing radiations.

For grapes production Balochistan is leading place whereas in Pakistan this fruit is consumed both in dried and in fresh form. During transport postharvest losses are main problems for perishable vegetables and cost of fruit per less annum which leads to low profit fruits. (Aujla *et al*., 2011). Fresh consumed grapes are table grapes with large berries and seedless into unfermented juice grapes cultivars with distinctive aroma and flavor are transformed. In Pakistan fresh table grapes produced are exported to Bahrain, Bangladesh, Germany, United Arab Emirates and United Kingdom. In 2008-2009, these countries valued 9054000 rupees quantity of 184256 kg fresh grapes was exported (Reisch *et al*., 2012). The quality of kinnow fruits for 20 days is maintained and shrink film improved the shelf-life for 20 days under supermarket conditions only in case of unpacked control fruits as against 10 days (Mahajan and Singh 2014). When exposed to low non-freezing temperatures different citrus cultivars may develop CI symptoms (Holland et al., 2002). As a post-harvest food preservation process for many years gamma irradiation has been used (Antonio *et al*., 2012). Over a limited period of time tomatoes are usually harvested to regulate marketing and preserve high quality it is therefore necessary to provide storage for the fruits. On most of the quality traits of tomato such as colour and firmness of fruits environmental conditions have strong impact (Causse *et al*., 2002). In Pakistan under specific conditions food can be preserved by using gamma irradiation practically and economically. Due to depletion of the stratosphere ozone layer the increased levels of UV radiation reaching the surface of the earth in recent decades to better understand the effect of UV radiation on agriculture including grape and wine ozone layer sparked the interest of research (Keller & Torres-Martinez, 2002).

Effect of Gamma Irradiation

For the decomposition of various pollutants like pesticides residues radiation process is one of the most powerful AOPs (advanced oxidation process), where irradiation with a beam of accelerated electrons or gamma radiation is employed. By many scientists the food irradiation was investigated but on the effect of gamma irradiation on degradation of pesticide residues below MRLs (maximum residue limits) limited studies focused.

From different types of vegetables gamma irradiation is used for pesticide degradation. By the world health organization above the maximum residue levels many of the samples contained pesticides and 6-7% samples had residual levels were determined. With increasing radiation doses gamma irradiation decreased pesticide levels proportionately. When a radiation strength of 0.5 kGy was utilized Diazinon, chlorpyrifos and phosphamid on were reduced by 40-48%, 35-43% and 30-45% respectively. In eggplant samples three carbamates (carbaryl, carbofuran and pirimicarb) and six organophosphates (phenthoate, diazinon, parathion, dimethoate, phosphamidon, and pirimiphos-methyl) were detected in eggplant samples at 1.86 mg/kg the highest carbofuran level was detected while at 0.311 mg/kg phenothate was detected. However, pesticides were reduced to 85-90%, 80-91% and 90-95% respectively when the radiation dose was increased to 1.0 kGy.

Advantages and Limitations of Food Irradiation

By irradiation disinfection and shelf-life extension improvements provided can be used to control and minimize the post-harvest losses in grain, pulses and fruits caused by insect infestation. For the developing countries this point is more important during the post-harvest stage whereas the losses are high. By irradiation of foods one estimate suggested that 30% of all food storage losses could be prevented. With pathogenic microorganisms or parasites many foods are contaminated. For all foods the food irradiation process is not suitable but for all foods there is no preservation method that can be used. In standardizing the radiation processing variability in effects leads to difficulty. Serious disadvantage of irradiation is vitamin losses that are often mentioned. Compared to thermal processing a clear disadvantage of irradiation is the lack of enzyme inhibition in foods, for commercial sterilization even at the high radiation doses are required. In combination with other treatments irradiation with other methods of food preservation one way to overcome disadvantages and limitations is to use irradiation.

Table 1: On leaf physiological parameters of kinnow effect of different doses of gamma rays (Mallick et al., 2016).

Treatment	Leaf area (cm^2)	Fresh mass (g)	Dry mass (g)
Control	19.38^c	0.598^g	0.230^e
Gamma rays(Gy)			
5	18.36^d	0.670^e	0.249^c
10	22.94^a	0.920^a	0.309^a
15	23.34^a	0.896^b	0.300^b
20	15.96^e	0.683^d	0.244^d

By the different doses of physical and chemical mutagens leaf area was significantly affected. Significant reduction in leaf area (17.64%) was noticed at the maximum dose of mutagenic treatments i.e., 20 Gy and 0.5% EMS as compared to the non-mutated plant (wild type).In leaf area at 10 and 15 Gy stimulated increase of 18.36 and 20.43% in leaf area without any statistical difference was noticed. In the mutant developed with 0.2%EMS enlarged leaf area

(5.72% higher) was recorded. After treatment with 10 Gy followed by 15 Gy and 0.2% EMS, treatment which declined drastically in the plants treated with 20 Gy and 0.5% EMS leaf fresh and dry mass were recorded maximum in plants derived.

Table 2: Physical characteristics of kinnow and its seedless mutant (Khalil et al., 2011).

Treatment(Gy)	Fruit size diameter(mm)	Juice yield (%)	Peel thickness (mm)
Control	73.6	48.04	2.34
20	72.4	46.47	2.34
40	70.78	46.20	3.34
60	79.5	46.00	3.05
80	76.5	46.20	3.11
120	75.7	46.31	3.35

By the exposure of gamma radiations the fruit size diameter is reduced from 79.5mm at 60 Gy to 70.78mm at 40 Gy. Percentage of juice yield is 46.00 by the exposure of gamma irradiations at 60Gy.Maximum peel thickness by the exposure of gamma irradiations at 120 Gy is 3.35.

Table 3: On mortality of immature stages of Mediterranean fruit flies in guavas effects of ionizing radiation (Doria et al., 2007).

Treatment (Gy)	**N^0 Insects Treated**		
	Eggs	**L_{1-2}**	**L_{-3}**
50	2580	600	600
100	2580	600	600
150	2580	600	600
200	-	600	600
250	-	600	600
Treatment (Gy)		Insects Killed	
	Eggs	L_{1-2}	L_{-3}
50	2010	270	330
100	2250	180	360
150	2370	420	480
200	-	330	390
250	-	420	450
Treatment (Gy)		% Mortality	
	Eggs	L_{1-2}	L_{-3}
50	78.3	44.8	53.2
100	87.3	28.2	60.5
150	92.4	70.2	79.2
200	-	55.2	64.2
250	-	71.5	75.5

Based on control population mortality of immature was calculated from actual recovery pupae formed compared to the number projected to have been present. With the dose egg mortality increased but for young (1^{st} and 2^{nd}) and old larvae (3^{rd}) the mortality was variable.

Table 4: On H_2O_2 content, CAT, SOD and APX activities in tomato seedlings under chilling stress effect of exogenous GABA (Malekzadeh *et al*., 2014).

GABA concentration	H_2O_2 content	CAT activity	SOD activity
Control	3.50±0.28a	2.93±0.28a	24.54±6.8a
0	9.97±1.08c	5.56±0.6b	41.01±7.6c
100	7.76±0.49c	7.44±0.81c	35.64±3.3 bc
250	6.09±0.46b	7.87±0.69c	31.90±3.2 abc
500	4.26±0.45a	14.59±0.43e	31.40±3.1 ab
750	4.13±1.00a	12.21±1.1d	26.73±2.9 ab

In tomato seedlings the content of H_2O_2 was lower in control GABA concentration. CAT activity is maximum at 500 GABA concentration. SOD activity is minimum at control GABA concentration.

Table 5: Quality attributes of unirradiated and irradiated tomatoes (Singh *et al*., 2016).

Dose(kGy)	Titratable Acidity	pH	Anthocyanin content
0	3.02±0.07	5.25±0.30	0.119±0.012
0.5	2.95±0.11	4.97±0.24	0.095±0.003
0.75	2.26±0.07	4.84±0.28	0.091±0.002
1.0	2.14±0.02	5.13±0.26	0.087±0.001
1.5	2.05±0.22	4.97±0.25	0.086±0.001
2.0	2.16±0.11	4.63±0.12	0.085±0.001
3.0	2.70±0.07	4.60±0.14	0.089±0.002
4.0	2.62±0.09	4.63±0.12	0.092±0.006

In pH of gamma irradiated tomatoes as compared to control untreated tomatoes there is slight decrease. For treated tomatoes pH varied from 4.60±0.14 to 5.13±0.26 and of untreated was 5.25±0.30. In gamma irradiated tomatoes titratable acidity was found to decrease. As compared to unirradiated tomatoes (3.02%) titratable acidity was significantly lower (2.05-2.26%) in fruits treated with 0.75 to 2.0kGy.

Table 6: On vegetative parameters of Grape cv. 'Muscat' effect of gamma rays (Surakshitha et al., 2017).

Dose (Gy)	Shoot length(cm)			No. of leaves			Leaf length(cm)		
	Actual	Percent over control (%)	Percent reduction over control (%)	Actual	Percent over control (%)	Percent reduction over control (%)	Actual	Percent over control (%)	Percent reduction over control (%)
0	8.93	100.00	-	6.06	100.00	-	7.36	100.00	-
5	8.79	98.41	1.59	5.50	90.66	9.33	7.12	96.71	3.28
10	8.20	91.79	8.20	4.20	69.23	30.76	7.09	96.29	3.70
15	7.49	83.94	16.05	4.28	70.63	29.36	6.04	81.99	18.00
20	5.70	63.89	36.10	4.50	74.18	25.81	6.50	88.24	11.75
25	5.29	59.22	40.77	4.33	71.38	28.61	6.20	84.27	15.72
30	4.46	49.94	50.66	3.98	65.67	34.33	5.30	72.01	27.99
35	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
40	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
45	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
50	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00

At 0Gy actual shoot length is 8.93cm and percent over control is 100% whereas percent reduction over control is 100.00 at radiation doses of 35Gy, 40 Gy, 45Gy and 50 Gy. Actual no. of leaves is 6.06 at 0Gy and percent over control is 0.00 at 35Gy, 40 Gy, 45Gy and 50 Gy. Maximum percent reduction over control is 34.33 at 30 Gy. At 0Gy actual leaf length is 7.36 cm and percent over control is 100.00 at 0 Gy. The percent reduction over control is 100.00 at 35Gy, 40 Gy, 45Gy and 50 Gy.

Table 7: Total soluble solids (TSS), Vitamin C content, Total sugar content (%) in gamma irradiated and non-irradiated litchi samples. (Pandey et al., 2013).

Radiation dose(kGy)	TSS(^{0}Bx) for samples on storage for 13 days		Vitamin C content for samples on storage for 13 days		Total sugar content (%) for samples on storage for 19 days	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Control	14.17	0.49	57.88	2.03	12.47	0.45
0.5	15.42	0.39	43.77	1.13	12.81	0.36
1.0	14.53	0.12	40.77	1.39	13.54	0.74
1.5	14.83	1.01	41.74	2.93	13.83	0.30
3.5	14.40	0.40	35.67	4.28	12.63	0.37

Mean value of TSS (^{0}Bx) for samples on storage for 13 days is 15.42 at 0.5 kGy and standard deviation is 1.01 at 1.5 kGy. Mean value of Vitamin C content for samples on storage for 13 days at 3.5kGy is minimum and standard deviation is maximum at 3.5 kGy. Total sugar content (%) for samples on storage for 19 days at 1.5kGy is maximum and standard deviation is minimum at 1.5 kGy.

Table 8: On phenolic compounds profile (ppm) effect of different doses of gamma irradiation of strawberry fruits after irradiation immediately. (Maraei & Elsawy., 2017).

Irradiation dose (Gy)	Phenolic Compound			
	Pyrogallol	Gallic	Catechol	Cinnamic
0	165.82	8.45	23.02	2.28
300	373.01	11.15	27.13	2.85
600	269.82	14.95	36.53	2.77
900	203.16	9.65	51.46	1.04

Maximum pyrogallol is 373.01 at 300 Gy. Minimum Gallic is 8.45 at 0Gy. Catechol is maximum at 900 Gy and at 900 Gy minimum value is of Cinnamic.

CONCLUSION

In reducing rotting and enhancing the shelf life of tomatoes gamma irradiation at 0.75 to 1.0 kGy was effective. Under ambient conditions gamma irradiation at 0.75 kGy significantly extended the storage life of tomatoes by 7 days. When polyethylene-based wax is used as coating and mandarins are stored at 5^0C the CI and peel pitting is minimized. In enhancing shelf life of grapes gamma irradiation proved to be beneficial. During cold storage on fungal growth and physiological activity in guava fruits lemongrass oil and $CaCl_2$ exerted strong inhibitory effects. To maintain the sugar content of the kinnow fruits all coatings were effective to check the physiological loss in weight. In the browning and decay control of litchi fruit it was suggested that the application of pyrogallol could be beneficial. For the strawberry variety the consistent increase of 4-hydroxy benzoic acid with dose is significant.

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