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Effect of Radiation on the Physico - Chemical Characteristics of Tomato During Storage

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Tomato samples, collected from Peshawar market, were irradiated with different doses of gamma radiation, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 3.0 and 4.0 kGy and a control sample was kept for comparison. The irradiated samples were analysed every day for physico-chemical analysis i.e. pH, acidity, optical density, ascorbic acid (vitamin - C) and % ripening. Ascorbic acid and acidity were determined titrimetrically while optical density was measured with the spectrophotometer. Physical separation, ripening and spoilage were determined by visual examinations. The results showed that the ascorbic acid contents were higher in control as well as in samples irradiated with lower doses while it decreased to a level of 12.3 mg/100 g for high doses. The acidity and optical density also decreased during storage. The ripening process was delayed at higher doses.

***Key words**:* Tomato, Irradiation, Physico - chemical analysis.

Introduction

Tomato is one of the most popular vegetable grown throughout the world. This edible fruit belongs to the genus *Lycopersicon esculentum*. It can be consumed either fresh or processed into many different products. The common tomato plays a vital role in maintaining health and vigour and helpful in healing wounds because of antibiotic properties found in the ripe fruit. It is also a good source of vitamins (Anon 1982). Tomato is a perishable fruit and its average life may not exceed more than a few days under normal circumstances. It is claimed as vegetable as well as a fruit in the literature (Kader and Morris 1976; Luh and Woodroof 1982).

The use of neutrons, X-rays, and beta and gamma rays is described and interpreted, with some new data on levels of radiation required to preserve different foods (Vidal 1960). Irradiation can be applied for ripening delay, preservation and extending storage life of various crops, fruits and vegetables (Ahmad *et al* 1972; Khan *et al* 1985; Badshah *et al* 1992). Some physico-chemical changes may occur after radiation treatment of fresh fruits and vegetables (Poole 1956; Burns and Desrosier 1957; El-Sayed 1978; Assi *et al* 1997). The chemical changes brought about by irradiation treatment in foods have been studied very thoroughly owing to the fears that some of these changes may produce toxic compounds (Vidal 1960; Maxie and Sommer 1968; Tencheva 1976). Gamma irradiation is also used for decontamination of food items (Akhtar *et al* 1995).

Because of various preservation methods, tomato is now available throughout the year. Techniques like freezing, canning, dehydration and salting are applied to extend the shelf-life of the commodity. Irradiation is a new technique enabling the extension of tomato shelf-life upto 13 days (Burns and Desrosier 1957; Kader *et al* 1965; Assi *et al* 1977; El-Sayed 1978). Effect of gamma irradiation on the post-harvest behaviour of tomatoes (Bhatti *et al* 1967; Sattar *et al* 1970) and cooking methods on the nutritional and organoleptic properties of two vegetables are reported (Zeb *et al* 1995). The research reported here was carried out to see the quality changes in tomato fruits after postharvest treatment with gamma radiation used for extending the shelf-life.

Materials and Methods

A) *Sampling*. Tomato samples were purchased from the local market of Peshawar. Fruits of equal size and uniform maturity were selected and washed with distilled water.

B) *Instrumentation*. Following radiation source and instruments were applied in the present study:

i. Co-60 gamma irradiator (ISSLEDOVATEL)
ii. Shimadzu UV-Visible Recording Spectrophotometer UV-160
iii. pH Meter 215 Corning Incorporated USA

C) *Procedure*. About 1 kg (10-15 tomatoes) were grouped for each radiation dose. Different radiation doses i.e. 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 3.0 and 4.0 kGy were given. A control sample was taken without irradiation. As tomato perishes rapidly, fruits showing sign of deterioration were separated from the lots. Physico-chemical analyses were conducted in triplicate after every 24 h. The standard procedures for selective parameters (Williams 1984) are outlined below:

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Table 1
Doses for treatment of fresh fruits and vegetables

Class	Description	Purpose of Irradiation	Dose(kGy) max
1	Bulbs, roots and tubers	To inhibit sprouting during storage	0.2
2	Fresh fruit and vegetables (other than class 1).	a) To improve keeping quality by delaying ripening	1.0
		b) To control insect infestation.	1.0
		c) To prolong storage life by partial elimination of spoilage organisms.	2.0
		d) To satisfy quarantine requirements.	1.0
3	Cereals/pulses, their products dried vegetables/nuts/fruits.	To control insect infestation.	1.0
4	Raw fish and seafood and their products (fresh and frozen).	a) To ensure hygienic quality by reducing the number of pathogenic microorganisms.	5.0
		b) To prolong shelflife by partial elimination of spoilage organisms.	3.0
5	Raw poultry and meat and their products (fresh and frozen).	a) To ensure hygienic quality by reducing the number of pathogenic microorganisms.	5.0
		b) To prolong shelflife by partial elimination of spoilage organisms.	3.0
6	Dried herbs, spices, condiments.	a) To ensure hygienic quality by reducing the number of pathogenic microorganisms.	10.0
		b) To control insect infestation.	1.0
7	Dried food of animal origin.	To control insect infestation.	1.0

i. pH. The pH was measured in slurry of sample using pH meter.
ii. Acidity. An aliquot of 10 ml from sample solution (10 g/ 100 ml) was titrated against 0.1N NaOH using phenol-phthalene indicator.
iii. Vitamin - C. A 10 ml aliquot of sample solution (1 g sample in 10 ml 0.4% oxalic acid) was titrated against a standard dye (2,6-dichlorophenolindophenol). Standard solution of ascorbic acid (1 mg/ml) was used for calibration.
iv. Optical density. Samples were filtered and optical density was determined with the help of spectrophotometer at 520 nm.
v. % Ripening. The % ripening of tomato sample was noted subjectively.

Results and Discussion

The moisture content of tomato is 93% and hence, it is normally spoiled due to chemical reactions, autolysis and microbial activities. Storage of tomato under low temperature using refrigerator, may prolong their shelf-life. But in very rare cases such food lasts for upto 4 weeks. Tomatoes are normally grown throughout the year, therefore it is necessary to reduce their production losses, extend their shelf-life and reduces the chances of spoilage. To achieve these goals, food processor commercially used some food preservation methods based on the principle that is removal of chemical and physical reactions, microbial activity and losses caused by attack of insects.

Application of ionising radiation is carried out for preservation and disinfestation of food. The absorption of electromagnetic radiations by food depends upon several factors including their nature, source and intensity (Balla and Kiszel 1963). Previous studies have revealed that irradiation has the ability to inhibit sprouting of root crops and tubers, delay ripening in fruits, prevent reproduction in insects, kill insects and parasites, and destroy or inactivate moulds, yeasts and bacteria, including spores (Burns and Desrosier 1957; Balla and Kiszel 1963). Detailed report on irradiation of food in Pakistan are available in the literature (Muhammed and Sattar 1971; Sattar 1992).

The technique of food preservation by ionising radiations has become established among other technological methods. The main advantage of these radiations lies in its strong

Table 2
Effect of different radiation doses on change in pH of tomatoes during one week storage

Dose	Storage time (days)							
(kGy)	0	1	2	3	4	5	6	7
0.00	4.60	4.00	4.30	4.00	4.20	4.20	4.00	3.80
0.20	4.60	3.80	4.30	4.60	4.10	4.10	4.10	3.70
0.30	4.60	4.00	4.60	4.30	4.20	4.20	4.20	3.90
0.40	4.60	3.80	4.60	4.30	4.20	4.20	4.20	4.30
0.50	4.60	3.80	4.70	4.40	4.20	4.20	4.20	4.20
1.00	4.60	3.70	4.40	4.60	4.20	4.30	4.20	4.20
2.00	4.60	3.60	4.50	4.60	4.10	4.50	4.20	4.60
3.00	4.60	3.60	5.00	4.60	4.40	4.60	4.50	4.20
4.00	4.60	3.50	4.60	4.60	4.60	4.60	4.40	4.50

Table 3
Effect of different radiation doses on change in % acidity of tomatoes during one week storage

Dose	Storage time (days)						
(kGy)	0	1	2	3	4	5	6
0.00	0.54	0.52	0.52	0.43	0.41	0.39	0.38
0.20	0.54	0.53	0.53	0.42	0.40	0.38	0.38
0.30	0.54	0.52	0.52	0.45	0.46	0.43	0.40
0.40	0.54	0.54	0.54	0.48	0.48	0.44	0.43
0.50	0.54	0.49	0.49	0.44	0.42	0.40	0.39
1.00	0.54	0.54	0.54	0.47	0.45	0.43	0.40
2.00	0.54	0.51	0.51	0.44	0.43	0.39	0.35
3.00	0.54	0.51	0.51	0.47	0.45	0.35	0.33
4.00	0.54	0.50	0.49	0.44	0.41	0.38	0.37

penetrating power. Gamma and X-rays have germicidal properties and are being exploited in food industry for preservation. The X-rays are produced by the X-ray tubes, while gamma rays are emitted from radioactive substances such as cobalt-60 and caesium-137. (Balla and Kiszel 1963). Still the most commonly employed unit for measurement of radiation energy absorbed has been the 'rad' (Awan 1995). A rad is equivalent to 10^{-5} Joules (J) of energy absorbed per gram of material receiving ionising radiation. Kilorad (krad) is used when heavy doses are employed. In accordance with the recommendations of the International Organisation for Standardisation (ISO), the rad has been replaced by Gray (Gy) which corresponds to 100 rad. The Gy is the new unit of System International (SI) system (IAEA 1994).

A dose range of 70-220 krad was used for tomato irradiation in a study (Assi *et al* 1997). Low levels of radiation appear to have the most promising immediate application in the food field (Burns and Desroiser 1957). Pre-irradiation was effective in controlling rot decay during storage of irradiated fruits. A dose of 1.0 kGy extended the tomato shelf-life for 13 days without effect on fruit quality measured in terms of their content of vitamin - C, sugars and amino acids (El-Sayed 1978). But the use of ionising irradiations in food preservation is slow to gain the desired acceptability, owing to fears that consumption of foods may prove toxic to the consumer (Awan 1995). It is claimed that radiations bring changes in food materials that are not fully understood and that products of radiolysis could prove toxic (Tencheva 1976). The effects of ionising radiations on the different storage properties of fruits are given (Clarke 1968). Recent studies (Sattar *et al* 1992; Sattar 1993) have removed all fears, the radiolytic products have been detected and FAO/IAEA/WHO (IAEA 1997; IAEA 1998) expert committee has permitted irradiation of food materials to any dose level whereby the technological properties are not affected. Initially, the FAO/IAEA/WHO experts committee had allowed irradiation of foods upto a maximum of 10 kGy. Keeping this in view, present study was conducted to evaluate the effect of radiation on the physico-chemical characteristics of tomato during storage. Doses in the range of 20-400 krad were used for irradiation. The prescribed doses for treatment of fresh fruits and vegetables are given in Table 1 (Anon 1996).

The results for pH, acidity, ascorbic acid, optical density and % ripening are given in Tables 2 - 6. The data show that the pH (Table 2) decreased from 4.6 to 3.7 at lower doses while at higher doses very slight decrease was observed. As is clear from Table 3, the % acidity also decreased from 0.54 to 0.43, nevertheless, no proper pattern appeared. Brecht *et al* (1976) reported that table ripe tomatoes were higher in titratable acidity and lower in pH of the mature-green fruits. Kader *et al* (1976) found significant differences in the levels of pH and titratable acidity. The pH was lowest in fruits picked at the breaker (B) and typical mature green (TMG) stages while fruits picked at or near the table-ripe (TR) stage had highest pH values. The differences for titratable acidity were not significant but generally inversely related to pH.

The results on ascorbic acid (vitamin - C) are given in Table 4. The levels of vitamin - C increased at lower doses during storage, while remained almost stable at doses of 2.0 and 3.0 kGy. At higher dose i.e. 4.0 kGy, the vitamin - C contents decreased. Ionizing radiations decreased ascorbic acid in peprika puree and increased dehydroascorbic acid (Balla and Kiszel 1963). No prominent differences in total ascorbic acid were noted (Kader and Morris 1976). There were large differences in ascorbic acid content, fruits analyzed soon after picking (AR stage) had the highest level. The earlier the picking stage, the lower the ascorbic acid concentration, fruit harvested green and ripened at 20°C contained about 55 - 65 %

Table 4
Effect of different radiation doses on change in vitamin - C contents (mg/100g) of tomatoes during one week storage

Dose	Storage time (days)						
(kGy)	0	1	2	3	4	5	6
0.0	16.00	15.35	15.87	16.42	16.92	18.99	19.50
0.2	15.00	15.26	15.58	15.90	16.44	17.65	18.54
0.3	15.00	15.52	15.80	18.40	19.28	19.50	20.36
0.4	15.00	15.50	15.66	16.00	16.40	17.34	18.55
0.5	15.00	15.14	15.45	17.14	17.46	17.85	18.75
1.0	15.00	15.56	15.64	17.41	18.76	19.99	18.62
2.0	15.00	15.18	15.65	17.14	16.36	16.16	15.24
3.0	15.00	15.20	15.68	16.74	16.48	16.36	15.47
4.0	15.00	14.04	13.55	12.85	12.72	12.45	12.31

Table 5
Effect of different radiation doses on change in optical density of tomatoes during one week storage

Dose	Storage time (days)							
(kGy)	0	1	2	3	4	5	6	7
0.0	0.381	0.296	0.126	0.106	0.048	0.043	0.043	0.047
0.2	0.381	0.292	0.205	0.120	0.430	0.041	0.041	0.042
0.3	0.381	0.302	0.170	0.133	0.061	0.098	0.074	0.052
0.4	0.381	0.342	0.222	0.074	0.049	0.041	0.042	0.040
0.5	0.381	0.187	0.199	0.087	0.046	0.051	0.051	0.047
1.0	0.381	0.283	0.169	0.159	0.051	0.470	0.052	0.040
2.0	0.381	0.163	0.106	0.122	0.065	0.061	0.046	0.042
3.0	0.381	0.165	0.152	0.131	0.065	0.052	0.058	0.047
4.0	0.381	0.252	0.196	0.081	0.051	0.046	0.043	0.043

ascorbic acid relative to those picked at TR stage. The importance of physiological state as it may affect vitamins content is reported earlier (Maxie and Soommer 1968). Mature green fruits radiated to 4.0 kGy, then subsequently ripened showed 8-6 % loss in ascorbic acid, while table ripe fruits subjected to 3.0 kGy lost 20.4%. However, in the latter fruit there was initially almost twice as much as ascorbic acid, so that even with higher percentage of destruction by irradiation, the fruits still contain 5 mg/100 g more than the fully ripened unirradiated fruits harvested as mature green. As reported earlier (Enachescu 1956), ascorbic acid contents of riped tomatoes kept for 15-17 days at room temperature, do not show large variations. The riped tomatoes contain more ascorbic acid than unripened ones.

The optical density determined during the studies is given in Table 5. The levels decreased in all cases by a factor of about 10 during one-week storage. Physical separation, ripening and spoilage were carried out with the help of naked eye. The results on % ripening are given in Table 6. Ripening percentage in the samples irradiated at lower doses was relatively stable during storage while higher doses showed comprehensive delayed ripening scores. Irradiation induced softening which was evident in fruits. Fruit irradiated at mature green stage softened during post-irradiation (Assi *et al* 1997). Van Kooy (1968) studied the effect of gamma irradiation. Dose levels are 0.5, 1.0, 2.0 and 3.0 kGy on tomatoes at different stages of maturity. The largest increases are found at the low dose level, indicating the existence of an optimum at the 2.0 kGy dose level.

Table 6
Effect of different radiation doses on change in ripening percentage of tomatoes during one week storage

Dose	Storage time (days)							
(kGy)	0	1	2	3	4	5	6	7
0.0	0	0	5	7	12	15	13	15
0.2	0	0	2	3	4	8	9	9
0.3	0	0	3	3	3	5	7	7
0.4	0	0	1	1	1	9	8	8
0.5	0	0	4	4	6	9	9	10
1.0	0	0	1	2	3	6	4	5
2.0	0	0	1	1	2	3	1	2
3.0	0	0	0	0	1	8	4	5
4.0	0	0	0	0	1	4	3	4

Irradiation induced softening was evident in mature green and pink fruit within hours following irradiation and differences between irradiated and control fruit persisted through post-irradiation storage. Trends of firmness loss were much more consistent and showed much greater dose dependency in pericarp tissue than in whole fruit (Assi *et al* 1997).

Conclusion

Irradiation is of particular advantage in developing countries where the standards of hygiene are low and it is usually difficult to maintain strict hygiene in food processing areas. However, the commercial application of irradiation has been slow mainly due to high economic risks involved in the initial investment and reluctant attitude of consumer towards the consumption of such foods.The effects of irradiation on some physico-chemical parameters were determined in the present study. Overall, the data showed that values of acidity, vitamin C and optical density were almost stable at doses less than 4.0 kGy. Our results are in line with reported data.

Keeping in view, the importance of tomato consumption in Pakistan more work on irradiation as well as higher storage is desired for complete assessment in order to see the effect of irradiation on physico-chemical qualities of tomatoes. In general, limited data are available on the specific changes induced by irradiation in fruit constituents. Hence, more knowledge is required on the effect of irradiation on the changes occurring during the ripening process i.e. the extension of shelf life by understanding the basic mechanism. It is concluded that a great deal of research needs to be completed in this new field.

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