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SOME PHYSICOCHEMICAL CHANGES IN IRRADIATED BER (ZIZYPHUS JUJUBA) DURING STORAGE AND RIPENING

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Abstract. Mature, hard green *bers* of *Umran 13* variety were subjected to gamma radiation and doses of 10, 20, 30, 40 and 50 Krads were administered. The irradiated and unirradiated fruits were stored at room temperature (30°±2°C) and changes in physiological and biochemical parameters like weight loss, change of skin colour, total soluble solids, acidity, sugars, ascorbic acid, pectic substances, chlorophyll and carotenoids were studied. Fruits subjected to dose of 20–40 Krads were relatively firmer and greener, as compared with unirradiated control after 8 days' storage. There was no significant loss of any nutritive constituents due to irradiation. Organoleptic tests also did not show any detectable adverse effect of taste and flavour in irradiated fruit.

Zizyphus jujuba Lam commonly known as *ber* is one of the the ancient fruits of Indo-Pakistan subcontinent. This fruit is a good source of ascorbic acid and minerals,[1] is also thought to have some medicinal properties. At the time of harvest, the market is glutted with this fruit because of its short ripening period. In order to stabilize its price in the market for good returns to the farmers and to feed the food processing industry of the country for jam, jelly and candy making, the losses due to over ripening of this fruit during transit must be controlled.

Fruits undergo many physiological and biochemical changes before reaching maturity. Irradiation affects some processes and can modify normal ripening sequence and, therefore, changes the quality of fruit on either side.[2,6] No work of this type has so far been reported on this fruit. It was, therefore, of interest to investigate some physical and biochemical changes in addition to ripening and consumer acceptability of irradiated *bers* during storage.

Materials and Methods

Mature green *bers* of the *Umran-13* variety were picked from the experimental garden of the Punjab Agricultural Research Institute, Lyallpur. Fruit sorting was done on the basis of uniformity of size and maturity and selected fruits irradiated in a gamma beam-150 (Co^{60} source of 950 curies) at doses of 10, 20, 30 40 and 50 Krad. A separate lot was kept as control. The fruits were held in wooden trays and stored at room temperature (30°±2°C) and humidity (70–72%). Duplicate samples were analysed after suitable intervals during storage.

Weight loss was recorded from units of twenty fruits kept separately. Total acidity, total soluble solids (TSS) and ascorbic acid were determined according to the methods of AOAC.[7] During storage, TSS–acid ratio was also calculated. Sugars were estimated spectrophotometrically using potassium ferricynide as an oxidizing agent.[8] Total carotenoids were assayed by the method of Higby.[9] Final extracts for carotenoids were measured in a Beckman spectrophotometer (model DB/G). Total chlorophyll was estimated in the extract from whole chloroplast using water and acetone in the ratio of 1:4 (v/v) and the absorbance was read at 625 nm.[10] Total pectin and pectin fractions were determined by the method of Rouse and Atkins.[11]

Ripening studies were conducted by visual observations. Organoleptic evaluation of control and irradiated samples was carried out one week after irradiation by the method of Krum[12] using an arbitrary scale ranging from 0 to 10. The judges scored the samples for attributes such as colour, flavour, taste and texture. General acceptability of the fruit was calculated by adding the scores of parameters mentioned above. Statistical analysis of the data was carried out by analyses of variance technique.[13]

Results and Discussion

Weight Loss. A gradual decrease in weight was observed during storage (Table 2). The loss in weight is mainly due to respiration and/or transpiration. The fruits in all cases lost moisture to almost the same degree, indicating that the irradiation does not have significant influence on the retention of moisture in fruits. Our results agree with the findings of Herrera and Valencia[14] who studied the weight loss in irradiated mangoes. However, this is not in line with the results reported by Mathur and Lewis[15] who have reported higher losses in weight in the unirradiated than in the irradiated mangoes.

Visual Observations. There was no immediate effect of irradiation on the various quality parameters of *bers* at doses up to 50 Krad as observed visually. Control and 10 Krad-treated samples ripened after 3 days while 20–40 Krad-treated samples were still green and hard. On the other hand 50 Krad fruits

developed irregular brown patches on 4th day after irradiation. Fruits subjected to 20–40 Krad were comparatively in good condition even up to 8th day. Control and 10 Krad samples were over ripe and shrivelled by that time. It was interesting to note that 50 Krad treatment also had similar effect. It was, therefore, evident that a dose of about 20–40 Krad had the potential of delaying ripening of this fruit. Similar trend has previously been observed in mangoes and guavas (30 Krad), bananas (30–35 Krad) and several other fruits.[16]

Biochemical analyses of fresh mature green *ber* fruit is given in Table 1 which shows that this fruit contains comparatively more ascorbic acid than the citrus fruit. The effects of radiation and storage time on the biochemical constituents are given in Figs. 1 and 2 and Table 2.

Ascorbic Acid. Ascorbic acid content decreased considerably throughout ripening period (Fig. 1). After 10 days of storage the loss of ascorbic acid in all the samples ranged between 70–80%. This loss was about 10% more in control and 50 Krad samples as compared to *bers* irradiated at 10–40 Krad. Though ascorbic acid is considered as one of the most radiation sensitive vitamins,[17,18] yet the continued decrease of this vitamin in *bers* during ripening does not agree with the findings of Farooqi *et al.*,[3] Ali *et al.*[4] and Sattar *et al.*,[5] who while working on mangoes, bananas and tomatoes reported that the ascorbic acid initially increased until the fruit was fully ripe and then decreased during the later storage time. However our results agree with those of other workers,[14,19–22] who have maintained that vitamin C content of fruits decreases continuously as the ripening stage advances. The reason for continuous loss of vitamin C in *bers* during ripening may be that it is synthesized in green chloroplast of fruit from carbohydrate precursors, i.e. D-galactose. That is why it is at highest level in young fruits and decreases with the maturation of the fruits.

Pigments. Immediate effect of irradiation on carotenoids was insignificant but it manifested considerably during storage thereby suppressing pigment formation in the irradiated samples (Fig. 2). However, there was rapid synthesis of carotenoids in control fruits. The trend of carotenoid development in *bers* during ripening is very much different from that reported in case of mangoes and papayas.[14,20,23] An increase in radiation dose from 10 to 50 Krad did not

TABLE 1. BIOCHEMICAL ANALYSES OF MATURE GREEN *Bers* (EDIBLE PORTION).

Constituent	Amount (%)
Ascorbic acid	0.066
Total carotenoids	1.5×10^{-4}
Chlorophyll	0.87
Total pectin	0.977*
NaOH-soluble pectin	0.780*
$(NH_4COO)_2$–soluble pectin	0.075*
H_2O-soluble pectin	0.122*
Acidity	0.166
Total soluble solids	10.40
Total sugar	6.29
Fructose	2.74
Glucose	0.47
Total reducing sugars	3.42
Sucrose	2.71
TSS/acidity ratio	62.65

*AGA, anhydrogalacturonic acid.

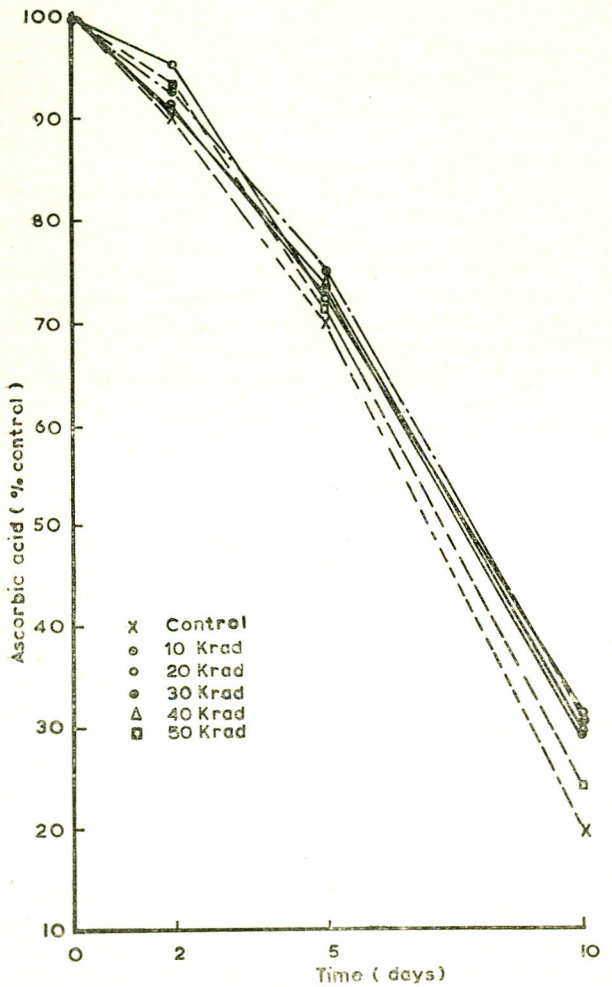

Fig. 1. Effect of irradiation on the ascorbic acid contents of *bers* during ripening.

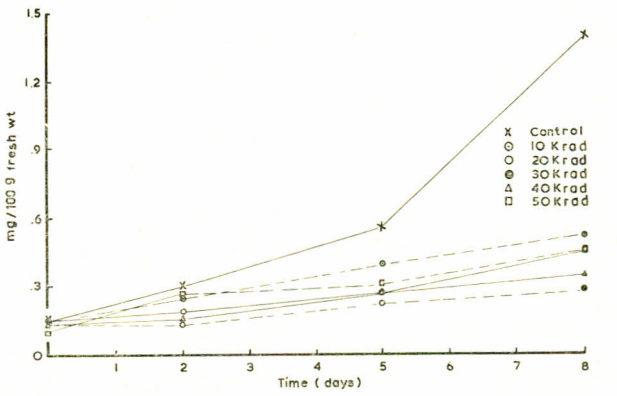

Fig. 2. Effect of irradiation on total carotenoid contents of *bers* during ripening.

TABLE 2. MEAN VALUES OF VARIOUS PHYSICOCHEMICAL CHARACTERISTICS OF IRRADIATED *Bers* DURING RIPENING AT DIFFERENT STORAGE INTERVALS.

Bers (%)	Storage time (days)					Radiation dose (Krads)						
	0	2	5	8	Significance L.S.D. P=0.05	0	10	20	30	40	50	Significance L.S.D. P=0.05
Acidity	0·162	0·158	0·130	0·109	0·0102**	0·137	0·132	0·147	0·137	0·144	0·141	0·0125†
TSS	9·44	10·32	11·41	12·36	1·3158**	11·76	11·47	10·87	10·26	10·99	10·71	N.S.
TSS/Acidity	61·53	65·52	88·41	114·39	11 3017**	89·89	91 02	77·33	76·82	78·34	81·38	N.S.
Glucose	0·44	0·57	0·88	1·41	0·1242**	0·77	0·81	0·82	0·77	0·92	0·87	N.S.
Fructose	2·92	3·21	3·03	3·17	N.S.	3·14	2·91	3·18	3·12	3·04	3·11	N.S.
Total reducing sugars	3·36	3·79	4·09	4·58	0 1768**	3·41	3·97	4·00	3·89	3·96	3·98	N.S.
Sucrose	2·51	2·60	3·18	3·65	0·2685**	3·10	3·02	2·85	2·92	3·02	3·00	N.S.
Total Sugars	6·00	6·53	7·43	8·43	0·3295**	7·18	7·15	7·00	6·97	7·15	7·15	N.S.
Weight loss	—	3·65	14·83	24·14	1·6975**	14·16	14·54	14·29	13·67	13·69	14·88	N.S.
Chlorophyll	0·735	0·101	0·074	0·056	0·08069**	0·272	0·308	0·247	0·222	0·212	0·189	N.S.
Water-soluble pectin*	0·150	0·205	0·403	0 485	0·02066**	0·317	0·307	0·312	0·307	0·301	0·302	N.S.
Ammonium oxalate soluble-pectin*	0·088	0·113	0·136	0·152	0·00953**	0·117	0·122	0·123	0·126	0·126	0·120	N.S.
Sodium hydroxide soluble-pectin*	0·729	0·633	0·403	0·254	0·03362**	0·487	0·490	0·506	0·516	0·521	0·510	N.S.
Total pectin*	0·967	0·952	0·944	0·891	0·02173**	0·922	0·919	0·941	0·949	0·949	0·952	N.S.

*Significant at P 0·05 **significant at P 0·01; N.S., not significant; †AGA, anhydrogalacturonic acid.

significantly change the pattern of carotenoid formation.

The changes that occurred in chlorophyll content revealed a sharp decrease on 2nd day following irradiation (Table 2). The contents decreased to negligible on 5th day in all the samples. The chlorophyll content varied among various lots due to difference in physiological stage of these fruits. However, there was no significant difference in the amount of chlorophyll at the end of experiment. Maxie *et al.*[2] also noted that irradiated peaches and nectarines lost their green colour more rapidly than did unirradiated fruits. However, Dharker *et al.*[20] working on mangoes, reported that the effects of radiation on fruit skin seemed to be manifested more in terms of inhibition in chlorophyll disappearance and carotenoid formation than in ripening changes in the pulp.

Pectic Substances. Total pectin gradually decreased during ripening in storage (Table 2) and the pectic contents were slightly less at the end of storage for 8 days. A progressive degradation of NaOH-soluble pectin fraction and increase in H_2O-soluble as well as $(NH_4COO)_2$-soluble pectin fractions clearly indicate that protopectin is gradually converted to pectates and pectinates during ripening and the effect was statistically significant on either side. It was noted that irradiation did not significantly affect pectin and its fractions during ripening. The trend of changes in pectic substances in *bers* is a normal behaviour of various fruits and vegetables during ripening.[5,24,25]

Sugars, Total Soluble Solids (TSS) and Acidity. There was no immediate or latent effect of irradiation on sugars but except fructose the contents increased during subsequent storage period (Table 2). However, the increase in sugars was not consistent and it may be due to difference in ripening behaviour of various samples. The increase in sugars is at the expense of starch which disappears during ripening. Similar results have been reported in other fruits.[3,5,19,26]

Total soluble solids (TSS) also increase during ripening in all the samples whereas irradiation treatment had no such influence. Similarly Agnihotri *et al.*[21] reported an increase in TSS due to the breakdown of starch in mangoes. Total acidity significantly decreased during ripening in all the samples. This may be due to the conversion of organic acids to other metabolites like alcohols, esters etc. TSS/acidity was not influenced by different radiation doses, but during ripening there was significant increase in the ratio due to increase in TSS and decrease in acidity.

Organoleptic Evaluation. Irradiated and unirradiated control fruit was evaluated organoleptically after 7 days ripening period. Statistical analysis (Table 3) showed that irradiation doses (10–50 Krad) did not affect colour, flavour, taste and acceptibility of the fruit, when compared to unirradiated samples. On the other hand, it was noted that irradiation treatments improved the texture of the fruit. It was, therefore, concluded that irradiation of this fruit resulted in the retention of flesh firmness. Our findings coincide with earlier reports where the control

TABLE 3. AVERAGE PANEL SCORES FOR COLOUR, FLAVOUR, TASTE, TEXTURE AND OVERALL ACCEPTABILITY OF *Bers* IRRADIATED AT 6 LEVELS AND HELD 1 WEEK.[1]

Radiation dose (Krads)	0	10	20	30	40	50	Significance L.S.D.P=0.05
Colour	5.50	5.25	5.25	4.75	6.25	4.63	N.S.
Flavour	5.50	5.00	5.13	5.13	5.25	5.38	N.S.
Taste	4.88	4.88	5.13	5.25	5.00	5.00	N.S.
Texture	4.00	5.88	6.25	5.50	7.38	5.62	1.002**
Overall evaluation	5.13	5.25	5.75	5.13	6.00	5.38	N.S.

[1]Mean of 8 judgements; N.S., non significant; **Highly significant.

fruits were found softer than irradiated fruits during storage and ripening.[3,4,5,20]

Conclusion

Irradiation caused delay in ripening of *bers* for 5 days over control samples. There was no significant loss of any nutritive constituents. Irradiated *bers* retained better texture, thus improving the quality of fruit.

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