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EFFECT OF GAMMA IRRADIATION ON THE POSTHARVEST QUALITY OF BLOOD RED ORANGES

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Different irradiation doses (5, 10, 25, 50, 100, 200, 300 krad) did not alter the weight loss pattern of oranges during postharvest storage (7-20°, 54-88% RH). Ascorbic acid, reducing, nonreducing and total sugars content and sugar/acid ratio of oranges were not significantly changed by irradiation doses applied, however, total acid content decreased as an effect of irradiation. Irradiation doses at 100 krad and above caused skin injury in the form of scald and pitting, hence external appearance scores were lowered. Flavour scores of unirradiated control oranges and those irradiated at different doses were comparable after 5 weeks of storage at room conditions.

Key words: Oranges, Irradiation, Postharvest quality.

Introduction

Blood red is a speciality orange and is produced in abundance in North West Frontier Province (NWFP) of Pakistan. This fruit can very easily compete with other citrus cultivars in national and international markets provided its quality is maintained during postharvest handling and storage. Insects and fungi mainly responsible for spoilage of citrus fruits are commonly controlled by the use of various chemicals. These chemicals have residual toxic effects and have proven to be injurious to biological systems. Irradiation is a nonresidual alternate technology which can be exploited for decreasing spoilage in fruits.

World Health Organization (WHO), Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA) of the United Nations [1], have cleared the use of irradiation in food upto 1 Mrad. Success of this method, however, depends on finding a dose for elimination of insects/fungi that does not cause significant damage to the fruit. The phytotoxic response of citrus fruits to irradiation varies from cultivar to cultivar [2]. This study was instituted to determine the phytotoxic response of Blood Red oranges to disinfestation/radurization doses of gamma irradiation.

Materials and Methods

Procurement, processing and storage of fruit. Fully mature Blood red oranges were procured from garden around Peshawar in the month of January, 1986 and transported to the Laboratory by road in cardboard boxes lined with newspaper sheets. The stalks were cut close to the shoulders and injured fruits were discarded. Fruits were washed in running tap water, dried and divided into eight equal lots. One lot was kept as unirradiated control whereas the remaining lots were separately irradiated at 5, 10, 25, 50, 100, 200 and 300 krad dose levels. Irradiation was carried out in Gamma Researcher, Cobalt-60 Source of USSR origin. Dose rate at the time of irradiation was 715 krad per hour. Irradiated and unirradiated lots were packed separately in perforated cardboard boxes lined with newspaper sheets (0.093 mm thick) and stored at ordinary room conditions (7-20°, 54-88% RH).

Following physicochemical analysis were carried out after weekly intervals.

(i) *Weight loss.* Ten fruits of control and irradiated lots were marked in the start of the experiment and kept separate for periodical weighing to calculate weight loss during storage.

(ii) *Chemical analysis.* Ascorbic acid and acidity content of citrus juice were determined titrimetrically by the AOAC [3] methods. Sugars were analysed colorimetrically using potassium ferricyanide as oxidizing agent by the method of Ting [4]. Total sugar and acid ratio was calculated.

(iii) *Organoleptic evaluation.* All the samples were evaluated sensorily for external appearance and flavour (odour + taste) by a panel of 10 judges using a scale from 0 to 10 where 0 indicated disliked extremely and 10 indicated liked extremely.

(iv) *Statistical analysis.* Data were analysed statistically by analysis of variance with least significant difference (LSD) between treatments and storage intervals means determined [5].

Results and Discussion

(i) *Weight loss.* Citrus, like other fruits, start losing weight immediately after picking. Excessive weight loss

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adversely affect the postharvest quality of citrus fruits as it can cause shrivelling and loss of gloss [6], decrease in resistance to deformation [7] and increased susceptibility to physiological disorders [8]. In present investigation irradiation of oranges upto 300 krad dose level did not cause any significant change in its weight loss, and the loss in weight was comparable in control and all the irradiated samples during five weeks of storage at room conditions (Table 1). Similar effect of irradiation on weight loss has been reported by Guerrero *et.al.* [9] in Washington Navel oranges, Monselise and Kahan [10] in Shamouti and Valencia oranges, Farooqi *et. al.* [11] in kinnow mandarins and Chaudry *et. al.* [12] in Fentrell's Early mandarins.

(ii) *Chemical constituents*. As the citrus fruits ripen on the tree, maturity standards are synonymous with internal quality standards [13]. Some of the changes characteristic of maturation, notably decrease in acidity and increase in total soluble solids (TSS), continues after storage [14]. Such normal changes in chemical constituents of Blood Red oranges during storage at room conditions were recorded in present experiment (Table 1).

Irradiation upto 300 krad did not cause any significant changes in reducing, nonreducing, total sugars and sugar/acid ratio of Blood Red oranges (Table 1). Ascorbic acid content of control fruits (49.14 mg/100 ml) were relatively higher than that of irradiated ones (43.76 to 47.63 mg/100 ml), however this difference was not statistically significant. Irradiation doses higher than 100 krad, significantly ($p < 0.01$) decreased acidity content of this cultivar of citrus fruit.

Results on the effect of irradiation on the chemical constituents of citrus fruits are note consistent. O'Mahony *et.al.*[15] reported that irradiated (60-85 krad) California Nevel oranges exhibited a greater soluble solids/total acid ratio increase and titratable acidity decrease which confirmed earlier work at higher (100-500 krad) radiation doses [9, 16-18]. As regards grapefruits, earlier studies of Moshonas and Shaw [19] indicated reduction in vitamin C at 60 krad but no change in sugar and acids. However, in latter studies [20] there was no marked difference in ascorbic acid, sugars or acid levels in juice from irradiated fruits (70 krad) when compared with those from unirradiated ones. As regards mandarins, present results are in total agreement with that of Farooqi *et. al.* [11] on kinnows, but do not agree with that of chaudry *et. al.* [12] on Feutrell's Early mandarins who reported decrease in ascorbic acid and acidity content and increase in TSS and TSS/acid ratio due to irradiation upto 300 krad dose level.

(iii) *Organoleptic characteristics*. Irradiation doses of 100 krad and above caused injury to the peel of fruit in present study. The injury was in the form of scald and pitting which lowered the external appearance scores of irradiated samples (Table 2). However, there was no significant skin damage problem with fruits irradiated below 100 krad dose levels. Different irradiation doses used did not cause any significant adverse change in flavour scores of Blood Red oranges. These scores, therefore, were comparable in control and irradiated samples after 5 weeks of storage at room conditions.

Due to carcinogenic nature of most of the fumigants, lot of interest has been shown recently to replace chemical

TABLE 1. EFFECT OF GAMMA IRRADIATION AND STORAGE INTERVALS ON THE PHYSICOCHEMICAL CHARACTERISTICS OF BLOOD RED ORANGES . STORED AT ROOM CONDITIONS (7-20°, 54-88% RH).

Parameters	Radiation doses (krads)								LSD	Storage periods (weeks)						LSD
	0	5	10	25	50	100	200	300	%	0	1	2	3	4	5	
Weight loss	10.1	10.1	10.3	10.3	10.0	10.3	10.5	10.2	NS	-	3.79	6.01	9.53	12.14	17.87	0.92
Ascorbic acid (mg/100 ml)	49.14	45.95	47.45	46.04	47.63	45.72	43.98	43.76	NS	50.51	46.66	46.10	45.90	45.41	43.04	4.35
Reducing sugars (g/100 ml)	5.27	5.46	4.96	5.36	5.29	5.22	5.17	5.20	NS	4.86	4.99	5.19	5.38	5.42	5.61	0.28
Non-reducing sugars (g/100 ml)	4.91	4.24	4.76	4.30	5.02	4.62	4.26	4.29	NS	4.26	4.27	4.06	4.58	4.62	5.53	0.72
Total sugars (g/100 ml)	10.18	9.70	9.72	9.66	10.31	9.84	9.43	9.49	NS	9.12	9.26	9.25	9.96	10.04	11.14	0.62
Acidity (g/100 g)	0.99	0.90	0.91	0.94	0.90	0.93	0.83	0.80	0.09	1.01	0.95	0.91	0.86	0.84	0.82	0.09
Sugar/acid (ratio)	11.14	11.00	10.68	10.28	11.46	10.58	11.36	11.86	NS	9.03	9.75	10.17	11.58	11.95	13.59	1.31

fumigation with low doses of irradiation. Moshonas and Shaw [19] reported flavour differences in pasteurized juice from grape fruit irradiated at 50 and 60 krad doses. In another study, Moshonas and Shaw [20] could not find abnormal flavour in grapefruit upto 30 krad, however, adverse flavour effects increased in products from grapefruits exposed to 60 and 90 krad dose levels.

Table 2. Mean Scores Showing Effect of Gamma Irradiation on the Organoleptic Characteristics of Blood Red Oranges After Five Weeks Storage at Room Conditions (7-20°, 54-88% RH).

Characteristics	Radiation doses (krad)								LSD
	0	5	10	25	50	100	200	300	1%
External appearance (0-10)*	6.70	6.50	6.40	6.40	6.50	4.40	3.95	3.50	0.95
Flavour (0-10)*	7.15	7.05	7.20	7.30	7.50	7.40	7.45	7.55	NS

All the scores are average of ten judgement.
*0=liked extremely. 10=Disliked extremely.

Hatton *et. al.* [21, 22] while working with Florida grape fruit arrived at similar conclusions. O'Mahony *et. al.* [15] reported more differences due to low irradiation doses (60-80 krad) in Navel oranges for degree of blemishing, but less differences were recorded for flavour by mouth. Phytotoxic effect of irradiation on fruits can be influenced by cultivar [2], time of harvest [20, 21, 22], postharvest treatments [23], storage condition [11] and storage period [15]. Variation in the results reported by various workers can be due to these factors.

Conclusion

Radiation doses below 100 krad can control insects especially fruit fly in citrus fruits [24], whereas doses above 100 krad are required to supress the growth of fungi [25]. It is, therefore, concluded from above mentioned results that disinfestation doses of gamma irradiation (below 100 krad) are safe for Blood Red oranges as they did not cause any adverse changes in weight loss, chemical constituents and organoleptic attributes of this cultivar during storage at room conditions.

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