academicJournals

Vol. 9(3) pp. 97-102, March, 2015
DOI: 10.5897/AJFS2014.1245
Article Number: AF4345450800
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Alphonso mango conservation through exposure to gamma radiation

M. K. Yadav[1]*, N. L. Patel[2], D. P. Patel[3], Kirtibardhan[3] and M. R. Parmar[4]

[1]Department of Horticulture, N. M. College of Agriculture, Navsari Agricultural University, Dandi Road, Navsari 396450, India.
[2]Department of Fruit Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Dandi Road, Navsari 396450, India.
[3]Department of Natural Resource Management, College of Forestry, Navsari Agricultural University, Dandi Road, Navsari 396450, India.
[4]Department of Agroforestry, College of Forestry, Navsari Agricultural University, Dandi Road, Navsari 396450, India.

Received 1 December, 2014; Accepted 27 January, 2015

Dispensation of fresh produce especially fruits through radiation, involves exposure to short wave energy to achieve a specific purpose *viz.* reduce the weight loss and extend the ripening. An experiment was carried out to study the effect of irradiation and storage conditions in Alphonso mango on physiological weight loss and ripening. The experiment was laid out in completely randomized block design with factorial concept with three repetitions. The fruits were exposed to gamma radiation for different doses from the source of ^{60}Co at Board of Radiation and Isotope Technology, Bhabha Atomic Research Centre, Mumbai. There were sixteen treatment combinations of irradiation dose (I_1 -0.00, I_2 -0.20, I_3 -0.40 and I_4 -0.60 kGy) and storage temperature (S_1-Ambient, S_2-9°C, S_3-12°C and S_4-CA storage (12°C, O_2 2%, CO_2 3%). The data indicated that the fruits irradiated with 0.40 kGy gamma rays (I_3) recorded significantly minimum percent reduction in physiological loss in weight and extended the ripening. Similar pattern was noted when fruits were kept at 9°C storage temperature. Combined effect of 0.40 kGy gamma rays irradiation and 9°C storage temperature (I_3S_2) also recorded maximum reduction in the physiological loss in weight and ripening percent throughout the storage period.

Key words: Gamma rays, *Mangifera indica* L., postharvest, ^{60}Co, refrigeration.

INTRODUCTION

Mangoes (*Mangifera indica* L.; family Anacardiacae) are known as luxuries and expensive fruit in the markets of many industrialized countries. Asia accounts for 77% of global mango production and the Americas and Africa account for 13 and 19%, respectively (Yadav and Parmar, 2014). India is the global leader in mango production (Yadav and Patel, 2013). The high cost of mangoes in importing countries is due primarily to air freight charges. Mature fruits may take from three to eight days to ripen and this short period certainly limits the commercialization at long distance. Sea

*Corresponding author. E-mail: manoj_bioversity@hotmail.com.

transport is less expensive and enables transportation of larger volumes and it thus would aid in the expansion of mango export industries. At the present stage of development, however, sea shipment does not guarantee good quality fruit on arrival for successful marketing. Mangoes are classified as climacteric fruits and ripen rapidly after harvest. Mango is generally harvested when physiologically mature and ripen under suitable conditions of air temperature and humidity. Therefore, if freshly harvested fruit is allowed to ripen at normal ambient conditions (this can vary between 22-32°C and 40-65% RH), ripening processes increase rapidly within the week (Yadav et al., 2013a).

The ripe fruit may stay edible for a few days thereafter. It is because of this fact that fruits must be stored under specific storage conditions, not only to maintain weight loss but also to prolong ripening. Mango is susceptible to chilling injury and an optimum air temperature of 12-13°C is generally recommended (Gomez-Lim, 1993). Irradiation of fruits has been successfully shown to delay ripening (Pimentel and Walder, 2004). Irradiation is also a physical process for the treatment of foods akin to conventional process like heating or freezing. It prevents food poisoning, reduces wastage to contamination and at the same time preserves quality (Mahindru, 2009). Therefore, the new knowledge is critical because it is important to maintain a balance between the optimum doses required to achieve safety and the minimum change in the quality of the fruit. In view of the above fact, it becomes quite clear that investigation for mango fruit is very important not only to reduce the ripening but also control the weight loss. So, irradiation can be used in combination with low temperature to assess the effects of different doses of gamma irradiation and storage temperature on reduction of the physiological loss in weight and ripening phenomena of fruit. The loss in weight of fruits is likely to reduce the quality of fruit drastically.

Therefore, one of the main objectives of any post harvest treatment is to reduce the extent of physiological loss in weight. The Alphonso variety of mango is famous for its excellent table fruit quality. This is a leading commercial mango cultivar of India and Pakistan and is taking position in the export market. The ripen fruits have attractive colour, and excellent sugar : acid blend. To study the combined effect of irradiation dose and storage temperature on prevention of mango was the main objective of study.

MATERIALS AND METHODS

The research was conducted during the months of June-July, in the year 2010 at Cold Storage, Post-Harvest Technology Unit and the laboratory of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat), India. Export grade mangoes of cv. Alphonso were harvested on 12th June 2010. The selected mangoes from class I as per the quality parameters were specified and described in "post harvest manual for mangoes" published by APEDA (Anon., 2007). There were sixteen treatment combinations of irradiation dose (I_1 -0.00, I_2 -0.20, I_3 -0.40 and I_4 -0.60 kGy) and storage temperature (S_1-Ambient, S_2-9°C, S_3-12°C and S_4-CA storage at 12°C). The fruits were exposed to gamma radiation for different doses from the radio isotope ^{60}Co at ISOMED plant, Board of Radiation and Isotope Technology, Bhabha Atomic Research Centre, Mumbai. The fruits were packed in CFB box and kept at various temperatures, that is, at ambient, 9°C (90% RH), 12°C (90% RH) and at control atmospheric storage (12°C, O_2 2%, CO_2 3% and RH 90%). The dimensions of CFB box were 370 x 275 x 90 mm and gross weight of box with fruits was 3.0 kg. One CFB box had nine fruits for each treatment, each treatment was replicated thrice. The individual fruit weight was from 250-350 g. During the irradiation process, the fruit boxes were kept in the irradiation chamber through a conveyor system. The source rack with its ^{60}Co pencils was raised from the storage pool by automated control system. The product packages are then moved around the radiation source in such a way that they are exposed to radiation for predefined time. Transportation of fruits for irradiation at BARC was carried out in an air conditioned vehicle. Four fruits from each treatment of each replication were earmarked during the investigation for measuring physiological loss in weight. Fruits were weighted on first day of treatment and subsequently their weight was recorded at six day interval up to the end of shelf life. The physiological loss in weight (PLW) was expressed in percentage and calculated as proposed by Yadav et al. (2013a).

PLW percent $= W_1 – W_2 / W_1 \times 100$

Where W_1 = initial weight and W_2 = final weight.

The ripening was measured by the number of fruits having change in colour from greenish to yellow and soft in texture which were counted at six day intervals up to eating ripeness and expressed in percentage over total number of fruits taken for study. After 12th day of storage, few treatments had 0.00 values for PLW and ripening due to completion of their shelf life and unripening, therefore, individual mean value of irradiation and storage temperature was different from the original. So, only interaction effect was interpreted. Statistical analysis of the two year data was done by following the Fisher's analysis of variance technique (Panse and Sukhatme, 1967) at Information Technology Centre, Department of Agricultural Statistics, N. M. College of Agriculture, Navsari Agricultural University, Navsari. Values were expressed as the mean standard deviation. The statistical significance of the differences was examined using analysis of variance. Results at probability value of less than 0.05 were considered signififcant.

RESULTS AND DISCUSSION

The data indicated that the physiological loss in weight of fruits increased with the advancement of storage period and significantly influenced by irradiation, storage temperature and their interaction. It is evident from Figure 1 that the physiological loss in weight was significantly influenced by various treatments of gamma rays. Consistently and significantly, minimum PLW was observed in treatment I_3 (0.40 kGy) at 6th, 12th, 18th, 24th, 30th and 36th days of storage, that is, 2.155, 3.856, 5.790, 3.810, 2.410 and 2.900 percent, respectively and the maximum PLW was observed in I_1 (0.00 kGy) at different storage conditions. Similarly, storage temperature affects the PLW and Figure 2 shows that the significantly minimum PLW was observed in treatment S2 (9°C) at 6th, 12th, 18th, 24th, 30th and 36th day of fruit storage (1.095, 2.209, 3.270, 4.670, 6.070 and 5.120%, respectively). Whereas, maximum PLW percent was recorded in fruits kept at ambient temperature (S¬1) at different storage conditions. Interaction between irradiation and

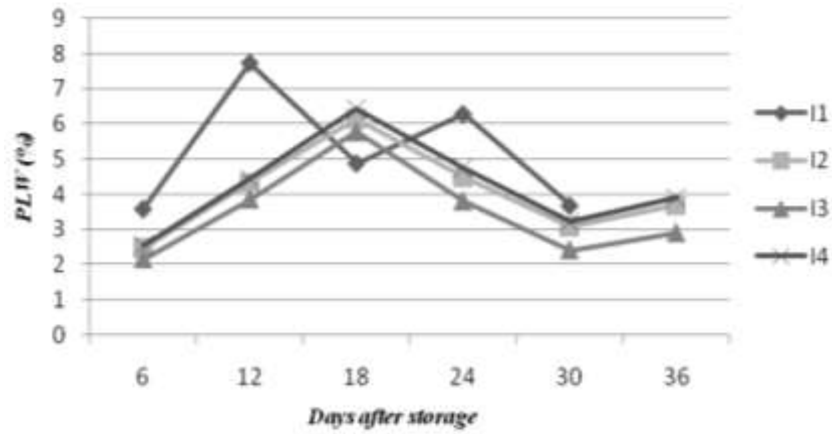

Figure 1. Exposure of gamma rays influenced PLW (%) of Alphonso mango at different days of storage.

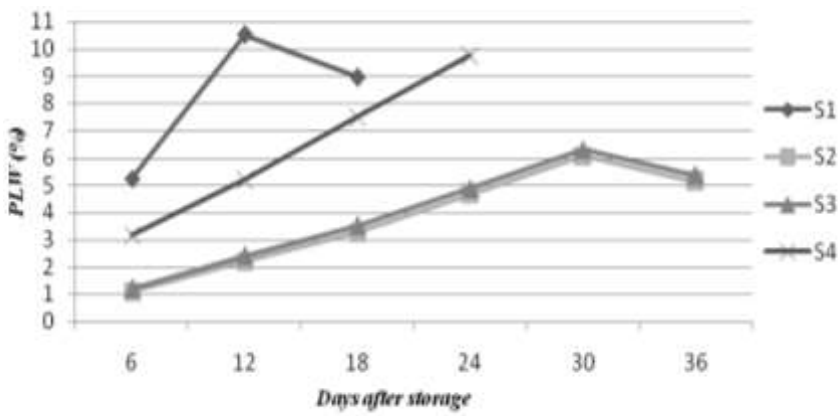

Figure 2. Storage condition influenced PLW (%) of Alphonso mango at different days of storage.

storage temperature was found significant and irradiated fruits significantly reduced the PLW over unirradiated fruits at all conditions of the storage. The shelf life extended up to 36 day, and on this day, only fruits exposed to 0.40 and 0.60 kGy irradiation and stored at 9°C has shelf life and the minimum reduction in PLW percent was recorded at six day interval in the fruits exposed with 0.40 kGy irradiation and stored at 9°C (I_3S_2), that is, 5.660% at 36th day, 4.720% at 30th day, 3.480% at 24th day, 2.750% at18th day, 1.777% at 12th day and 0.920 at 6th day of storage (Figure 2). The remaining treatments were discarded due to the lost of their shelf life at every stage of over ripening. The PLW was possibly on account of loss of moisture through transpiration and utilization of some reserve food materials in the process of respiration (Mayer et al., 1960). It is evident from the data that the physiological loss in weight of mango fruit was significantly influenced by the various exposed dose of gamma rays and different storage temperature (Figure 3). The irradiation significantly reduced PLW during storage period over control which might be attributed to reduction in utilization of reserve food material in the process of respiration (Purohit et al., 2009). The delay in respiration rate as a result of irradiation is also reported by Singh and Pal (2009) in guava. Similar findings were also observed by Yadav et al. (2013c), Prasadini et al. (2008) and El-Salhy et al*.* (2006) in mango. Similarly, in the different storage conditions, the highest physiological loss in weight was observed in fruits subjected to ambient temperature. Lower physiological loss in weight was noted in 9 and 12°C and in CA (12°C) storage temperature which might be due to lesser water vapour deficit as compared to ambient condition and the low temperature which had slowed down the metabolic activities like respiration and transpiration (Yadav et al., 2013b). The observations are in accordance with the results of Roy and Joshi (1989) and Waskar and Masalkar (1997) in mango; Nagaraju and Reddy (1995) and Aina (1999) in banana and Gutierrez et al. (2002) in guava.

The significant minimum reduction in PLW of mango fruits subjected to irradiation and stored at various temperatures, that is, at 9 and 12°C and in CA (12°C) might be due to the

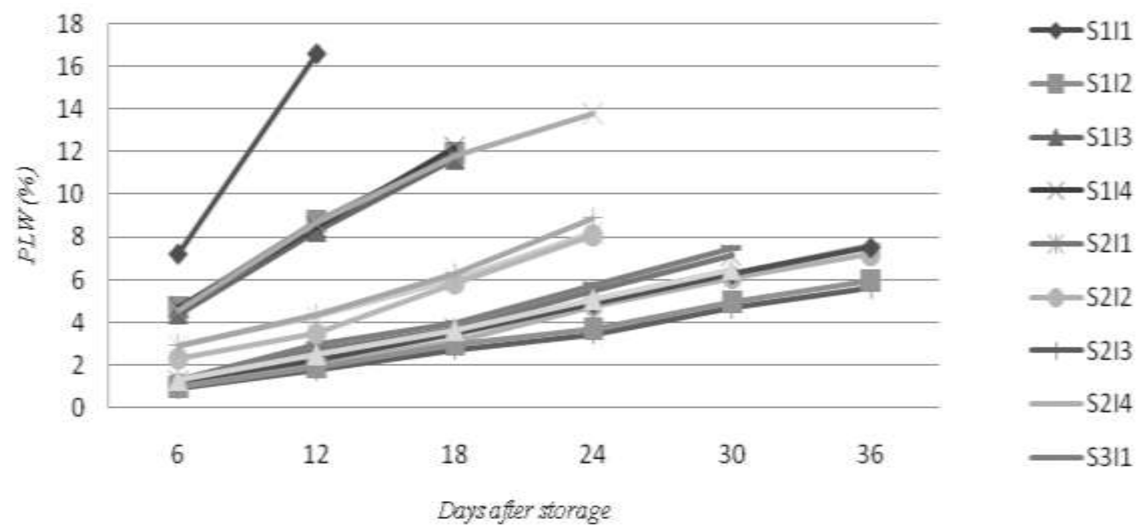

Figure 3. Combined effect of gamma rays and storage condition on Alphonso mango during storage.

Table 1. Irradiation and storage conditions influencing the ripening of Alphonso mango during storage.

Source	Ripening (%) days after storage														
	6					12					18				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
S_1	33.530 (35.374)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	8.380 (10.084)	97.480 (80.840)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	24.370 (21.450)	0.000* (1.65)	83.810 (66.250)	83.730 (66.182)	85.750 (67.794)	63.320 (50.471)
S_2	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)
S_3	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)
S_4	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	34.950 (36.227)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	8.740 (10.297)
Mean	8.380 (10.084)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)		24.370 (21.450)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)		8.740 (10.297)	20.950 (17.803)	20.930 (17.786)	21.440 (18.189)	
Source	I		S	I X S		I		S		I X S	I	S		I X S	
S.Em ±	0.003		0.003	0.006		0.003		0.003		0.007	0.014	0.014		0.029	
CD ($P≤0.05$)	0.009		0.009	0.019		0.010		0.010		0.022	0.043	0.043		0.086	

Table 1. Contd.

Source	Ripening (%) days after storage									
	24					30				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
S_1	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00 (1.65)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00 (1.65)
S_2	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	83.43 (65.95)	53.21 (46.82)	50.05 (46.82)	65.18 (45.01)	62.97 (52.90)
S_3	41.57 (40.13)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	10.39 (11.27)	97.82 (81.47)	58.16 (49.68)	51.93 (49.68)	74.03 (46.08)	70.48 (59.14)
S_4	98.26 (82.39)	79.56 (63.09)	75.05 (60.01)	83.57 (66.06)	84.11 (67.89)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00 (1.65)
Mean	34.96 (31.46)	19.89 (17.01)	18.76 (16.24)	20.89 (17.76)		45.31 (37.68)	27.84 (24.95)	25.49 (23.60)	34.80 (29.12)	
Source		I	S		I X S	I		S		I X S
S. Em ±		0.02	0.02		0.03	0.01		0.01		0.02
CD (*P*≤0.05)		0.05	0.05		0.10	0.03		0.03		0.06

Figures in parenthesis indicate ARC SINE transformed value, *Indicate fruits completely discarded, I = irradiation, S = storage temperature.

mutual complementary effect of irradiation and low temperature (Yadav et al., 2013a). Table 1 Indicates that the ripening percentage of fruits were influenced by the advancement of storage period and significantly affected by irradiation, storage temperature and their interaction. Irradiated fruits significantly delayed the ripening process over unirradiated fruits at all conditions of the storage. Irradiated fruits still did not fully ripe up to 30th day of storage, stored at 9°C. On this day, fruits exposed to 0.40 kGy recorded minimum unripe fruits, similarly, fruits stored at 9°C showed only 63.14 ripening in fruits. The remaining treatments were discarded due to the lost of their shelf life. The fruits exposed to gamma rays (0.20 and 0.40 kGy) and stored at 9 and 12°C had more than 50% unripe (I_3S_2 and I_3S_3) on 30th day of storage, they showed 50.05 and 51.93% ripening, respectively. The remaining of the treatments had high ripening or discarded due to completion of their shelf life.

The fruits exposed to gamma rays and stored at 9 (S_2) and 12°C (S_3) storage temperature as well as unirradiated fruits kept at 9°C remained unripe (I_1S_2) at 24th day of storage (Figure 3). Unirradiated and irradiated fruits kept at ambient temperature were discarded due to the end of their shelf life and the remaining were under ripening. At 18th day of storage, unirradiated fruits were discarded due to full ripening at ambient conditions, remaining unripe or showed minute ripening. At 6th and 12th day of storage, ripened fruits (33.530 and 97.480%, respectively) were observed in unirradiated fruits stored at ambient temperature (I_1S_1). The remaining of the treatments was fully unripe. Ripening percentage is a physiolo-gical process which designates the period from harvest until the fruits attain the stage of maximum consumer acceptability. The unirradiated mangoes early showed ripeness whereas, gamma rays exposed mangoes had significantly delayed ripening. The possible mechanisms that have been postulated include: a) irradiations results in decreased sensitivity to ripening action of ethylene and b) alteration in carbohydrates metabolism by regulating certain key enzymes, which interfere with production of ATP which is required for various synthetic processes during ripening (Udipi and Ghugre, 2010). Same findings were noted by Yadav and Patel (2014) and Farzana and Panhwar (2005) in mango and Aina et al. (1999) in banana. The lower and delayed ripening was noted at 9 and 12°C and in CA (12°C) storage as compared to ambient temperature. The decrease in ripening percent and increase in days for ripening at low temperature may be due to desirable inhibition of enzymatic activities leading to reduction in the respiration and ethylene production (Mane, 2009). These results are supported by Mann and Singh (1975) in mango and Deka et al. (2006) in banana. The minimum and delayed ripening in fruits is due to exposure to gamma rays and storage temperature at 9 and 12°C and in CA (12°C) storage as compared to fruits unirradiated and kept at ambient temperature in the present study which might be due to the joint balancing effect of irradiation and low temperature (Yadav and Patel, 2014).

Conflict of interests

The authors did not declare any conflict of interest.

REFERENCES

Aina JO, Adesiji OF, Ferris SRB (1999). Effect of gamma irradiation on post harvest ripening of plantain fruit (*Musa paradisiaca* L.). Cultivars. J. Sci. Food and Agric., 79(5):653-656.

Anonymous (2007). Post harvest manual for mangoes. APEDA, Ministry of Agriculture, Govt. of India.

Deka BC, Choudhury A, Bhattacharyya KH, Begum, Neog M (2006). Postharvest treatment for shelf life extension of banana under different storage environments. Acta Hort., 2:841-849.

El-Salhy,FTA, Khafagy SAA, Haggay LF (2006). The changes that occur in mango fruits treated by irradiation and hot water during cold storage. J. Appl. Res., 2 (11):864-868.

Farzana and Panhwar (2005). Post harvest technology of mango fruits, its development, physiology, pathology and marketing in Pakistan. Digital VerlagGmbH Pub., Germany.

Gomez-Lim MR (1993). Mango fruit ripening: Physiological and Molecular biology. *In*: Forth international mango symposium, Acta Hort., 341 (Eds. Bruce Schaffer) Tropical Research and Education Center, Florida. pp. 484-496.

Gutierrez AO, Nieto AD, Martinez D, Dominguez AMT, Delgadillo S, Qutierrez AJG (2002). Low temperature plastic film, maturity stage and shelf life of guava fruits. Revista Chapingo Serie Hort., 8 (2):283-301.

Mahindru SN (2009). Food preservation and irradiation. APH publishing corporation, New Delhi.

Mane SR (2009). Assessment of influence of maturity indices, post harvest treatments and storage temperatures on shelf life of mango (*Mangifera indica* L.) cv. Kesar. (Unpublished M. Sc. Thesis) Navsari Agricultural University, Navsari, India.

Mann SS, Singh RN (1975). Studies on cold storage of mango fruits(*Mangifera indica* L.) cv. Langra. Indian J. Hort., 32(1):7-14.

Mayer BS, Anderson DS, Bhing RH (1960). Introduction to plant physiology. D. Van Nastrand Co. Ltd., London.

Nagaraju CG, Reddy TV (1995). Deferral of banana fruit ripening by cool chamber storage. Adv. Hort. Sci., 9(4):162-166.

Panse VG, Sukhatme PV (1967). Statistical Methods for Agricultural workers. ICAR, New Delhi.

Pimentel RM, de Azeveda, Walder JMM (2004). Gamma irradiation in papaya harvested at three stages of maturation. Sci. Agric., 61 (2):140-150.

Prasadini PP, Khan MA, Reddy PG (2008). Effect of irradiation on shelf life and microbiological quality of mangoes (*Mangifera indica* L.). J. Res. ANGRU, 36(4):14-23.

Purohit AK, Rawat TS, Kumar A (2009). Shelf life and quality of ber fruit cv. Umran in response to post harvest application of ultraviolet radiation and paclobutrazole. Pl. Foods for Human Nut., 58 (3):1-7.

Roy SK, Joshi GD (1989). An approach to integrated post harvest handling of mango. Acta Hort., 231:469-661.

Singh SP, Pal RK (2009). Ionizing radiation treatment to improve postharvest life and maintain quality of fresh guava fruit. Radiation Phy. and Chem., 78:135-140.

Udipi SA, Ghurge PS (2010). Applications of food irradiation. *In*: Food irradiation (eds. Udipi SA, Ghugre PS). Agrotech Publishing academy, Udaipur, pp. 40-71.

Waskar DP, Masalkar SD (1997). Effect of hydrocooling and bavistin dip on the shelf life and quality of mango during storage under various environments. Acta Hort., 455:687-695.

Yadav MK, Parmar BR (2014). Response to γ radiation and storage temperature on quarantine pests of Alphonso mango. J. Hort. Forestry, 6(5):50-52.

Yadav MK, Patel NL (2014). Optimization of irradiation and storage temperature for delaying ripening process and maintaining quality of Alphonso mango fruit (*Mangifera indica* L.). Afr. J. Agric. Res., 9 (5):562-571.

Yadav MK, Patel NL (2013). Effect of Gamma Radiation and Storage Temperature on Post Harvest Rotting Management of Kesar Mango, J. Mycol. Plant Patho., 42(2):201-204.

Yadav MK, NL Patel, BR Parmar, Dileswar Nayak. (2013a). Evaluation of physiological and sensory changes of Kesar mango (*Mangifera indica* L.) influenced by ionizing radiation and storage temperature. SAARC Agric. J. 11 (2):69-80.

Yadav MK, Patel NL, Patel SR (2013b). Effect of irradiation and storage temperature on quality parameters of Kesar mango (*Mangifera indica* L.). Indian J. Plant Physiol.,18(3):313-317.

Yadav MK, Patel NL, Chaudhary AD, Parmar BR, (2013c). Gamma irradiation and storage temperature affects the physiological weight loss and ripening of Kesar mango. Int. J. Agri Med. Plant Res., 1(3):12-17.