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EXPOSURE OF MEDIUM DOSE GAMMA RAYS AND STORAGE CONDITIONS INFLUENCED THE WEIGHT LOSS AND RIPENING OF ALPHONSO MANGO

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ABSTRACT
Processing of fruits through radiation, involves exposure to short wave energy to achieve a specific purpose viz. reduced the weight loss and extended 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 withfactorial concept with three repetitions. 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 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. The data indicated that the fruits irradiated with 0.40 kGy gamma rays (I_3) recorded significantly minimum per cent reduction in PLW and extended the ripening. Same pattern noted when fruits kept at 9°C storage temperature. In combined effect of 0.40 kGy gamma rays irradiation and 9°C storage temperature (I_3S_2) also recorded maximum reduction in the PLW and ripening per cent throughout the storage period.

Keywords: Alphonso mango, Gamma irradiation, PLW, Ripening, Storage temperature, Storage

1. INTRODUCTION

Mangoes (*Mangiferaindica* 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 Patel, 2014). India is the global leader in mango production (Yadav and Patel, 2013). The significant mission of any postharvest skill is to be rising method by which decline of produce is controlled as much as possible during the stage between collect and consumption. As fruit, it's also remain alive after harvesting it is necessary to restrain their respiration and metabolic activity in order to maintain cell life and optimize post harvest quality by delayed ripening and senescence. For overcome these metabolic activities, innovation in irradiation and cold storage is the new tools for the enhancement of biochemical changes and health promoting components in most of climacteric fruits. The high cost of mangoes in importing countries is due primarily to air freight charges (Yadav and Parmar, 2014). Mature fruits may take from three to eight days to ripen and this short period certainly limits the commercialization at long distance. Sea transport is less expensive and enables transport 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 an arrival for successful marketing. Mangoes are classified as climacteric fruits and ripen rapidly after harvest. Mango is generally harvested when physiologically mature and is allow ripening under suitable conditions of temperature and humidity. Therefore, if freshly harvested fruit is allowed to ripen at normal ambient conditions (this can vary between 22°C- 32°C and 40 -65% RH), ripening processes increase rapidly within the week (Yadav *et al.*, 2013b). 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 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). As well as irradiation is 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 above fact, it becomes quite clear that

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investigation for mango fruit is very important for not only reduce the ripening but also control the weight loss. So, irradiation can be used in combination with low temperature for to assess the effects of different doses of gamma irradiation and storage temperature on reduction 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 objective of any post harvest treatment is to reduce the extend of physiological loss in weight. The Alphonso variety of mango is famous for its excellent table fruit quality. This is leading commercial mango cultivar of India and Pakistan and getting place in export market. The ripen fruits having attractive colour, shape, size, rich flavour, pleasant aroma, excellent taste and flesh is sweet and fibreless. It has excellent sugar: acid blend. Hot water (53^{0}C) or hot imazalil (0.1% *a.i.*) plus irradiation with 750Gy treatment delayed ripening and increased shelf life in Tommy Atkin Mangoes (Spalding and Reeder, 1986). McLauchlan *et al.* (1990) recorded a delay in ripening of 3 to 5 days at 20^{0}C at 300 and 600 Gy dose of gamma irradiation in Kensington pride mangoes. Singh (1974) recorded delaying ripening up to 7 weeks when Alphonso mango stored at 7-9^{0} C and 85-90% RH. Krishnamurthy and Joshi (1989) made a comparative study on the effect of low temperature storage of freshly harvested Alphonso mango at 7^{0}C and 30^{0}C and observed delaying in ripening at low temperature.

2. MATERIALS AND METHODS

Fruits and irradiation treatment: The experiment was set in the year 2008 at Department of Horticulture, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat .Export grade mangoes of cv. Alphonsowere harvested from University orchard. The selected mangoes from class I as per the quality parameters specified and described in "post harvest manual for mangoes" published by Agricultural Production and Export Development Authority (Anonymous, 2007). These fruits sorted by uniformity in size, maturity and freedom from defects. The fruits were kept in plastic crates with cushioned material and transported to cold storage of Post Harvest Technology Unit, Navsari Agricultural University, Navsari (Gujarat) India. Than after, fruits were again sorted to remove those with spotty and having bad appearance. The individual fruit weight was from 250-350g. The selected fruits wash with chlorine water and after drying fruits packed in corrugated fibre board boxes cushioned (CFB) with tissue paper. The dimension of CFB box was 370 X 275 X 90mm and gross weight of box with fruits was 3.0 kg. One box having nine fruits for each treatment and each treatment replicated thrice as per experimental design. The packed boxes kept in cold storage at 12^{o}C for 8 hours for pre-cooling treatment. The time gap between harvesting and pre-cooling was not more than 6 hours.

Place of irradiation: After pre-cooling, fruits transport to irradiation treatment in air conditioned vehicle. It was carried out at ISOMED plant, Board of Radiation and Isotope Technology, Sir Bhabha Atomic Research Centre, Mumbai (India). The fruits were exposed to gamma radiation for different doses from the source radio isotope ^{60}Co with energy 1.33MeV. There were four irradiation doses *i.e.* I_1 -0.00kGy (Unirradiated), I_2 -0.20kGy, I_3 -0.40kGy and I_4 -0.60kGy. The time gap from pre-cooling to irradiation was not more than 9 hours. After irradiation, fruits immediately transported to cold storage of university in air conditioned vehicle.

Storage conditions: The boxes were kept in cold storage at different temperature as per storage temperature treatments *viz.*, Ambient at 27±2^{o}C temperature and 65±5% relative humidity (S_1), 9^{0}C temperature and 90% relative humidity (S_2), 12^{0}C temperature and 90% relative humidity (S_1) and Control atmospheric storage at12^{0}C temperature, O_2 2%, CO_2 3% and 90% relative humidity(S_1). Post-harvest biochemical changes of these fruits were studied by measuring the total soluble solids, sugars, acidity and ascorbic acid content of fruits.

Measurement protocols: 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 PLW was expressed in percentage and calculated as follows.

PLW % = $W_1 - W_2 / W_1$ X 100, Where, W_1 = initial weight and W_2 =final weight (Yadav *et al.*, 2013a). The ripening was measured by the number of fruits having change in colour from greenish to yellow and soft in texture 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 has 0.00 values for PLW and ripening due to completed of their shelf life and unripening therefore, noted individual mean value of irradiation and storage temperature was differ from original. So, only interaction effect is interpreted.

Statistical analysis: The data analyzed were 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, NAU, 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.

3. RESULTS AND DISCUSSION

Physiological loss in weight: 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.

Effect of gamma rays: It is evident from Fig. 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 and 30th days of storage *i.e.* 2.183, 3.900, 5.810, 3.830 and 2.420 per cent, respectively and the maximum PLW was observed in I_1 (0.00 kGy) at different storage conditions.

Effect of storage temperature: Storage temperature affects the PLW and Fig. 2 showed that the significantly minimum PLW was observed in treatment S_2 (9^{0}C) at 6th, 12th, 18th, 24th and 30th day of fruit storage (1.128, 2.353, 3.520, 4.950 and 6.090 per cent, respectively). Whereas, maximum PLW per cent was recorded in fruits kept at ambient temperature (S_1) at different storage conditions.

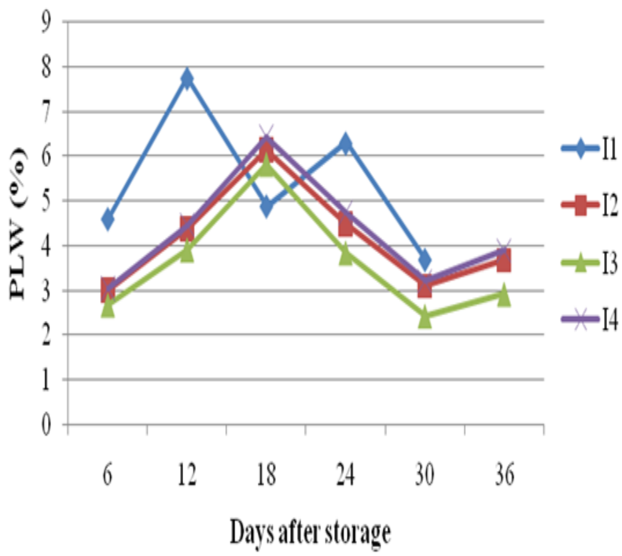

Fig-1. Gamma irradiation influnced the PLW(%) of Alphonso mango at different days after storage

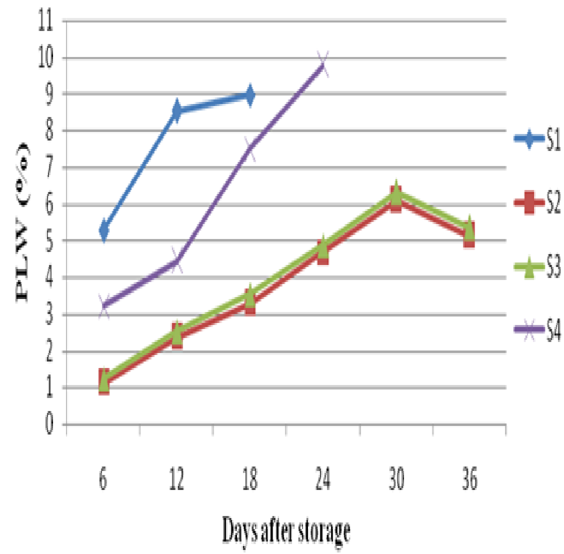

Fig-2. Storage condition influnced the PLW(%) of Alphonso mango at different days after storage

Interaction between irradiation and 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 more than 30 day, and on this day only fruits exposed with 0.40 and 0.60 kGy irradiation and stored at 9^{0}C has shelf life and the minimum reduction in PLW per cent was recorded at six day interval in the fruits exposed with 0.40 kGy irradiation and stored at 9^{0}C (I_3S_2) *i.e.* 4.740% at 30th day, 3.490% at 24th day, 2.770% at 18th day, 1.783% at 12th day and 1.352% at 6th day of storage (Fig 3). 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. 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^{0}C and 12^{0}C and in CA (12^{0}C) storage temperature, which might be due to lesser water vapour deficit 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 accordance with the results of Roy and Joshi (1989) and Waskar and Masalkar (1997) in mango; Nagaraju and Reddy (1995) in banana and Gutierrez *et al.* (2002) in guava. The significantly minimum reduction in PLW of mango fruits subjected to irradiation and stored at various temperatures *i.e.* at 9^{0}C and 12^{0}C and in CA (12^{0}C) might be due to the mutual complementary effect of irradiation and low temperature (Yadav *et al.*, 2013a).

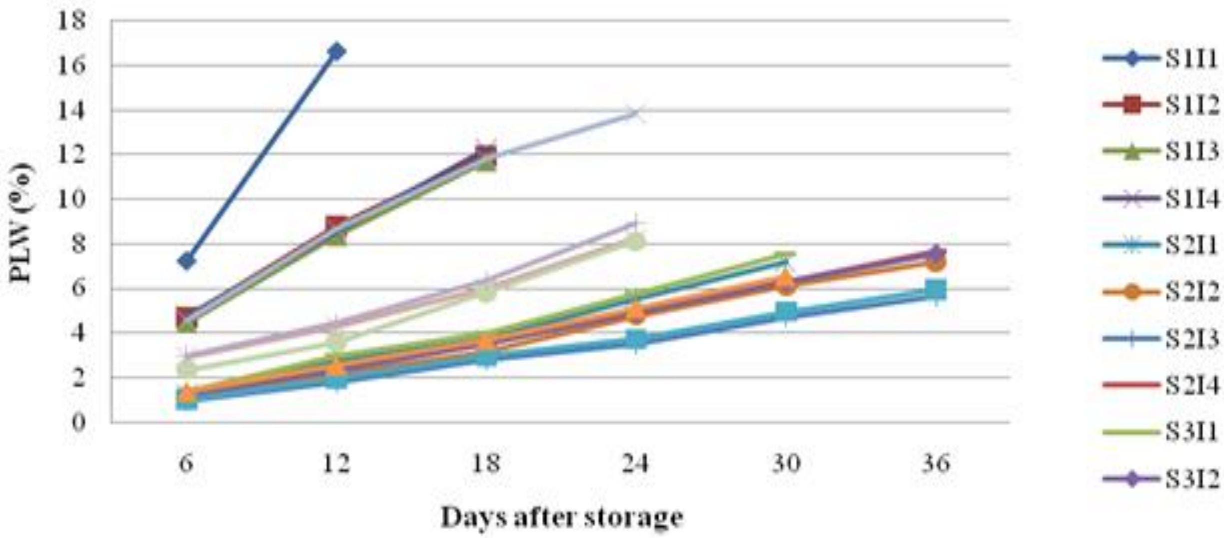

Fig-3. Comined effect of irradition and storage condition on Alphonso mango during storage

Ripening percentage: The Table 1, Indicated that the ripening percentage of fruits were influenced with the advancement of storage period and significantly affected by irradiation, storage temperature and their interaction.*Effect of irradiation and storage temperature:* Irradiated fruits significantly delayed the ripening process over unirradiated fruits at all conditions of the storage. Irradiated fruits still not fully ripe up to 30th day of storage, stored at 9⁰C. On this day, fruits exposed to 0.40 kGy recorded minimum unripe fruits, similarly, fruits stored at 9⁰C observed only 63.14 ripening in fruits. Rest of the treatments was discarded due to the lost of their shelf life. The fruits exposed to gamma rays (0.20 and 0.40 kGy) and stored at 9⁰C and 12⁰C were remained more than 50% unripe (I_3S_2 and I_3S_3) on 30th day of storage, they showed 50.15 and 52.06 per cent ripening, respectively. Rest of the treatments has high ripening or discarded due to complete of their shelf life. The fruits exposed to gamma rays and stored at 9⁰C (S_2) and 12⁰C (S_3) storage temperature as well as unirradiated fruits kept at 9⁰C were remained unripe (I_1S_2) at 24th day of storage. Unirradiated and irradiated fruits kept at ambient temperature were discarded due to the end of their shelf life and rest are under ripening. At 18th day of storage, unirradiated fruits discarded due to full ripening which stored at ambient conditions, remaining were unripe or showed minute ripening. At 6th and 12th day of storage, ripened fruits (34.140 and 97.700 per cent, respectively) were observed in unirradiated fruits stored at ambient temperature (I_1S_1). Rest of the treatments was fully unripe. Ripening percentage is a physiological process which designates the period from harvest until the fruits attain the stage of maximum consumer acceptability. The unirradiated mangoes had early ripeness whereas; gamma rays exposed mangoes had a 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 Ghurge, 2010). Same findings noted by Yadav and Patel (2014) and Farzana (2005)in mango and Aina *et al.* (1999) in banana. The lower and delayed ripening was noted at 9⁰C and 12⁰C and in CA (12⁰C) storage as compared to ambient temperature. The decrease of ripening per cent and increase in days for ripening at low temperature may be due to desirable inhibition of enzymatic activities leading 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 due to exposed to gamma rays and storage temperature at 9⁰C and 12⁰C and in CA (12⁰C) storage compared to fruits unirradiated and kept at ambient temperature in present study might be due to the joint balancing effect of irradiation and low temperature (Yadav and Patel, 2014).

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

	Ripening (%) days after storage														
	6					12					18				
Source	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	34.140 (35.739)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	8.530 (10.175)	97.700 (81.245)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	24.420 (21.551)	0.000* (1.654)	83.950 (66.359)	83.790 (66.234)	85.910 (67.929)	63.410 (50.544)
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)	35.05 (36.288)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)	8.760 (10.312)
Mean	8.530 (10.175)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)		24.420 (21.551)	0.000 (1.654)	0.000 (1.654)	0.000 (1.654)		8.760 (10.312)	20.980 (17.830)	20.950 (17.799)	21.480 (18.222)	

Source	I	S	I X S	I	S	I X S	I	S	I X S
S. Em ±	0.005	0.005	0.010	0.011	0.011	0.023	0.012	0.012	0.025
CD ($P \leq 0.05$)	0.015	0.015	0.030	0.034	0.034	0.068	0.036	0.036	0.072

Table: 1. Continue

	Ripening (%) days after storage									
	24					30				
Source	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)	83.58 (66.07)	53.49 (46.98)	50.15 (45.07)	65.36 (53.93)	63.14 (53.01)
S_3	41.88 (40.31)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	10.47 (11.32)	97.95 (81.74)	58.38 (49.81)	52.06 (46.16)	74.18 (59.44)	70.63 (59.29)
S_4	98.49 (82.92)	79.78 (63.25)	75.18 (60.10)	83.78 (66.23)	84.31 (68.12)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00* (1.65)	0.00 (1.65)
Mean	24.62 (31.63)	19.94 (17.05)	18.79 (16.26)	20.94 (17.80)		45.38 (37.78)	27.96 (25.04)	25.55 (23.64)	34.88 (29.17)	

Source	I	S	I X S	I	S	I X S
S. Em ±	0.02	0.02	0.04	0.02	0.02	0.04
CD ($P \leq 0.05$)	0.06	0.06	0.12	0.06	0.06	0.12

N.B. 1.-Figure in parenthesis indicates ARC SINE transformed value,
2.- * Indicated fruits completely discarded,
3.- Where, I=irradiation, S-storage temperature

4. CONCLUSION

The fruits of Alphonso mango subjected to 0.40kGy gamma rays irradiation subsequently stored at 9^{0}C temperature delayed the ripening process which maintained lover percentage of physiological loss in weight and ripening per cent. This was followed by the fruits treated with 0.40kGy gamma irradiation subsequently stored at 12^{0}C temperature.

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