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EVALUATION OF PHYSIOLOGICAL AND ORGALEPTIC PROPERTIES OF MANGO CV. KESAR AS INFLUENCED BY IONIZING RADIATION AND STORAGE TEMPERATURE

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ABSTRACT

Radiation processing of fruits involves exposure to short wave energy to achieve a specific purpose to maintain the physiological changes and sensory quality of the product. The effect of gamma irradiation and storage temperature on physiological changes and organoleptic properties of mango fruit var. Kesar was studied. The fruits were exposed to gamma radiation at different doses i.e. 0.00kGy, 0.20kGy, 0.40kGy and 0.60kGy from the radio isotope ^{60}Co and stored at different storage environments i.e. at ambient storage (27±2^{o}Cwith 60-70% RH); at 9^{0}C with 90% RH; at 12^{0}C with 90% RH and control atmosphere storage (at 12^{0}C, O_2 2%, CO_2 3% and RH 90%). The fruits irradiated with 0.40kGy gamma rays and stored at 9^{0}C storage temperature with 90% RH recorded maximum reduction in physiological loss in weight and reduced ripening. The minimum physiological loss in weight and ripening and highest marketability of fruits was recorded from fruits irradiated with 0.40kGy gamma rays and stored at 12^{o}C storage temperature with 90 RH including maximum scores on skin colour, pulp colour, texture, taste and overall acceptability at the end of shelf life (41.43 days).

Key words: Colour, gamma irradiation, Kesar mango, marketability, ripening, storage temperature, taste

INTRODUCTION

Mango (*Mangifera indica* L.) is a tropical to sub-tropical fruit; its rapid ripening process and infection caused by microorganism are the major causes of postharvest losses and limit the transport of fresh fruit from the site of harvest to market (Mitra, 1997). Mangoes are growing in over 90 countries worldwide and Asia accounts

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for 77% of global mango production, whereas the America and Africa account for 13 and 19%, respectively (Pereira et al., 2010). Kesar, one of the leading mango cultivars of India is recently emerged out for establishing commercial mango orchard. In export market it becomes more favorite to Alphonso. The ripe fruit has attractive colour, shape and size, rich flavour, pleasant aroma, excellent taste, sweet and fibrelees fleshs. It has excellent sugar: acid blend. Mangoes are extremely perishable in nature and to extend their ripening during long distance shipment, fruits are generally harvested at physiologically mature stage, stored at low temperatures and ripened at destination under favorable conditions (Yimyong et al., 2011). At the present stage of development, however, sea shipment does not guarantee good quality fruit on arrival for successful marketing. Therefore, if freshly harvested fruit is allowed to ripe at normal ambient conditions (this can vary between 22^0C- 32^0C and 40-65% RH), ripening processes increase rapidly within the week; the ripe fruit may stay edible for a few days thereafter (Udipi and Ghurge, 2010). The most commonly encountered postharvest problems for mango are shriveling due to water loss, fast ripening and ultimately less marketability. Moreover, chilling injury may occur under low temperature. On the other hand, as the temperature increases, the higher will be the fruits water loss. Mango is susceptible to chilling injury and an optimum temperature of 12-13^0C is generally recommended (Gomez – Lim, 1993; Yimyong et al., 2011). Irradiation of fruits has been successfully shown to delay ripening (Pimentel and Walder, 2004) and is the most recent commercial phytosanitary treatment for fresh commodities. Irradiation is a physical process for the treatment of foods compared to conventional process like heating or freezing. It prevents food poisoning, reduces wastage 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 sensory quality of the fruit. Therefore, a balance between the required effective dose and tolerance of fruit to irradiation has to be investigated under various storage temperatures. So, irradiation can be used in combination with low temperature for assessing the effects of different doses of gamma irradiation and storage temperature on physiological and organoleptic quality of the fruit. The loss in appearance, taste and texture of fruits is likely to reduce the consumer's acceptability drastically. The objectives of the study were to evaluate the effect of irradiation and storage temperature on physiological and sensory changes during storage. Kesar mangoes from Gujarat have captured sizeable Indian market and have good export potential, but the protocol for their irradiation and post harvest storage needed to be standardized. In this paper the results of studies for standardization protocol of irradiation and storage are presented and discussed.

MATERIALS AND METHODS

Material and preparation

The present experiment was carried out at Navsari Agricultural University, Navsari (Gujarat) India during the year 2008-2010. The export grade mangoes of cv. Kesar were harvested from university orchard and were sorted for uniformity in size, maturity and free from defects and washed with chlorinated water. After drying, fruits were packed in corrugated fibre board (CFB) boxes (370 X 275 X 90mm) cushioned with tissue paper. The packed boxes were kept in cold storage at 12^{o}C for 8 h for pre-cooling.

Radiation processing

After pre-cooling; fruits were irradiated 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 (Non-radiated), I_2 -0.20kGy (1.15hrs), I_3 -0.40kGy (2.30hrs) and I_4 -0.60kGy (3.45 hrs).

Storage conditions

The CFB boxes were stored in cold storage as per storage temperature treatments. The treatments were S_1-Ambient (27±2^{o}C, 60-70% RH), S_2-9^{0}C, 90% RH, S_3-12^{0}C, 90% RH and S_4- Control atmosphere (CA) storage (12^{0}C, O_2 2%, CO_2 3% and RH 90%).The relative humidity maintained through automated RH sensors.

Parameters and evaluation protocols

The selected parameters and protocols were performed at Post Harvest Technology Unit of American Sprayers and Pressing Equipments (ASPEE) College of Horticulture and Forestry, Navsari Agricultural University, Navsari, India. The parameters and protocols are discussed below.

Physiological loss in weight (%)

Four fruits from each treatment were weighed 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 follows.

$$\text{PLW \%} = \frac{W_1 - W_2}{W_1} \times 100$$

Where, W_1 = initial weight and W_2 =final weight (Shankar et al., 2009)

Ripening (%)

Ripening was measured by the number of fruits having change in colour from greenish to yellow and soft in texture were counted from day 2 day of storage to at six day interval up to the eating ripeness and expressed in percentage over total number of fruits taken for the study.

Marketable fruits (%)

The number of good quality and visibly sound fruits that could be marketed were counted and expressed as percentage over the total number of fruits at prescribed interval up to 90 per cent fruits had marketability.

For senso organoleptic evaluation

The various treatments were evaluated by a panel consisted of twenty trained panelists and evaluated the sample on the basis of colour , taste, aroma and by pressing the fruit and points were given as per hedonic scale procedure (Rangana, 1986). Higher scoring was treated as more acceptable from the attraction point of view.

Statistical analysis

The two years data obtained from experiment was analyzed using ANOVA for completely randomized design with factorial concept in three repetitions. Significance of differences among treatments means were compared using the Fisher's analysis of variance at 5% probability level, technique as followed by Panse and Sukhatme (1967). The data were subjected to appropriate transformation (arcsine) to meet the assumptions of normality.

RESULTS AND DISCUSSION

Physiological loss in weight (%)

It is evident from the data (Figure1) that the shelf life was extended up to 38 days and on this day the significantly minimum PLW (5.850%) was recorded in the fruits exposed to 0.40kGy gamma rays (I_3S_2) followed by 0.20kGy (I_2S_2) gamma rays (7.470%) fruits stored at 9^0C temperature. In general, gamma rays @ 0.40kGy (I_3) was the most effective treatment in reducing the physiological weight loss in Kesar mango at 9^0C (S_2) and 12^0C (S_3) storage temperature as compared to all other treatments. The physiological loss in weight 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). The irradiation significantly reduced physiological loss in weight 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., 2004). 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 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. Minimum physiological loss in weight was noted in cold 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 (Mane, 2009). The results are at par 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 physiological loss in weight of mango fruits subjected to irradiation and stored at various temperatures i.e. at 9^0C,12^0C and in CA (12^0C) might be due to the mutual complementary effect of irradiation and low temperature.

Fruit ripening (%)

Figure 2 indicated that the irradiated fruits did not fully ripe up to 38^{th} day of storage when fruits were exposed to 0.40kGy gamma rays and kept at 12^0C (I_3S_3) and 0.60kGy kept at 9^0C (I_4S_2) storage temperature were discarded due to the end of their shelf life. The fruits exposed to 0.20kGy and 0.40kGy gamma rays showed 97.93 and 97.30 per cent ripening, respectively at 9^0C storage (I_2S_2 and I_3S_2). Mangoes are classified as climacteric fruits and ripe rapidly after harvest. The un-irradiated mangoes had early ripeness whereas; gamma ray 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 Ghugre, 2010). Same findings were noted by Farzana (2005) in mango and Aina et al. (1999) in banana. The lower and delayed ripening was noted at 9^0C and 12^0C and in CA (12^0C) storage as compared to ambient temperature. The decrease of ripening per cent and increase in days to 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.

Marketable fruits (%)

The data on per cent marketable fruit are presented in figure 3. The maximum marketable fruit (97.69%) was noted in the fruits irradiated with 0.40kGy gamma rays and stored at 12^0C (I_3S_3), which was followed by I_2S_3 and I_4S_3. The fruits stored at either at 9^0C (S_2) or at 12^0C (S_3) temperature with (I_2, I_3 and I_4) or without (I_1) gamma rays treatment also showed considerable marketable fruits percentage for long time. The regulation of ripening is an extremely important factor in supplying the consumers with fruit of acceptable eating quality. Innovation in irradiation and cold storage are the new tools for the enhancement of physiological changes and health promoting components in climacteric fruits so, the fruits provide long time marketability. The per cent marketable fruit was significantly influenced by various doses of gamma irradiation and storage temperatures possibly due to the fact that irradiation maintains water content in the fruit and low temperature coupled with high humidity in cold storage maintains the health of the fruits. Control ripening also a possible reason for long time and higher marketability. These results are in conformity with the findings of El-Salhy et al. (2006) with respect to irradiation and Mane (2009) with respect to low temperature in mango.

Skin and pulp colour

The data pertaining to skin colour showed (Table 1) significant effect on skin and pulp colour. Due to irradiation the maximum score (7.8) for skin colour was obtained in the fruits treated with treatment I_3 (0.40kGy). The maximum score (8.0) for skin colour was obtained in the fruits stored under treatment S_3 (12^0C).Combined effect of irradiation and storage temperature recorded maximum skin colour score (8.5) when fruits were exposed to 0.40kGy gamma rays stored at 12^0C storage temperature (I_3S_3). Significantly the maximum pulp colour score (7.5) of fruits was recorded (Table 1) when fruits were exposed to 0.40kGy gamma rays (I_3). The maximum score (7.7) for pulp colour obtained from fruits stored under treatment S_3 (12^0C). Combinedly the maximum pulp colour score of fruits (7.8) was recorded in fruits exposed to 0.40kGy gamma rays and stored at 12^0C storage temperature (I_3S_3). The visual changes in the colour of the fruits were noticeable throughout the storage. It was noticed that outer skin and inner pulp of mango fruits irradiated at medium (0.40kGy) and lower dose (0.20kGy) of gamma rays had greener skin and yellow to pink pulp than the skin and pulp of the higher dose (0.60kGy) exposed fruits at the end of storage. The large changes in skin and tissue colour during ripening may have overwhelmed any irradiation responses (Zhao et al., 1996). Similar results were also found by El- Salhy et al., (2006) in mango and by Paull (1996) in papaya. The storage temperature had significant effect on skin and pulp colour. The fruit stored at 12^0C, ambient temperature and in CA (12^0C) storage recorded higher colour score whereas, minimum colour score was recorded in fruits stored at 9^0C. It may be due to the slow degradation of chlorophyll due to slow rate of respiration and ethylene production by desired temperature and it is also associated with chloroplast to chromoplast transition. The present results support the results of Medlicott et al. (1990), Waskar and Masalkar (1997) and El-Salhy et al. (2006) in mango and Gutierrez et al. (2002) in guava.

Texture of fruit

The panelists found significant differences in the texture of the un-irradiated and irradiated fruits. It is evident from the data, presented in Table 2 that significantly maximum texture score (7.6) was recorded in fruits exposed to treatment I_3 (0.40kGy). Maximum score (7.8) for texture was obtained from fruits stored at treatment S_3(12^0C). Collectively the maximum texture value (8.0) was recorded in fruits exposed to 0.40kGy gamma rays and stored at 12^0C storage (I_3S_3). The panelists found a significant difference between the dose levels of gamma ray with respect to texture score. The possible reasons may be that medium to lower dose of irradiation can break chemical bonds, increase membrane permeability and metabolic activity, which will lead to more water vapor movement to intercellular space and maintain the texture of the fruit and another reason may be that the changes in pectin by irradiation are possible cause of the radiation induced softening (Zhao et al. 1996). These results are in agreement with findings of Moreno et al. (2006), El-Salhy et al. (2006) and Lacroix et al. (1990) in mango; Pimentel and Walder (2004) in banana and Singh and Pal (2007) and Singh and Pal (2009) in guava. Significantly better texture score was recorded at the full ripening stage in fruits stored at 12^0C, ambient temperature and in CA (12^0C) storage compared to fruits stored at 9^0C temperature, which may be due to retardation of the biochemical changes and ripening process at desired temperature (Mane, 2009) and significantly decrease in texture during storage of fruits was due to changes in nature of pectin substances which cementing the cell wall and hydrolysis of starch, hemicelluloses and cellulose during ripening of fruit (Leopold, 1964). This finding is in conformity with the findings of Waskar and Masalkar (1997) in mango; Purvoko (2002) in banana.

Taste of fruits

Significantly the maximum (Table 2) taste score (7.7) was recorded in fruits exposed to 0.40kGy gamma rays (I_3). Similarly, maximum score (7.9) for taste obtained in fruits stored under treatment S_3 (12^0C) followed by treatment ambient storage (S_1). In combination, the maximum taste score (8.2) was recorded in fruits exposed to 0.40kGy gamma rays stored at 12^0C (I_3S_3) Significantly enhanced taste of fruits might be due to optimum moisture and uniform ripening at desired temperature and radiation dose. The 9^0C stored fruits lost their taste and flavour due to prolonged storage of mango fruits at lower temperature and high humidity (Dhemre and Waskar, 2004).

Overall acceptability

Significantly the maximum overall acceptability score (7.8) was recorded (Table 2) in fruits exposed to 0.40kGy gamma rays (I_3). The maximum score (7.9) for overall acceptability obtained when fruits were stored under treatment S_3 (12^0C). Combined effect of irradiation and storage temperature showed the maximum overall acceptability score (8.4) in fruits exposed to 0.40kGy gamma rays and stored at 12^0C storage (I_3S_3). The higher score of acceptability of fruits in these treatments may be due to good appearance, better texture and best in taste. Another reason is that the combined advantage of irradiation and desired temperature which reduces undesirable sensory changes, since free radicals are less mobile at low temperature and hence their ability to interact with other constituents reduces (Udipi and Ghurge, 2010). The same results were obtained by Rajput et al. (2004) in apple with respect to irradiation and Mane (2009) in mango with respect to storage temperature.

CONCLUSION

Exposure of mango fruits (var. Kesar) to 0.40kGy gamma rays subsequently stored at 9^0C temperature delayed the ripening process which maintained lower percentage of physiological loss in weight and ripening per cent and higher percentage of marketable fruits. This was followed by the fruits treated with 0.40kGy gamma irradiation subsequently stored at 12^0C temperature. The highest score for skin and pulp colour; texture and taste of fruit and overall acceptability was observed in fruits exposed to 0.40kGy gamma rays and stored under 12^0C storage temperature compared to minimum in fruits stored at 9^0C temperature irradiated with 0.60kGy gamma radiation. Overall conclusions are that the irradiation increases the fruit health and overall acceptability for consumers point of view. It fulfills the quarantine briers for export purpose.

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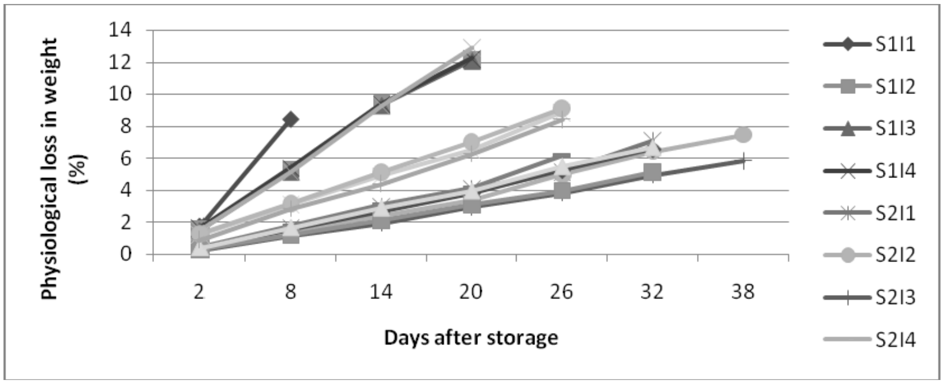

Figure 1: Weight loss by irradiation and storage temperature during storage of mango cv. Kesar

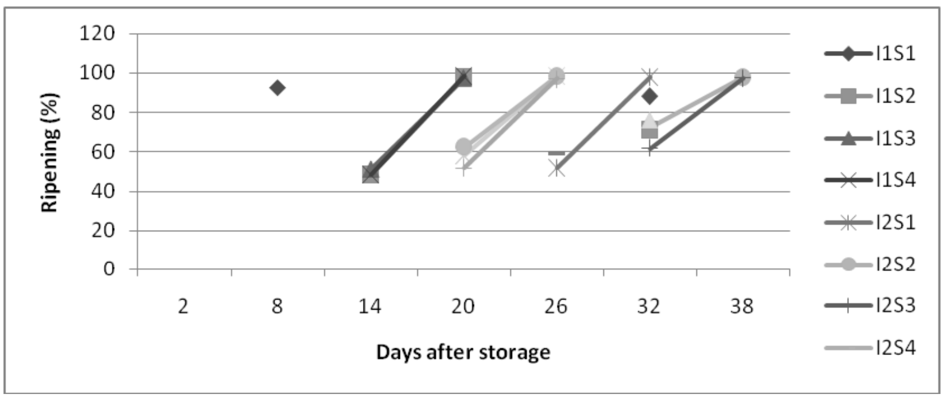

Figure 2: Ripening changes by irradiation and storage temperature of mango cv. Kesar during storage

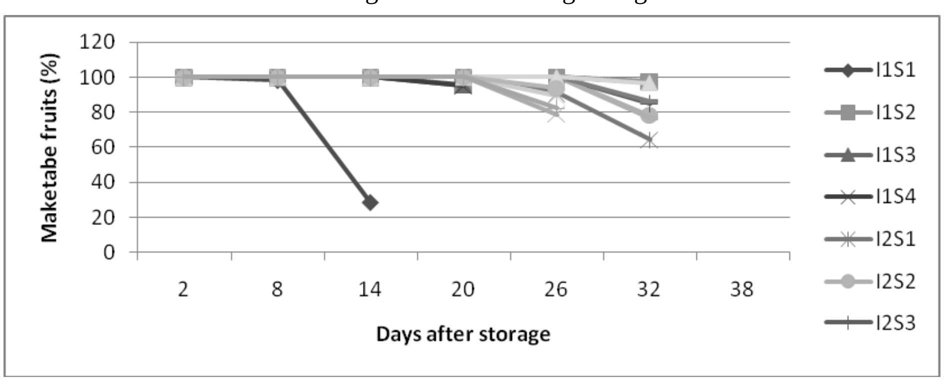

Figure 3: Response to irradiation and storage temperature on marketable fruits of mango cv. Kesar

Table 1: Effect of irradiation and storage temperature on skin and pulp colour score of mango cv.Kesar

Factors	Skin colour					Pulp colour				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
S_1	7.5	7.8	7.8	7.0	7.5	7.4	7.5	7.7	7.3	7.5
S_2	6.8	7.0	7.0	6.7	6.9	6.2	6.8	7.1	6.2	6.5
S_3	7.9	8.0	8.5	7.7	8.0	7.5	7.7	7.8	7.5	7.7
S_4	7.5	7.7	7.8	7.2	7.5	7.2	7.2	7.5	7.2	7.3
Mean	7.5	7.6	7.8	7.1		7.1	7.3	7.5	7.0	

Factors	I	S	I X S	I	S	I X S
S. Em ±	0.004	0.004	0.008	0.009	0.005	0.009
CD (P≤0.05)	0.012	0.012	0.023	0.026	0.014	0.026

Where, I=irradiation, S-storage temperature

Table 2: Effect of irradiation and storage temperature on texture, taste and overall acceptability score mango CV Kesar

Factors	Texture					Taste					Overall acceptability				
	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	7.4	7.5	7.8	7.0	7.5	7.6	7.7	7.9	7.5	7.7	7.4	7.6	7.7	7.1	7.5
S_2	6.6	6.8	7.1	6.4	6.7	6.7	6.8	7.2	6.5	6.8	6.6	6.8	7.5	6.5	6.8
S_3	7.8	8.0	8.0	7.5	7.8	7.8	7.9	8.2	7.7	7.9	7.6	8.1	8.4	7.5	7.9
S_4	7.2	7.3	7.4	7.0	7.2	7.5	7.6	7.7	7.4	7.6	7.3	7.4	7.6	7.2	7.4
Mean	7.2	7.4	7.6	7.0		7.4	7.5	7.7	7.2		7.2	7.5	7.8	7.1	

Factors	I	S	I X S	I	S	I X S	I	S	I X S
S. Em ±	0.005	0.005	0.010	0.005	0.005	0.010	0.005	0.005	0.010
CD (P≤0.05)	0.015	0.015	0.028	0.015	0.015	0.030	0.016	0.016	0.030

Where, I=irradiation, S-storage temperature