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Postharvest application of calcium, packaging material and hot water treatment on quality of mango (*Mangifera indica* L.) cv. Zardalu

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ABSTRACT

Development of methods for delaying ripening and senescence of mango without adverse effect on quality is of immense value in prolonging shelf life and increasing the marketing potential. The Zardalu mango fruits were subjected to different chemicals and their effect of fruit quality during storage was assessed. The minimum PLW (9.93%) was recorded in fruits packed under perforated polyethylene bag + $CaCl_2$ 2% (T_6). The highest PLW (15.19%) was obtained in fruits stored under control (T_8). However, minimum ripening (42.29%) was observed in fruits treated with $CaCl_2$ 2% and packed in perforated polyethylene bag (T_6) while the highest ripening (56.67%) was noted under control (T_8). The minimum spoilage loss (8.60%) was obtained with perforated polyethylene bag + $CaCl_2$ 2 % (T_6) which proved its superiority over remaining treatments. However, the next effective treatment was perforated polyethylene bag + $CaCl_2$ 1 % (T_5) in reducing spoilage loss of fruits. The maximum spoilage loss (14.81%) was recorded under control (T_8). It is obvious from the data that the fruits stored under perforated polyethylene bag + $CaCl_2$ 2% (T_6), scored maximum marks and rated as good grade followed by perforated polyethylene bag + $CaCl_2$ 1% (T_5), while poor grade was obtained under control.

Keywords: Mango, $CaCl_2$, packaging materials, hot water treatment, postharvest, spoilage

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INTRODUCTION

Mango is generally a sweet fruit although the, taste and texture of the flesh varies across cultivars, some having a soft pulp texture, while the flesh of other is firm or may have a fibrous texture. It is rich in phyto-chemicals and nutrients. The fruit pulp is high in prebiotic dietary fibre, vitamin C, diverse poly phenols and the most important is pro-vitamin A, carotenoids and contains other essential vitamins and dietary minerals. The antioxidant vitamin A, C and E composes 25%, 76% and 9%, respectively of the Dietary Reference Intake (DRI) in a 165 gm, serving. Both ripe and unripe fruits are utilized or consumed in different ways and forms. Though the ripe fruit is liked by all age group of people and also utilized for preparing several products and has a great potential as an item of export both as fresh and in processed form. Mango pulp export from our country was in a tune of 97.7 per cent of global data (Hindu Survey of Indian Agriculture, 2005). Though India has vast varietal diversity with about 1100 named varieties. But only few are grown on a commercial scale. Especially in Bihar there is immense scope of mango crop

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because the agro climatic conditions of Bihar are very congenial for mango production and the state has enormous wealth for mango genotypes. Among the prominent cultivars of mango, “Zardalu” is considered to be matchless fruit of Bihar in general and Bhagalpur in particular. Fruits of mango cv. Zardalu are medium in size, oblong-oval in shape (with a slight sinus) and have attractive apricot yellow colour. The attractive yellow colour is responsible for its varietal nomenclature as the word Zardalu has come from a Persian word i.e. ‘Zard’ meaning yellow and “aalood’ means entirely covered. The fruit quality is good with a pleasant flavour. It is biennial in bearing and the fruit is harvested during the last week of May. The fruit is of sweet taste and juice moderately abundant but the keeping quality is low. So, there is need to use various measures to increase its shelf life for good economic return by delaying its senescence. It has been reported that the storage becomes uneconomical if the spoilage percentage exceed 10-15 per cent.

In India mango accounts for 39% area of total fruit cultivation i.e. 1.56 million hectare and 23% of total fruit production i.e. 10.64 million tonnes (Anonymous, 2009). Although, India is the largest producer of mango, we export only a negligible proportion of fresh fruits. The magnitude of post harvest losses in fresh mango is estimated to be 17-40 per cent in India. The losses also occur on account of improper handling, poor transportation, inadequate storage facilities, lack of packaging and refrigerated storage condition. Under ambient condition, fruits become un-consumable very soon and marketability declines at a very sharp rate.

Mango is a climacteric fruit and being perishable in nature. It possesses a very short shelf life of 3-4 days at ambient condition, once the ripening is initiated. Fruits are living entities and biologically active even after harvest. They undergo continuous enzymatic and bio-chemical changes and carry out large processes like respiration and transpiration, which accelerate ripening and deteriorate the quality of the produce and finally make it un-consumable. These are also exposed to microbial invasion. These entirephenomenons are influenced by temperature, humidity and concentration of ethylene produced by fruits and presence of oxygen and spores of microbes in surrounding of the harvested fruits.

The ripening and softening of fruits are due to PME and polygalacturonase. In order to have good returns and to avoid glut in the market, it becomes essential to store fruits for considerable period. There is negligible commercial storage facility of mango in India; hence growers are to sell their produce soon after harvest. Proper storage provides an environment, which minimizes the biological activities and pathological deterioration of fruits. Temperature and humidity management are most important for keeping freshness of fruits throughout the period of storage, reducing the temperature at ambient condition. Slows down the rate of respiration, ethylene production, ripening, undesirable biochemical changes and desiccation. Moreover, in our country cold storage facilities are not adequate to meet the demand of the fruits growers. Thus, to preserve freshness of mango fruits for considerable period. Some inexpensive and convenient storage measures are in need to be adopted. Extension of shelf life is possible by delaying ripening, inhibiting ethylene production, reducing respiration and minimizing oxidative metabolism and activities of various enzymes at prevailing warm ambient condition at which the bulk of fruits is handled in India.

Development of methods for delaying ripening and senescence without adverse effect on quality would therefore is of immense value in prolonging shelf life and increasing the marketing potential. Extension of shelf-life of mango and other fruits at warm ambient conditions successfully been achieved with the use of certain chemical, pre-packaging and hot water treatment. Usefulness of chemicals like calcium chloride has been established in various climacteric fruit like banana, mango, sapota etc. This chemical counteracts ethylene production and reduces the rate of respiration leading to lower rate of oxidative metabolism and pectin hydrolysis through declined catalase and PME activities. Among the different methods, pre-packaging decidedly seems to be the cheapest and practical device for prolonging the shelf-life of perishable commodities. Packaging is an essential and indispensable component in transportation of fruits. It has exhibited great significance in minimizing the wastage by inhibiting undesirable physiological events, bruising and pathological deterioration during storage, transportation and marketing. Polyethylene bags are used extensively to prolong shipment and storage life of mango and other fruits. As they retard respiration and transpiration and retain quality of fruits. Hot water treatment has also proved effective in extending the shelf-life of fruits by minimizing infestation of diseases and microbes during storage. The protection of fruits up to the final chain of consumer is totally dependent on the selection of proper packaging materials.

MATERIALS AND METHODS

The experiment was conducted with the fruits of Zardalu mango at Bihar Agricultural College, Sabour. The eight treatments comprised of T1 - $CaCl_2$ 1%, T2-$CaCl_2$ 2%, T3 - perforated polyethylene bag (6 % vent), T4 - hot water treatment at 52^{O}C for 5 min., T5 - $CaCl_2$ 1% + perforated polyethylene bag (6 % vent), T6 - $CaCl_2$ 2% + perforated polyethylene bag (6 % vent), T7 - hot water treatment at 52^{O}C for 5 min + perforated polyethylene bag (6 % vent) and T8 - control. The fruits were kept on the table under ambient condition at thermocol-plate. The experiment was set up under Completely Randomized Design (CRD) replicated thrice. Treated fruits were stored at room temperature.

Physiological loss in weight of fruit

The cumulative physiological loss in weight was determined on the basis of initial weight of the fruits and by how much loss in weight occurred at 1 day interval after storage and results were showed in per cent. The per cent loss in weight was calculated by the formula

$$\text{Physiological loss in weight (\%)} = \frac{\text{Original weight - Final weight}}{\text{Original weight}} \times 100$$

Spoilage of fruits

The spoiled fruits on each day of observations were expressed out by replication wise from all the treatments. The fruits so obtained were weighed separately and thus the percentage of spoiled fruits on each date was calculated by using the following formula

$$\text{Spoilage (\%)} = \frac{\text{Weight of spoiled fruits}}{\text{Original weight of fruit}} \times 100$$

Ripening percentage

Ripening percentage was assessed visually on the basis of skin colour development and softness by a panel of 5 judges (Ranganna, 1986).

Sensory evaluation

To assess the consumer's acceptability, organoleptic studies were conducted by score card system with the panel of five judges. The organoleptic rating was recorded on the basis of shape, colour, shine, firmness, texture, taste and flavour. The observations were conducted when 75 per cent of the ripened fruits remained under normal condition and following marks were allotted to each attribute of quality for the scoring.

Sl. No.	Quality Character	Maximum Marks Allotted
1.	Shape, colour and shine	20
2.	Texture and Firmness	20
3.	Taste	20
4.	Flavour	20
5.	Overall General Appearance	20
	Total	100

Sl. No.	Rating	Organoleptic score
1.	Excellent	90-100
2.	Good	80-89
3.	Fair	70-79
4.	Poor	Less than 70

Statistical methods

Observations recorded during the investigation were subjected to analysis of variance using completely randomized design as described by Cooharan and Cox (1975) and the significance of different source of variation was tested by error mean square by 'F' test.

RESULTS AND DISCUSSION

The PLW of mango fruits enhanced with successive increment in storage periods, irrespective of treatments (Table 1). The rate of increase in PLW was the highest in control (T_8) whereas the lowest was noted in fruits treated with $CaCl_2$ 2% + perforated polyethylene bag (T_6) followed by perforated polyethylene bag + $CaCl_2$ 1% (T_5). These also corroborate the findings of Scott et al. (1971), Rao and Rao (1979) in banana, Babu et al. (1994) in mango.

Unpacked fruits were kept at ambient condition in room during storage. Hence, the highest weight loss in unpacked fruits might be due to greater loss of moisture, high rates of respiration and metabolic activities. The reduction in weight loss with the application of $CaCl_2$ could be attributed to reduced rate of respiration and inhibition in cellular disintegration by maintaining protein and nucleic acid synthesis. Calcium treatment helps to retain fruit firmness, delay senescence and decrease storage breakdown (Faust, 1978 and Bangerth, 1978). The results of the present investigation in terms of PLW are in conformity with the findings of Singh et al. (1993) in guava and Wazir et al. (2007) in strawberry.

Table 1: Post-Harvest Application of $CaCl_2$, Packaging Material and Hot Water Treatment on PLW (%) of Mango cv. Zardalu

Treatments	1st day	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	Mean
T_1 - $CaCl_2$ 1%	0.00	3.58 (10.91)	6.12 (14.32)	9.53 (17.98)	12.21 (20.45)	15.28 (23.01)	18.16 (25.22)	24.19 (29.46)	12.72 (23.56)
T_2 - $CaCl_2$ 1%	0.00	3.36 (10.56)	5.68 (13.79)	8.74 (17.19)	11.45 (19.78)	14.57 (22.44)	17.34 (24.61)	22.28 (28.16)	11.92 (22.75)
T_3 -PPB	0.00	3.28 (10.43)	5.36 (13.39)	8.35 (16.79)	10.58 (18.98)	13.64 (21.67)	16.35 (23.85)	21.04 (27.39)	11.23 (22.07)
T_4 - HWT	0.00	3.75 (9.87)	6.80 (13.04)	10.28 (15.47)	12.65 (18.31)	16.76 (20.95)	19.24 (23.13)	25.48 (26.10)	13.57 (21.15)
T_5 - $CaCl_2$ 1%+PPB	0.00	2.94 (9.87)	5.09 (13.04)	7.12 (15.47)	9.87 (18.31)	12.78 (20.95)	15.43 (23.13)	19.36 (26.10)	10.37 (21.15)
T_6 - $CaCl_2$ 2%+PPB	0.00	2.76 (9.56)	4.78 (12.63)	6.62 (14.91)	9.08 (17.54)	11.97 (20.24)	14.18 (22.12)	20.14 (26.66)	9.93 (20.61)
T_7 - HWT+PPB	0.00	3.05 (10.06)	5.27 (13.27)	7.59 (15.99)	10.96 (19.33)	12.63 (20.82)	15.98 (23.56)	20.68 (27.05)	10.88 (21.68)
T_8 - Control	0.00	4.21 (11.84)	6.93 (15.26)	11.24 (19.59)	13.84 (21.84)	19.10 (25.91)	22.17 (28.09)	28.84 (32.48)	15.19 (25.84)
Mean		3.36 (10.55)	5.75 (13.85)	8.68 (17.08)	11.33 (19.63)	14.51 (22.40)	17.36 (24.57)	22.75 (28.44)	11.98 (19.50)
S.E. diff. mean					C.D at 5 %				
Treatment	0.09				0.17				
Dates	0.08				0.16				
T x D	0.23				0.45				

Table 2: Post-Harvest Application of $CaCl_2$, Packaging Material and Hot Water Treatment on Ripening Behavior (%) of fruit of Mango cv. Zardalu

Treatments	1st day	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	Mean
T_1 - $CaCl_2$ 1%	0.00	12.34 (20.56)	22.68 (28.44)	34.43 (35.93)	54.29 (47.46)	76.64 (61.11)	100 (90.00)	100 (90.00)	50.06 (47.25)
T_2 - $CaCl_2$ 1%	0.00	10.81 (19.19)	20.74 (27.09)	31.56 (34.18)	51.30 (45.75)	72.53 (58.40)	98.36 (82.74)	100.00 (90.00)	47.55 (44.56)
T_3 -PPB	0.00	14.11 (22.06)	25.62 (30.41)	40.27 (30.39)	60.74 (51.20)	88.69 (70.42)	100.00 (90.00)	100.00 (90.00)	54.91 (50.58)
T_4 - HWT	0.00	13.74 (21.76)	23.39 (28.92)	38.41 (38.30)	58.86 (50.11)	85.32 (67.51)	100.00 (90.00)	100.00 (90.00)	53.29 (49.43)
T_5 - $CaCl_2$1%+PPB	0.00	9.85 (18.29)	18.92 (25.78)	28.51 (32.27)	49.78 (44.87)	68.46 (55.84)	95.42 (77.94)	100.00 (90.00)	45.16 (42.50)
T_6 - $CaCl_2$ 2%+PPB	0.00	8.32 (16.76)	16.71 (24.13)	26.17 (30.77)	46.85 (43.19)	65.57 (54.08)	90.12 (71.76)	100.00 (90.00)	42.29 (40.11)
T_7 - HWT+PPB	0.00	12.80 (20.96)	22.16 (28.08)	37.21 (37.59)	57.58 (49.36)	82.27 (65.13)	100.00 (90.00)	100.00 (90.00)	52.00 (48.52)
T_8 - Control	0.00	15.36 (23.02)	28.45 (32.23)	41.35 (40.02)	62.70 (52.36)	92.14 (73.85)	100.00 (90.00)	100.00 (90.00)	56.67 (51.92)
Mean		12.17 (20.33)	22.33 (28.13)	34.74 (36.05)	35.26 (48.04)	78.95 (63.29)	97.99 (85.30)	100.00 (90.00))	50.24 (46.86)
S.E. diff. mean					C.D at 5 %				
Treatment	19.40				NS				
Dates	18.14				35.95				
T x D	51.32				NS				

The ripening of mango fruits was observed on 6th day of storage and it increased gradually with the advancement of storage period (Table 2). The minimum rate of ripening was observed in fruits packed under perforated polyethylene bag + $CaCl_2$ 2% (T_6) followed by perforated polyethylene bag + $Cacl_2$ 1% (T_5) and the highest were under control (T_8). The decrease in ripening rate with calcium salt might be due to reduction in endogenous substrate catabolism by limiting the diffusion of substrates from the vacuole to the cytoplasm (Scott and Wills, 1995). Calcium feeding also inhibits ethylene biosynthesis and retards activities of various enzymes and maintain firmness of fruits. These results are correlated with the findings of Ramana et al. (1989) in banana. Singh et al. (1998) also noticed similar results in mango.

Table 3: Post-Harvest Application of $CaCl_2$, Packaging Material and Hot Water Treatment on Spoilage (%) of Mango cv. Zardalu

Treatments	1st day	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	Mean
T_1 - $CaCl_2$ 1%	0.00	0.00	1.72 (7.54)	5.64 (13.74)	7.85 (16.27)	10.12 (18.55)	15.17 (22.92)	22.17 (28.09)	10.45 (17.85)
T_2 - $CaCl_2$ 1%	0.00	0.00	1.54 (7.13)	4.88 (12.76)	6.91 (15.24)	9.38 (17.83)	14.68 (22.53)	20.76 (27.10)	9.69 (17.10)
T_3 -PPB	0.00	0.00	1.97 (8.07)	7.66 (16.07)	10.72 (19.11)	12.48 (20.69)	20.52 (26.93)	27.15 (31.40)	13.42 (20.38)
T_4 - HWT	0.00	0.00	1.85 (7.82)	6.87 (15.19)	9.58 (18.03)	13.15 (21.26)	19.30 (26.06)	26.24 (30.81)	12.83 (19.86)
T_5 - $CaCl_2$ 1%+PPB	0.00	0.00	1.38 (6.75)	4.79 (12.64)	6.75 (15.06)	9.06 (17.52)	12.06 (20.32)	20.17 (26.69)	9.04 (16.49)
T_6 - $CaCl_2$ 2%+PPB	0.00	0.00	1.27 (6.47)	4.21 (11.84)	6.22 (14.44)	8.79 (17.24)	11.58 (19.89)	19.54 (26.23)	8.60 (16.02)
T_7 - HWT+PPB	0.00	0.00	1.81 (7.73)	6.51 (14.78)	9.18 (17.64)	12.04 (20.30)	18.45 (25.44)	25.21 (30.14)	12.20 (19.34)
T_8 - Control	0.00	0.00	3.12 (10.17)	8.16 (16.60)	11.84 (20.13)	15.10 (22.87)	21.31 (27.49)	29.32 (32.78)	14.81 (21.67)
Mean			1.83 (7.71)	6.09 (14.20)	8.63 (16.99)	11.27 (19.53)	16.63 (23.95)	23.82 (29.16)	11.38 (18.59)
S.E. diff. mean					C.D at 5 %				
Treatment	0.10				0.20				
Dates	0.71				0.14				
T x D	0.24				0.48				

It is distinct from the data that the spoilage of fruits started from 5th day of storage and significantly increased till last day of storage and increased up to 23.82 per cent on 15th day of storage. The spoilage losses on 13th and 15th day of storage were 16.63 and 23.82 per cent respectively which were uneconomical due to high percentage of spoilage (Table 3).

The spoilage of fruits increased with the advancement of storage period, regardless of treatments. This might be due to existing pathogens on the surface of fruits which might have proliferated with pace of time resulting in increased rotting. Scott et al. (1971) and Emereld and Sreenarayanan (1999) also observed that rotting of banana fruits increased with prolongation of storage period. The highest decay of banana fruits during storage was obtained under control (T_8). At the end of the trial, the least spoilage was noted in fruits packed under perforated polyethylene bag + $CaCl_2$% (T_6) followed by perforated polyethylene bag + $Cacl_2$ 1% (T_5) and maximum was under control (T_8). The unpacked fruits were open and exposed and had direct contact with air and temperature of surrounding environment, so they might have respired more and transpired rapidly. Ethylene evolution, degradative metabolism and pectin hydrolysis were also at higher rate resulting in increased spoilage.

Further, fruits under control were exposed to pathogens of the surrounding atmosphere, which easily invaded and multiplied with the pace of time resulting in increased decay. The polyethylene bag acted as an effective barrier to surrounding atmosphere and reduced exposure of fruits to microflora. Perforated polyethylene bag slowed down the rate of respirated, ethylene evaluation, oxidative metabolism and pectin hydrolysis resulting in retention of firmness. Thus in turn, might have imparted some resistance against the growth of the pathogens on fruits. These results also get support from Emeralds and Sreenarayanan (1999), Scott and wills (1975) in banana, Banik et al. (1988) in jamun, Siddiqui et al., (1989) in ber and Wazir et al. (2007) in strawberry.

The sensory evaluation of fruits was started from 5th day of storage. The rating pertaining to sensory evaluation revealed that on 5th day, all the treatments produced excellent grade of fruits except in control (T_8). On 9th day of storage, fruit scored maximum marks and rated as good when packed with perforated polyethylene bag + $CaCl_2$ 2% (T_6) and perforated polyethylene bag + $CaCl_2$ 1%(T_5) and fruits under control were rated as poor.

On 13th day of storage fruits scored fair good with perforated polyethylene bag + $CaCl_2$ 2% (T_6) and perforated polyethylene bag + $CaCl_2$ 1% (T_5) and remaining treatment combinations showed poor grade. On last day of storage all the treatment combinations were failed to produce either excellent or good or fair good grade fruits and fruits under control were rated to dislike extremely (Table 4).

Table 4: Post-Harvest Application of $CaCl_2$, Packaging Material and Hot Water Treatment on Sensory Evaluation (%) of Mango cv. Zardalu

Treatments	1st day	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	Mean
T_1 - $CaCl_2$ 1%	0.00	0.00	94.31 (76.24)	90.18 (71.85)	76.15 (60.78)	65.27 (53.90)	51.47 (45.84)	32.56 (34.79)	68.32 (57.23)
T_2 - $CaCl_2$ 1%	0.00	0.00	95.48 (77.79)	92.56 (74.35)	79.35 (63.00)	68.33 (55.76)	56.19 (48.56)	40.34 (39.43)	72.04 (59.81)
T_3-PPB	0.00	0.00	92.63 (74.28)	88.63 (70.38)	73.25 (58.87)	57.61 (49.38)	38.40 (38.29)	21.72 (27.78)	62.04 (53.16)
T_4 - HWT	0.00	0.00	90.26 (71.83)	85.37 (67.56)	70.39 (57.04)	54.38 (47.51)	45.39 (42.35)	26.64 (31.07)	62.07 (52.90)
T_5 - $CaCl_2$ 1%+PPB	0.00	0.00	96.35 (79.08)	93.52 (75.48)	80.29 (63.67)	72.50 (58.38)	60.52 (51.07)	46.12 (42.77)	74.88 (61.74)
T_6 - $CaCl_2$ 2%+PPB	0.00	0.00	98.64 (83.82)	95.40 (78.05)	84.31 (66.71)	76.39 (60.94)	68.43 (55.82)	49.38 (44.64)	78.76 (65.00)
T_7 - HWT+PPB	0.00	0.00	91.62 (73.20)	89.26 (70.96)	74.62 (59.76)	62.48 (52.23)	41.30 (39.99)	20.54 (26.95)	63.30 (53.85)
T_8 - Control	0.00	0.00	88.17 (69.89)	76.68 (61.14)	63.54 (52.86)	50.28 (45.16)	31.69 (34.23)	19.65 (26.31)	54.99 (48.27)
Mean			93.43 (75.77)	88.95 (71.22)	75.24 (60.34)	63.41 (52.91)	49.17 (44.52)	32.12 (34.22)	67.05 (56.49)
S.E. diff. mean					C.D at 5 %				
Treatment	0.53				1.05				
Dates	0.37				0.74				
T x D	1.29				2.57				

During the course of investigation sensory evaluation of fruits were evaluated for assessing the consumers acceptability of fruits. There was a gradual decrease in sensory evaluation scoring under all the treatments with the prolongation of storage period. Similar changes in rating of sensory evaluation was noted by some earlier workers (Kumar et al., 1992; Brahmachari et al., 1999) in guava. The decline in score during storage under all the treatments may be due to gradual loss in moisture and firmness resulting in fruit shrinkage, softness, dull appearance and rotting. Fruit treated with $CaCl_2$ and packed in perforated polyethylene bag secured maximum score under which fruits were acceptable up to 12 days of storage. Higher consumer acceptability of fruits under this treatment might be due to slower degradation of the biochemical constituents of fruits and prevention of spoilage. These results are in conformity with the findings of Jawandha et al. (2007) in ber, Wazir et al. (2007) in strawberry and Ishaque et al. (2009) in apricot.

REFERENCES

Anonymous, 2009.Estimated area and production of major Horticultural groups. Economic survey, Ministry of Agriculture, Govt. of India, p: 162.

Babu, K. H. and Krishnamurthy Shantha, 1994.Effect of calcium on physic chemical changes in Alphanso mango during ripening and storage Australian Centre for international Agricultural research; 390-392.

Bangerth, F; D.R.Dilley and Dewey D. H. 1978.Effect of post harvest calcium treatment on internal breakdown and respiration of apple fruits, J. Amer. Soc. Hort. Sci. 97 (4)679-682.

Brahmachari, V. S., Rajesh Kumar and Rani Ruby, 1999.Effect of pre harvest application of different chemicals on shelf life of litchi fruits.Haryana J. Hort. Sci, 28 (3 & 4): 182-185.

Cochran, W.G. and Cox, G.M. 1957. Experimental designs, 2nd Edition, John Willy and Sons. Inc.New York, Cubin M.

Emerald, M.E.F. and Sreenarayanan V.V. 1999.prolonging storage life of banana fruits by sub-atmospheric pressure. Indian Fd. Packer, 53 (3):22-25.

Faust, M., 1978.The role of calcium in the respiratory mechanism of apples.Colloguies international delscientifique No. 238: 87-92.

Hindu Survey of Indian Agriculture, 2005

Ishaque, S.,RathoreH.A.,MasudT.and Ali S.,2009. Influence of post harvest calcium chloride application, ethylene absorbent and modified atmosphere on quality characteristics and shelf-life of apricot (Prunusarmeniaca L.) fruit during storage. Pakisatan J. Nutrition, 8 (6): 861-865.

Jawandha, S. K.,Randhawa J. S. and Gill P.P. S. 2007.Effect of different pre-harvest treatments on the storage of ber.Haryana J. Hort. Sci;36 (3 & 4): 251-254.

Kumar, R.,Kaushik R.A. and Chharia A.S. 1992.Effect of post harvest treatment on the quality of mango during storage.Haryana J. Hort. Sci., 21 (1-2): 46-55.

Ramana, S. V., Mohan B. L. and Jayaraman K.S.,1989. Effect of post harvest treatments and modified atmosphere on the storage life of fresh banana and guava under ambient temperature. Ind. Fd. Packer, 43 (1): 29-35.

Ranganna, S. 1986. Handbook of analysis and quality control for fruit and vegetable products.

Rao, D. Madhava and. Rama Rao M. 1979. Post harvest changes in banana cv. Robusta. Indian J. Hort. 36 (4): 387-393.

Scott, K. J., BlakeJ. R.,StachanG.,Tugwell B. L. and Mc. Glassom W. B. 1971. Transport of banana at ambient temperature using polyethylene bags, Trop. Agril.48: 245-254.

Siddiqui, S., Gupta O. P. and Yamdagni R. 1989. Effect of pre harvest sprays of chemicals on the shelf life of ber (ZizyphusmauritianaLamk) fruits cv. Umran. Haryana J. Hort. Sci.18 (3-4): 177-183.

Singh, B. P., Tondon D. K. and Kalra S. K., 1993. Changes in post harvest quality of mangoes affected by pre-harvest application of calcium salts. Scientia Hort. 54 : 211-219.

Wazir, Singh,Godara A. K. and Goyal R. K. 2007.Effect of calcium chloride on shelf-life of strawberry cv. Oso Grande.Haryana J. Hort. Sci. 36 (1 & 2): 29-30.