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Impact of salicylic acid and card board carton on quality attributes of mango varieties

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Abstract
The present investigation had sixteen treatment combinations, which had been replicated three times and was laid out in Completely Randomized Design. At maturity condition mango fruits were harvested and stored in cardboard card board carton by post harvest application of salicylic acid at 0.1, 0.5 and 1.0 g/l doses. The data revealed that lowest physiological loss weight (2.12 %) was recorded in Langra variety at five days storage by 0.5 g/l salicylic acid application. Maximum pectin content (1.96 %) was recorded in Langra variety at 15 days ambient storage period by 0.5 g/l salicylic acid application. Highest pectin methyl esterase (0.91 units/g) reported in variety Dashahari at 5 days storage by 1.0 g/l salicylic acid application. The highest polyphenol oxidase enzyme activity (56.38 units/g) was noticed in variety Dashahari at 5 days storage by 0.1 g/l salicylic acid treatment. Highest peroxidase activity and beta carotene content (463.69 units/g and 3495.93 µg/100g) was reported in Dashahari variety at 20 days ambient storage period by 0.5 g/l salicylic acid application. Maximum TSS content (28.00 Brix^0) was reported in variety Chausa at 20 days ambient storage period by 0.5 g/l salicylic acid treatment. Thus the presented study indicated that salicylic acid enhanced the TSS, beta carotene, peroxidase activity but decreased the polyphenol oxidase and pectin methyl esterase enzyme activity. Salicylic acid significantly decreased the physiological loss weight during storage in cardboard carton.

Keywords: mango, salicylic acid, card board carton, PME, polyphenol oxidase, peroxidase, TSS, beta carotene, physiological loss weight

Introduction
India is an agriculture based country where, different types of fruits and vegetables are grown. The total production of fruits and vegetables in the world is around 370 million tonnes. India ranks first in the world with an annual output of 32 million tonnes fruits; accounts for about 8 per cent the world fruits production [1]. The total production of mango fruit in India is 15188 million tonnes with an area of about 2297 hectare. The mango fruit has been cultivated in Indian sub-continent for over 4000 years and has been the favorite of the Kings and commoners because of its nutritive values, taste, attractive fragrance and health promoting qualities and now it is recognized as one of the best fruit in the world market and also designated as 'King of Fruits'. The biochemical composition of mango fruit differs among the cultivars and the stage of maturity. Mango fruit is rich in carbohydrates, carotenoids, organic acids, polyphenols, vitamins and minerals etc.

According to the Ministry of Food Processing Industry statement '' the lack of processing and storage of fruits and vegetables results in huge wastages estimated at about 35 per cent the value of which is approximately Rs. 33000 crores for perishable and Rs. 15000 crores for non-perishable annually.'' Due to mishandling, inadequate storage or lack of post harvest technical knowledge, producer and traders have to face about 30-40 per cent losses [2]. Spoilage of mango due to end rot and anthracnose limit its storage potential and the shelf life is decided on the basis of spoilage during storage. The loss of water from fruit is due to skin evaporation (transpiration) and to some extent respiration. When the fruit losses weight, shriveling will occur and the appearance will deteriorate, thus reducing its market value [3].

Salicylic acid (SA) is a colourless, crystalline organic carboxylic acid which is found in plants, especially in fruits, in the form of methyl salicylate. It is also known as 2-hydroxybenzoic acid with functions as a plant hormone. Most investigators have focused on the role of salicylic acid in induction of disease resistance. Exogenous supply of salicylic acid has been reported to delay the ripening of apples [4], peach [5], persimmon [6], mango and tomato fruits [7] probably

through inhibition of ethylene biosynthesis [8]. Salicylic acid (SA) has been shown to inhibit the conversion of 1-amino cyclopropane 1-carboxylic acid (ACC) into ethylene [9] by suppressing ACC oxidase activity [10]. Furthermore, [11] demonstrated an inhibitory effects of SA on accumulation of wound induced ACC synthase transcrypt in tomato fruit. Very less literature is available on the application of salicylic acid during ripening and storage of mango varieties.

Materials and Methods

The experiment was conducted after harvesting of mango fruits cv. Dashahari, Chausa, Langra and Safeda at maturity. The salicylic acid treatments were applied at 0.1 g/l (S_1), 0.5 g/l (S_2), 1.0 g/l (S_3) and water (control, S_0). All the fruits were stored in cardboard carton after salicylic acid application at ambient temperature and biochemical analysis was done at five days intervals. The experiment was laid out in Factorial Completely Randomized Design (CRD) and the treatments were replicated three times. The per cent physiological loss weight was calculated on initial weight basis at five days intervals after storage. Pectin methyl esterase activity was measured by the method given by Line Weaber and Janson [12]. Polyphenol enzyme activity was measured by the methods of Herewitz *et al*. [13]. Peroxidase enzyme activity was measured calorimetrically by the method of McCune and Galston [14]. The β- carotene content was estimated in fresh fruit sample using the method developed by Rangana [15]. Fruits were randomly selected and crushed by using pestle and mortor. Juice was squeezed in muslin cloth and used for determination of TSS value using hand Refractometer. The value of TSS ($Brix^0$) from the Refractometer scale were recorded for various cultivars at each date of observation.

Results and Discussion

The data pertaining to physiological loss weight of mango varieties by salicylic acid application stored in cardboard carton was given in Table-1. Maximum physiological loss weight (9.12 %) was reported in Safeda variety at five days ambient storage period in the control treatment. After salicylic acid application lowest physiological loss weight (2.12 %) was recorded in Langra variety at five days of storage by 0.5 g/l salicylic acid treatment. Various concentration of salicylic acid significantly effects the physiological loss weight of mango varieties during entire storage period in cardboard carton. In control treatment, all the fruits were destroyed due to rotting and microbial infection after five days storage in all the mango varieties at ambient temperature. The losses of weight in mango fruits may be mainly due to loss of water by transpiration. Its thought that salicylic acid can decrease respiration rate throughout inhibition of ethylene biosynthesis or action. The findings of the present investigation are well supported by Srivastava and Dwivedi [16], Fattahi *et al*. [17]. Application of salicylic acid is also effective in decreasing the transpiration rate and fruit weight loss by closing stomata [18].

The data regarding to pectin methyl esterase enzyme activity in various mango varieties by salicylic acid application stored in cardboard carton was presented in Table-2. In control treatment maximum pectin methyl esterase activity (0.93 units/g) was recorded in variety Dashahari at five days storage period but after salicylic acid treatment highest pectin methyl esterase activity (0.91 units/g) was reported in variety Dashahari at five days storage period by 1.0 g/l salicylic acid application. Statistical analysis of data revealed that salicylic acid treatments significantly effected the pectin methyl esterase enzyme activity of the mango varieties during entire storage period stored in cardboard carton. In control treatments all the fruits were destroyed due to rotting and microbial infection after five days ambient storage in all the mango varieties. The activity of this enzyme decreases during entire storage period may be due to increasing content of pectins from maturity to ripening. This enzyme is actively utilized in ripening process, so its activity due to application of salicylic acid decreased. The main role of salicylic acid in ripening process may be delayed by reducing the ethylene synthesis with the use of antisense gene for ethylene biosynthetic enzyme namely pectin methyl esterase and polygalacturonase which involved in the ripening process itself. The decreased activity of this enzyme in the present investigation may be due to less activity of these enzymes during storage as given by Chaesworth *et al.* [19]. The similar finding was also observed by Zhixi and Yuxing [20].

The data containing polyphenol oxidase enzyme activity in mango varieties by application of salicylic acid stored in cardboard carton was shown in Table-3. Maximum polyphenol oxidase enzyme activity (59.64 units/g) in mango varieties was noticed in the variety Dashahari at five days ambient storage period in the control treatment. The highest polyphenol oxidase enzyme activity (56.38 units/g) was noticed in the variety Dashahari at five days ambient storage period by the application of 0.1 g/l salicylic treatment. Statistical analysis of the data revealed that salicylic acid treatment significantly effected the polyphenol oxidase enzyme activity of mango fruits stored in card board carton. In control treatment all the fruits were destroyed due to rotting and microbial infection after five days storage in all the mango varieties. The activity of polyphenol oxidase enzyme tends to decrease in salicylic acid treated fruits during ambient storage. Phenolics are secondary plant metabolites, are synthesized by all plants. Salicylic acid treated ‘’Cara Cara’’ navel orange had increased total phenolics content and higher salicylic acid concentration was observed with further profound effect in this respect [21]. Similar findings were also reported by Tareen *et al.* [22].

The data regarding to peroxidase enzyme activity in mango varieties by salicylic acid application stored in cardboard carton was given in Table-4. In control treatment maximum peroxidase activity (356.23 units/g) was reported in the variety Dashahari at five days ambient storage period. After salicylic acid application highest peroxidase activity (463.69 units/g) was reported in Dashahari variety at 20 days ambient storage period by 0.5 g/l salicylic acid treatment. Salicylic acid treatment significantly effected the peroxidase enzyme activity of mango fruits stored in cardboard carton of mango varieties during entire period of storage. In control treatment all the fruits were destroyed due to rotting and microbial infection after five days storage period in all the varieties of mango fruits. The activity of peroxidase enzyme in various varieties of mango fruits by the application of salicylic acid during storage was found in increasing pattern, it may be due to salicylic acid mediated hypersensitive and systemic acquired resistance against pathogenic attack and proposed to be mediated fruits through inhibition of catalase, which subsequently rases extracellular hydrogen peroxide. Peroxidases increased intracellular hydrogen peroxide concentration is converted into hydrogen peroxide and oxygen by increased activity of peroxidase enzyme. Lamikanra and Watson [23, 24] indicated that the ascorbate dependency of peroxidase enzyme in a number of commonly fresh cut processed fruits, whose activity appears to be related

to the level of oxidative stress in cut fruit. The results were also supported by Kazemi *et al.* [25].

The data related to beta carotene content in mango varieties by salicylic acid application stored in cardboard carton was given in Table-5. Highest beta carotene content (2434.00 µg/100 g) was recorded in variety Dashahari at five days ambient storage period during control treatment. Maximum beta carotene content (3495.93 µg/100 g) was reported in the variety Dashahari at 20 days ambient storage period by 0.5 g/l salicylic acid treatment. Statistical data showed that salicylic acid treatment significantly effected the beta carotene content of mango varieties during storage in cardboard carton. In control treatment all the fruits were destroyed due to rotting and microbial infection after five days in all the mango varieties. The increasing content of beta carotene during ripening and storage may be due to degradation of chlorophyll and increased synthesis and accumulation of carotenoids in the plastids which are formed from simple five carbon isoprenoid units followed by cyclisation of terminal bond finally converted into 40 carbon beta carotene. During ripening and storage, the amounts of chlorophyll decreased while the carotenes of major carotenoids namely alpha carotene, beta carotene and lutin where increased as given by Gross *et al.* [26]. Beta carotene pigment were increased during storage after salicylic acid treatment. This result was well supported by Zheng *et al.* [27].

The data pertaining to TSS content in mango fruits by salicylic acid application stored in cardboard carton was given in Table-6. In control treatment highest TSS content (19.00 $Brix^0$) was found in the variety Chausa at five days ambient storage period. Maximum TSS content (28.00 $Brix^0$) was recorded in the variety Chausa at 20 days ambient storage period by 0.5 g/l salicylic acid treatment. A significant correlation was observed regarding salicylic acid treatment with TSS content of mango varieties during entire storage period in cardboard carton. In control treatment all the fruits were destroyed due to rotting and microbial infection after five days storage period in all the varieties studied under investigation. In the present investigation total soluble solids of mango fruits significantly increased after salicylic acid application during entire storage period. The total soluble solids content of fruits during storage is considered as an index of fruit ripening and an increase in TSS corresponds to conversion of starch in to sugars [28]. Singh *et al.* [29] reported that total soluble solids were increased after salicylic acid treatment in various fruits.

Table 1: Physiological loss weight (%) of mango fruits at different intervals during storage in cardboard carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	8.76	8.53	8.68	9.12		
	10 d	0.00	0.00	0.00	0.00	V	0.102
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	0.102
S_1	5 d	4.52	4.23	4.36	5.07		
	10d	4.63	4.35	4.48	5.19	T	0.102
	15 d	4.76	4.48	4.60	5.32		
	20 d	5.96	5.75	5.87	6.58	V X S	0.204
S_2	5 d	2.24	2.12	2.18	3.11		
	10 d	2.31	2.23	2.29	3.24	V X T	0.204
	15 d	2.47	2.33	2.41	3.39		
	20 d	3.16	3.12	3.14	4.12	S X T	0.204
S_3	5 d	4.72	4.44	4.55	5.26		
	10 d	4.83	4.57	4.67	5.38		
	15 d	4.95	4.69	4.82	5.53	V X S X T	0.408
	20 d	6.94	5.97	6.82	7.18		

Table 2: Pectin methyl esterase enzyme activity (units/g) of mango fruits at different intervals during storage in cardboard carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	**0.93***	0.84	0.91	0.78		
	10 d	0.00	0.00	0.00	0.00	V	0.013
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	0.013
S_1	5 d	0.88	0.79	0.86	0.62		
	10d	0.82	0.64	0.81	0.56	T	0.013
	15 d	0.73	0.56	0.72	0.51		
	20 d	0.64	0.42	0.61	0.39	V X S	0.025
S_2	5 d	0.78	0.67	0.76	0.58		
	10 d	0.71	0.60	0.69	0.53	V X T	0.025
	15 d	0.67	0.57	0.62	0.45		
	20 d	0.51	0.43	0.47	0.39	S X T	0.025
S_3	5 d	0.91	0.81	0.89	0.65		
	10 d	0.83	0.67	0.84	0.60		
	15 d	0.76	0.59	0.75	0.54	V X S X T	0.050
	20 d	0.67	0.45	0.65	0.44		

Table 3: Polyphenol oxidase enzyme activity (units/g) of mango fruits at different intervals during storage in card board carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	59.64	54.78	57.73	51.74		
	10 d	0.00	0.00	0.00	0.00	V	0.961
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	0.961
S_1	5 d	56.38	51.47	53.84	48.49		
	10d	55.47	50.39	52.79	47.52	T	0.961
	15 d	54.58	49.68	51.65	46.59		
	20 d	53.12	48.32	50.19	45.31	V X S	1.923
S_2	5 d	54.76	50.38	51.76	47.78		
	10 d	53.48	49.93	50.39	46.52	V X T	1.923
	15 d	52.31	48.79	49.72	45.32		
	20 d	51.08	47.38	48.19	44.08	S X T	1.923
S_3	5 d	56.12	51.38	53.56	48.23		
	10 d	55.31	50.17	52.47	47.31		
	15 d	54.34	49.42	51.36	46.27	V X S X T	3.846
	20 d	53.02	48.13	50.07	45.07		

Table 4: Peroxidase enzyme activity (units/g) of mango fruits at different intervals during storage in card board carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	356.23	348.63	351.46	342.37		
	10 d	0.00	0.00	0.00	0.00	V	7.812
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	7.812
S_1	5 d	376.75	367.75	372.76	357.78		
	10d	389.72	378.65	386.67	363.93	T	7.812
	15 d	412.56	392.93	402.39	387.34		
	20 d	425.37	406.71	419.59	405.56	V X S	15.624
S_2	5 d	397.75	388.89	392.94	376.72		
	10 d	423.36	412.13	418.83	393.94	V X T	15.624
	15 d	446.72	433.69	439.39	411.14		
	20 d	463.69	451.58	460.64	433.63	S X T	15.624
S_3	5 d	375.72	365.67	370.72	355.46		
	10 d	387.64	376.79	383.84	361.67		
	15 d	409.58	390.78	398.42	385.56	V X S X T	31.248
	20 d	423.31	402.96	416.79	400.98		

Table 5: Beta carotene content (µg/100g fresh weight) of mango fruits at different intervals during storage in card board carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	2434.00	2218.35	2374.67	2064.84		
	10 d	0.00	0.00	0.00	0.00	V	46.760
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	46.760
S_1	5 d	2664.32	2228.31	2576.74	2271.86		
	10d	2694.54	2435.52	2658.79	2312.33	T	46.760
	15 d	2768.68	2512.32	2712.32	2430.39		
	20 d	2859.35	2665.47	2832.57	2495.98	V X S	93.520
S_2	5 d	2715.58	2351.49	2667.64	2352.84		
	10 d	2897.95	2465.44	2758.46	2447.76	V X T	93.520
	15 d	3085.65	2595.13	2968.95	2594.81		
	20 d	3495.93	2778.59	3264.97	2691.89	S X T	93.520
S_3	5 d	2612.58	2218.35	2556.83	2257.59		
	10 d	2681.55	2415.37	2622.80	2297.84		
	15 d	2748.32	2498.85	2702.67	2415.68	V X S X T	187.039
	20 d	2812.22	2627.95	2812.84	2485.47		

Table 6: TSS content (Brix^0) of mango fruits at different intervals during storage in card board carton after salicylic acid application

Treatments \ Varieties		V_1	V_2	V_3	V_4	CD at 5 %	
S_0	5 d	18.00	16.00	19.00	15.00		
	10 d	0.00	0.00	0.00	0.00	V	0.338
	15 d	0.00	0.00	0.00	0.00		
	20 d	0.00	0.00	0.00	0.00	S	0.338
S_1	5 d	19.00	17.00	21.00	17.00		
	10d	20.00	19.00	22.00	18.00	T	0.338
	15 d	22.00	21.00	23.00	19.00		
	20 d	23.00	22.00	25.00	21.00	V X S	0.676
S_2	5 d	21.00	18.00	23.00	17.00		
	10 d	22.00	21.00	24.00	19.00	V X T	0.676
	15 d	24.00	22.00	26.00	20.00		
	20 d	26.00	24.00	28.00	21.00	S X T	0.676
S_3	5 d	19.00	17.00	21.00	15.00		
	10 d	20.00	18.00	22.00	16.00	V X S X T	1.351
	15 d	23.00	21.00	23.00	17.00		
	20 d	24.00	22.00	24.00	19.00		

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