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Research Article

STORAGE BEHAVIOUR OF GUAVA AS INFLUENCED BY PLANT GROWTH SUBSTANCES AND CARNAUBA WAX

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Abstract- Freshly harvested, fully mature green guava fruits of *cv.* Khaza (Local) were subjected to different post harvest treatments *viz.*, ^{6}N- Benzyl adenine (BA) 50 ppm (T_1), Gibberellic acid (GA_3) 50 ppm (T_2), Carnauba wax (CW) 1% (T_3), BA 50 ppm + CW1% (T_4), GA_3 50 ppm + CW1% (T_5) and Control (T_6) with 4 replications in Factorial CRD design and stored in ambient condition (Temp: minimum 18^{0}C, maximum 24^{0}C, and RH: 57-84%). Observations were recorded on physiological loss of weight (PLW %), fruit firmness (Kg/cm^2), TSS (°Brix), titratable acidity (%), ascorbic acid (mg/100g), organoleptic quality and physical characters at three days interval. The results indicated that PLW in carnauba wax treatments with or without growth substances remained low throughout the period of storage. Treatment of fruits with benzyl adenine and carnauba wax (BA+CW) *i.e.,* T_4 exhibited least PLW and retained higher firmness, TSS, acidity, ascorbic acid and organoleptic quality during storage compared to other treatment, this was followed by T_5 (GA_3+CW) and T_3 (CW). In general, firmness and ascorbic acid continuously decreased during storage while TSS, acidity and organoleptic quality increased up to 3rd day of storage; there after it steadily decreased during subsequent period of storage. Organoleptic rating revealed superiority of T_4 and T_5 over other treatments while the control fruits were undesirable on 9th day.

Keywords- Biochemical characters, Carnauba Wax, Growth Substances, Guava, Organoleptic quality, PLW, and Storage.

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Introduction

Guava (*Psidium guajava L.*) is a delicious and popular fruit. It is widely grown in tropical and sub tropical regions of the country and is considered to be poor man's apple. At present, it ranks fifth among the fruits grown in India occupying 2.55 lakh hectare area with annual production of 4.1 million tonnes [1]. However, the post harvest loss of guava in India is about 25-30% *i.e.* 4.5 lakh tonnes worth rupees 180 crores [2]. The losses are due to undesirable physiological and biochemical changes and infection of disease. The fruit is a rich source of Vitamin C and pectin. Guava fruits are climacteric in their respiratory behaviour with ethylene triggering the respiratory rise [3]. It ripens rapidly after harvest and therefore has a short shelf-life. It is a highly perishable fruit and loses its texture and quality in 3-4 days in ambient temperature. Fruit ripening is regulated by hormones. The application of Gibberellic acid (GA_3) has been reported to delay senescence of fruits and vegetables [4,5]. The senescence delaying ability of cytokinins particularly ^{6}N-Benzyladenine (BA) has been explored in guava [6,7] lettuce, Brussels sprouts broccoli and celery [8].

Carnauba wax is an edible coating material under the lipid groups, which is recovered from the inside of leaves of a Brazilian palm tree and mainly used to reduce water loss and improve gloss [9]. The prospect of utilization of carnauba wax in guava has been indicated earlier by [10,11]. Guava is usually coated in one-layer plastic wrapping as commonly found in other fruits in many countries. However, as environmental problems may arise from the frequent use of plastic wrapping, a more environmentally friendly fruit coating with or without growth substances needs to investigated. Thus considering the importance of guava fruit and the problem mentioned above, present investigation on, "Storage behaviour of guava as influenced by plant growth substances and carnauba wax" was undertaken.

Materials and Methods

The present study was carried out in the laboratory of Department of Post Harvest Technology of Horticultural Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, during the period from December 2015 to January 2016. Guava *cv.* Local (Khaza) were harvested at green mature stage and fruits free from mechanical damage and blemishes were sorted out. The fruits were then well washed with running tap water to remove the dirt, soil and other foreign matters. The fruits of specific gravity >1 were selected for experiment. After washing, the excess moisture was drained out from the fruits and then dried lightly at room temperature.

Guava fruits after preparation were subjected to different treatment combination of growth substances (GA_3 and BA) and wax emulsion (carnauba wax) for 2 minutes. The treatment consist of T_1= ^{6}N- benzyl adenine (BA) 50ppm, T_2= Gibberellic acid (GA_3) 50 ppm, T_3 = Carnauba wax (CW) 1%, T_4= BA 50 ppm + CW1%, T_5= GA_3 50 ppm + CW1%, T_6= Control (water), each treatment was replicated four times and each replicate consist of 54 fruits and the experiment was laid out in Factorial Completely Randomized Design. The treated fruits were stored in cool, dry place on racks at room temperature. The maximum and minimum temperature during the period at ambient condition varied from 24^{0}C and 18^{0}C respectively and relative humidity from 57 to 84% during the period of storage.

Observations were recorded on physiological loss in weight, fruit firmness, total soluble solids, titratable acidity, ascorbic acid and organoleptic evaluation on the basis of fruit appearance (colour), taste, firmness and flavor. For determining the physiological loss in weight, fruits were numbered and weighed individually on the

day of observation. It was expressed as percentage of the original fresh weights of the fruit. Penetrometer (Model no. FT-327) was used to determine the firmness of the representative sample by puncturing at three different places of fruit (upper, middle and lower portion). Average firmness was expressed as kg/cm^2. Physical characters of fruits ie., changes in surface colour of fruits from green to yellow and fruit texture from hard to semi-hard and soft was recorded at different days of storage. Total soluble solid contents was estimated with a hand refractometer (Erma, Japan) and expressed as ^{0}Brix. Titratable acidity was determined as percentage citric acid according to method described in [12]. Ascorbic acid content of guava pulp samples were determined by 2, 6-dichlorophenol indophenol titration method as described by [13]. Organoleptic evaluation was recorded of physical characters of fruits *viz,* fruit appearance (colour), taste, firmness and flavour by a panel of judges as per "hedonic scale" (1-9 point), which is as follows : extremely desirable (MD)=9, very much desirable (VMD)=8, moderately desirable (MD), slightly desirable (SD)=6 neither desirable (ND) nor undesirable (UD)=5 slightly undesirable (SUD)=4 moderately undesirable (MUD)=3 very much undesirable (VMUD)=2, and extremely undesirable (EUD)=1, [14]. The analysis of data obtained in experiment was analyzed by Factorial Completely Randomized Design with two factors, i)treatments and ii) storage period by adopting the statistical procedures of [15].

Results and Discussion

Physiological loss of weight (PLW %) of different treatments during storage of guava fruits is presented in [Table-1]. PLW was significantly different for treatment, duration of storage while treatment × duration interaction was non-significant at 5% level. Mean PLW of treatment during the period of storage up to 9 days was highest (11.08%) in control and least (9.12%) in T_4 (BA+CW). Irrespective of treatments, mean PLW increased significantly with the enhancement of storage duration from 3.94% on 3rd day to 15.48 on 9th day of storage. It was found that throughout the period of storage PLW was significantly low in T_4 (BA+CW), T_5 (GA_3+CW) and T_3 (CW %). On 9th day of storage the PLW of T_4, T_5 and T_3 was 14.63%, 14.72% and 15.03 % respectively compared to 15.48% in control.

Table-1 *Effect of treatments on Firmness (kg/cm^2), PLW (%) and Organoleptic score on during storage*

Treatment	Firmness (kg/cm^2)			PLW (%)			Organoleptic score		
	Days			Days			Days		
	3rd	6th	9th	3rd	6th	9th	3rd	6th	9th
T_1(BA 50ppm)	19.00	14.50	6.92	4.00	10.38	15.85	8.31	7.81	6.79
$_2$ (GA_3 50ppm)	21.50	14.33	6.67	4.11	10.54	15.07	8.08	7.01	6.18
T_3 (CW1%)	20.33	15.50	9.83	3.77	9.72	15.03	8.89	8.21	7.03
T_4 (BA+CW)	25.58	16.67	13.92	3.49	9.23	14.63	8.69	8.26	7.49
T_5 (GA_3+CW)	24.08	16.08	10.25	3.65	9.11	14.72	8.88	8.56	7.49
T_6 (Control)	18.25	11.00	3.58	4.62	11.07	17.55	8.16	6.56	3.80
Mean	21.46	14.68	8.53	3.94	10.01	15.48	8.16	7.74	6.46
	T	S	T × S	T	S	T × S	T	S	T × S
S. Em±	0.381	0.269	0.66	0.305	0.216	0.528	0.264	0.186	0.456
CD at 5%	1.08	0.762	1.871	0.864	0.612	NS	0.748	0.527	NS

Initial organoleptic score ('0' days) = 8.00 NS = non significant

Fruit firmness exhibited significant difference between treatment, storage duration and treatment × storage duration interaction at 5% level [Table-1]. Mean firmness of treated fruits on different days of storage decreased with advancement of storage period from 21.46 kg/cm^2 on 3rd day to 8.53 kg/cm2 on 9th day of storage. Firmness decreased steadily in T_4 (BA+CW), T_5 (GA_3+CW) and T_3 (CW) during storage. Irrespective of storage average firmness of different treatments was recorded to be maximum (18.72 kg/cm^2) in T_4 (BA+CW) followed by 16.81 kg/cm^2 in T_5 (GA_3+CW) , 15.22 kg/cm^2 in T_3 (CW) 14.16 Kg/cm^2 in T_2 (GA_3), 13.47 kg/cm^2 in T_1 (BA) and 10.94 kg/cm^2 in T_6 (control) in that decreasing order. On 9th day of storage firmness of T_4 remained significantly higher than other treatments and it was also observed that firmness of T_4, T_5 and T_3 was higher than the mean firmness value. Firmness of control fruits decreased abruptly and became as low as 3.58 kg/cm^2 on 9th day of storage.

Total soluble solids (TSS) as affected by different post harvest treatments during storage are shown in [Table-2]. TSS was significantly influenced by treatment, storage duration and interaction of treatment × storage duration at 5% level. Initial TSS of fruit *i.e.,* on the day of treatment ('0' days of storage) was observed to be 8.51 ^{0}Brix. In all the treatment except T_4 (BA+CW) the TSS increased up to 3rd day and then it gradually decreased up to 9th day of storage. In T_4, TSS increased up to 6th day (though not significant) and then it decreased during subsequent days of storage. In general, mean TSS of different treated stored fruits remained high in T_3 (CW), T_4 (BA+CW) and T_5 (GA_3+CW) *i.e.,* 10.58 ^{0}Brix, 10.36 ^{0}Brix and 10.45 ^{0}Brix respectively with no significant difference between T_3, T_4 and T_5. Irrespective of treatments mean TSS decreased significantly during storage from 3rd (11.43 ^{0}Brix) to 6th day (10.29 ^{0}Brix) and subsequently to 9th day (8.30 ^{0}Brix). On 9th day of storage the TSS of T_4 (BA+CW) was maximum (9.30 ^{0}Brix) followed by T_5 (GA_3+CW), T_3 (CW), T_2 (GA_3), T_1 (BA) and T_6 (control) in that decreasing order.

Table-2 *Effect of treatments TSS (^{0}Brix), Acidity (%) and Ascorbic acid (mg/100gm) on during storage*

Treatment	TSS (^{0}Brix)			Acidity (%)			Ascorbic acid (mg/100gm)		
	Days			Days			Days		
	3rd	6th	9th	3rd	6th	9th	3rd	6th	9th
T_1(BA 50ppm)	11.95	9.93	8.13	0.43	0.33	0.32	349.60	295.63	261.03
T_2 (GA_3 50ppm)	11.05	10.13	8.25	0.43	0.34	0.30	327.02	277.85	239.01
T_3 (CW1%)	11.55	11.05	9.13	0.44	0.38	0.32	372.55	303.76	298.75
T_4 (BA+CW)	10.85	10.93	9.30	0.49	0.38	0.37	383.98	337.43	306.70
T_5 (GA_3+CW)	11.10	11.05	9.20	0.45	0.31	0.37	379.00	321.45	289.81
T_6 (Control)	12.05	8.65	5.80	0.43	0.35	0.25	318.32	223.51	192.26
Mean	11.43	10.29	8.30	0.45	0.35	0.32	355.08	293.27	264.59
	T	S	T × S	T	S	T × S	T	S	T × S
S. Em±	0.175	0.124	0.304	0.012	0.008	0.021	6.478	4.581	11.221
CD at 5%	0.496	0.351	0.861	0.034	0.022	NS	18.367	12.988	31.815

Initial TSS (fresh sample) = 8.51 ^{0}Brix
Initial Acidity (fresh sample) = 0.384%
Initial ascorbic acid (fresh sample) = 397.11 mg/100gm
T= Treatment,
S= Storage
NS = non significant

Acidity of guava as affected by different post harvest treatments during storage is shown in [Table-2]. Acidity had a significant effect for treatment and storage

duration but non-significant for treatment × storage interaction at 5% level. Initial acidity on the day of post of treatment ('0' days of storage) was recorded to be 0.384%. Acidity increased up to 3rd day in all the treatments then it gradually declined during the subsequently period of storage. Acidity on 9th day of storage was highest (0.41%) in T_4 (BA+CW) followed by T_5 (GA_3+CW), T_3 (CW), T_2 (GA_3), T_1(BA) and control in that decreasing order. Irrespective of treatments, mean acidity of different days of storage decreased significantly from 0.45% on 3rd day to 0.35% on 6th day followed by 0.32% on 9th day. Throughout storage period T_4 (BA+CW) retained higher acidity compared to other treatments and on 9th day maximum acidity (0.37%) was retained by T_4 and T_5 followed by T_3 (0.32%).

The changes of ascorbic acid content as influenced by different treatments and storage period has been presented in [Table-2]. Ascorbic acid exhibited significant effect for treatment, storage duration and interaction of treatment × storage duration at 5% level. Initial ascorbic acid content of guava fruits on the day of treatment was estimated to be 397.11 mg/100g. Ascorbic acid continuously decreased in all the treatments during storage. Mean ascorbic acid content due to storage was observed to be maximum (342.70 mg/100g) in T_4 (BA+CW) followed by (330.09 mg/100g) in T_5 (GA3+CW), (325.02 mg/100g) in T_3(CW), (302.08 mg/100g) in T_1 (BA), (281.29 mg/100g) in T_2 (GA_3) and (244.70 mg/100g in T_6 (Control) in that decreased order. However, T_3, T_4 and T_5 did not differ significantly with respect to mean ascorbic acid content during storage. Irrespective of treatment, mean ascorbic acid content decreased significantly from 3rd day (355.08 mg/100g) to 6th day (293.27 mg/100g) and then 9th day (264.70 mg/100g) respectively. Throughout the period of storage T_3, T_4 and T_5 retained high ascorbic acid content and on 9th day maximum ascorbic acid content was observed in T_4 (306.76 mg/100gm) followed by T_5 (289.81 mg/100g) and T_3 (298.75 mg/100g) respectively. However, there was no significant difference between T_4, T_5 and T_3 with respect to ascorbic acid on 9th day. Control fruit possessed least ascorbic acid content (192.26 mg/100g).

Organoleptic evaluation on the basis of appearance (colour), taste, texture and flavour exhibited significant effect for treatment and storage duration but non significant for treatment × storage at 5% level [Table-1]. In this study, I observed all the treatments showing gradually decrease of organoleptic quality due to deterioration of quality during storage. The mean organoleptic score at different storage period recorded high score of 8.31 in T_5 (GA_3+CW) followed by 8.15 in T_4 (BA+CW) and 8.04 in T_3 (CW). However, T_3, T_4 and T_5 were at par and did not differ significantly. Irrespective of treatments, mean organoleptic score decreased significantly from 8.50 on 3rd day to 6.46 on 9th day. 0n 9th day the organoleptic score of T_4 and T_5 was high i.e., 7.49 followed by T_3 (7.03), T_1 (6.79), T_2 (6.18) and T_6 (3.80) respectively showing that T_4 and T_5 and to some extend T_3 maintained higher quality during later period of storage. Colour of fruit on 9th day of storage has been showed in [Fig-1], which indicated that T_4 is best treatment.

T_1= BA 50 ppm

T_2 = GA_3 50 ppm

T_3 = CW1%

T_4 = BA 50 ppm + CW1%

T_5 = GA_3 50 ppm+CW1%

T_6 = CONTROL

Fig-1 Appearance of fruits of different treatments on 9th day on storage.

The results indicated that post harvest treatment of fruits with benzyl adenine and carnauba wax (BA+CW) i.e., T_4 exhibited least PLW and retained higher firmness, TSS, acidity, ascorbic acid and organoleptic quality during storage compared to other treatments, this was followed by T_5 (GA_3+CW) and T_4 (CW). However, for most of the parameters significant difference among these treatments did not exit.

The skin-coating plugs the openings of the fruit skin surface, thereby reduces their respiration and transpiration, thus successfully prolonging their storage life and impart better gloss to guava fruits [16-22]. Coating manipulates levels of oxygen and carbon-dioxide within fruits and creates modified atmospheres rich in CO_2, which is known to delay ripening [23]. In the present investigation waxed fruits with or without BA or GA_3 *i.e.,* T_3, T_4 and T_5 have low PLW and retained better fruit firmness than fruits treated with BA and GA_3 only and control fruits, which is in conformity with earlier findings with carnauba wax [24, 25]. The effect of waxing to retard the firmness loss is due to its role in checking the activity of cell wall

enzymes. It might also be attributed to change in the turgor pressure of the cells and changes in the composition of cell wall pectin and lipo pectin membrane bordering the cells [26]. Post harvest use of GA_3 has senescence delaying effect in fruits and vegetables [27]. [28] suggested that GA_3 @100ppm significantly suppress the succinate activities of malate-dehydrogenase during post-harvest ripening of papaya fruits and thus retarded ripening. Benzyl adenine has been reported to possess free radical quenching property which inhibited ethylene biosynthesis resulting in retardation of senescence and gradual build up of sugars (as in mango) [29]. Softening in fruits is caused either by a breakdown of insoluble pectin or by hydrolysis of starch [30]. BA has a retarding effect on decreasing the pectin content thereby delaying ripening and softening of guava fruits [6]. In T_4 and T_5 where fruits were treated with GA_3 and BA along with carnauba wax, additive effect due to cumulative action of growth substances and wax emulsion was significantly pronounced as manifested by retardation of senescence by reducing the weight loss, retaining the firmness, TSS, acidity, ascorbic acid and organoleptic quality for a longer period.

The increase in TSS during storage possibly due to starch is converted into sugars as on complete hydrolysis of starch, no further increase occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration [31]. The decrease in titratable acidity during ripening and storage may be attributed to an increase in malic enzyme and pyruvate decarboxylation reaction during climacteric period [32] The decrease in ascorbic acid was caused by oxidation of ascorbic acid in storage [33 and 34]. Low oxygen created by modified atmosphere causing reduced activities of oxidizing enzymes in wax coated treatments *ie.,* T_3, T_4 and T_5 which might be the possible reason of higher ascorbic acid content during storage. In the present investigation considering senescence delaying ability with regard to all the quality parameters, T_4 (BA+CW) was found to be the best treatment followed by T_5 (GA_3+CW) and T_3 (CW).

Conclusion

Thus it can be concluded that benzyl adenine 50 ppm with carnauba wax (1%) i.e., T_4 (BA+CW) can be regarded best treatment combination because it exhibited least PLW and retained higher firmness, TSS, acidity and ascorbic acid content during storage compared to other treatments, this was followed by T_5 (GA_3+CW) and T_3 (CW). Organoleptic quality also revealed superiority of T_4, T_5 and T_3 because of high sensory score over other treatments while the control fruits were undesirable on 9th day due to low score.

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Abbreviations

%	:	Percent/Percentage
@	:	at the rate of
0C	:	degree Celsius
cm	:	centimetre
°B	:	Degree Brix
Fig.	:	Figure
CRD	:	Completely Randomized Design
Kg	:	kilogram
RH	:	Relative Humidity
TSS	:	Total Soluble solid
CD	:	Critical Difference
S.Em	:	Standard error mean
Wt.	:	Weight
BA	:	6N- benzyl adenine
GA3	:	Gibberellic acid
CW	:	Carnauba wax
PLW	:	physiological loss in weight

Conflict of Interest: None declared

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