INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 4, p. 168-179, 2013

RESEARCH PAPER OPEN ACCESS

Effect of post-harvest treatments on physiochemical characters during storage of two banana (*Musa* spp. L.) cv. Sabri and Amritasagar

K. A. Hakim[1*], M. A. R. Sarkar[2], M. Z. H. Khan[3], S. M. Rahman[2], M. Ibrahim[4], M. K. Islam[1]

[1]*Department of Crop Science and Technology, University of Rajshahi, Bangladesh*

[2]*Department of Genetic Engineering and Biotechnology, Jessore Science and Technology University, Jessore 7408, Bangladesh*

[3]*Department of Chemical Engineering, Jessore Science and Technology University, Jessore 7408, Bangladesh*

[4]*Bangladesh Council of Scientific and Industrial Research, Rajshahi, Bangladesh*

Key words: Physiochemical characters, pulp pH, shelf life, post harvest treatments, banana.

doi: http://dx.doi.org/10.12692/ijb/3.4.168-179 Article published on April 22, 2013

Abstract

Various observations were made on external and internal fruit attributes, physio-chemical properties such as physiological weight loss, pulp to peel ratio, moisture content, dry matter content, pulp pH and shelf life. The results revealed that marked variations were found between two banana varieties in relation to various physical and biochemical characteristics. Peel color of Amritasagar changed faster than Sabri. The differences of physiological weight loss between two varieties were noticed to be significant during storage. The physiological weight loss was higher (21.35%) in Amrtasagar than Sabri (18.69%) at 12th day. Pulp to peel ratio was noticed to be higher in Sabri (1.88 and 3.08) than Amritasagar (1.40 and 2.39) at 3rd and 9th days of storage. The moisture content was higher (71.04 %) in Amritasagar than Sabri (70.35 %). Also dry matter content was recorded higher (26.10%) in Sabri than Amritasagar (25.89%). Significant variation in pulp pH was observed between varieties during stotage. At 9th days of storage, higher pH value (6.36%) was found in Sabri than the pH value of (6.33%) in Amritasagar. Highly significant variations were observed on shelf life in two varieties of bananas. The shelf life (11.41 days) of Sabri was higher than that of Amritasagar (10.09 days). The maximum shelf life (13.0 days) was observed in the fruit treated with 400 ppm GA_3 and the minimum (8.16 days) was recorded from control.

* **Corresponding Author:** K. A. Hakim ✉ hakim.crop82@yahoo.com

Introduction

Banana (*Musa spp.* L.) constitutes the fourth most important staple food commodity of the world, after rice, wheat and maize. In Asian and Pacific regions, banana has great socio-economic significance. Banana is one of the most important food and cash crop in Bangladesh and grown around the year in the country as a commercial purpose and homestead area for local consumption. In addition, banana stood first position among the fruits producing in the country and supplies 42% of the total fruit requirements in the country and also its financial return as a crop is higher compared to other fruits and field crops (Haque, 1988).

The importance of banana in the world fruit trade is second only next to that of citrus (Samson, 1980). It is also a nutritious fruit crop in the world and grown in many tropical areas where they are used both as a staple food and dietary supplements (Assani *et al.,* 2001). In Bangladesh, total banana production in year the 1999-2001 was about 0.580 million tons but it increased to 0.654 million tons in the year 2003 (FAO, 2004).

Banana contains nutrients in a more balanced proportion than many other fruits. It has nearly all the essential nutrients including minerals and vitamins. It is also a rich source of energy. Per head per day availability of fruits in Bangladesh is 54 g which rather low as compared to the advanced countries. This is mainly due to a vast population against low yield and total production of fruits. This situation is further aggravated by high level of postharvest loss ranged from 25-50% (Amiruzzaman, 1990).

Amritasagar is the best banana of Bangladesh and is considered to be the leading commercial cultivar in this country. After ripening, it has soft pulp with fine textures and good aroma and is completely seedless. On the other hand, Sabri is one of the most important commercial varieties in Bangladesh and is considered even better than Amritasagar by many consumers. Pulp of the ripe fruit is soft with mild to distinct aroma (Sultana *et al.,* 2012).

Banana in Bangladesh, a considerable quantity of Banana is being spoiled every year due to prevailing high temperature and high humidity through loss of weight of banana due to respiration and transpiration, softening of flesh and loss of resistance to microbial attack. Such losses occur either during transpiration and or in market. Hence, it is necessary to check such post harvest losses. Prolongation of shelf life of banana may be done by some techniques like using packaging materials, hot water, fungicides, ethylene absorbents and growth regulators. It had been reported that ripening of banana can be delayed by the use of chemical like GA_3, Kinetin, BA, Benlate and ethylene absorbent (Vendrell 1971; Weaver 1972; Kapor and Turner, 1976; Rao and Chundawat, 1984; and Prasad and Singh, 1993). Patil and Hulamani (1998) had also carried out an experiment with GA_3 and found that in significantly lower physiological weight loss, decay loss, percent fruit ripening and pulp to peel ratio throughout the storage period. These techniques may arrest the growth and spread of micro organism by reducing the shriveling which ultimately leads to an increased shelf life and maintain the marketability of the fruit for a longer period (Sudha *et al.,* 2007). Growth regulator is usually described as a natural or synthetic substance that modifies biochemical or physiological processes of banana. Delay or hasten banana ripening by using growth regulators like auxins, gibbrellins, cytokinins and growth retardants, both natural and synthetic would be great value to regulate the self life (Vendrell 1969).

Thus the experiment was undertaken to investigate the effect of different treatments on the storage of shelf life of banana and also to determine the biochemical changes occurring during storage when the fruits are treated by these materials.

Materials and methods

Plant materials

Mature banana fruits, physically similar fruits approximately more or less uniform in size, shape and color were selected from both the varieties for conducting the experiment. The post harvest treatments used in the present study were randomly assigned to the selected banana fruits. After the application of treatments the fruits were kept on a brown paper previously placed on laboratory floor at room temperature. Fruits were used in the experiment were monitored carefully in every day. Data on change in different physical characters total weight loss, pulp to peel ratio, percent moisture content, percent dry matter, pulp pH and self life of banana were recorded. Shelf life of banana was calculated by counting the day require to ripe fully as to retaining optimum marketing and eating quality.

Data analysis

The study was conducted in completely randomized design with three replications. There were two factor experiments with two banana cultivars *viz.*, Amritasagar and Sabri, while five treatments were control, paraffin coating, hot water treatment (52±2)°C, gibberellic acid, GA_3 (400 ppm), bavistin DF (750 ppm), maleic hydrazide (400 ppm).

The collected data were statistically analyzed to find out the variation resulting from experimental treatments following F variance test. The significance of difference between the pair of means was compared by LSD test (Gomez and Gomez, 1984).

Results and discussion

Changes in skin

Variety Amritasagor attained yellow color at 6 days from control, whereas var. Sabri attained yellow color at 9 days preceded by perforated hot water treated fruit. Full yellow color was developed at 9 days of storage in Amritsagar from fruit treated with 400 ppm GA_3, paraffin coating, maleic hydrazide (400 ppm) and basvistin DF (750 ppm) whereas yellow color was developed at 11 days of storage in case of Sabri followed by all the treated fruits (Table 1).

The result indicate that control treatment enhanced the development of color of banana followed by hot water treatment while, paraffin coating, GA_3 and bavistin DF delayed its development. The color of banana was developed rapidly from the fruit treated with hot water (52±2)°C. This event might be possible due to the effect of the activities of some enzymes that were responsible for the ripening of banana.

Delay ripening and senescence of banana fruits vis-à-vis color development through paraffin coating, bavistin DF, GA_3 and maleic hydrazide treatment might be attributed to the ability of these chemicals in retaining the total chlorophyll a and chlorophyll b in banana fruits. The findings in this respect also support the results of Prasad and Singh (1993).

Changes in physical characters during storage

Physiological weight loss

Statistically significant variation was found in respect of physiological weight loss of banana varieties between varieties means at different days of storage except 3rd day. At 6th and 9th days of storage, the physiological weight losses were of 8.1% and 12.99% which gradually increased up to 21.35% at 12th days of storage in Amritasagar while in Sabri at 6th, 9th and 12th days of storage, the physiological weight losses were of 7.39%, 12.43% and 18.69% respectively (Fig. 1). It was observed from it that weight loss of Amritasagar was higher than Sabri. Physiological weight loss increased with the advancement of storage times as reported Bhadra and Sen (1997) and Baiyeri and Igbelina (2002).

Different treatment used in the experiment showed a significant effect on physiological weight loss of banana during storage. At 6th, 9th and 12th days of storage, control treatment reduced the maximum (9.90%, 14.45% and 25.83%) weight whereas the minimum weight losses (7.15%, 10.73% and 17.81%) were recorded from GA_3retarded the physiological weight loss. The results of the investigation are

strongly supported by the finding of Mary and Sathimoorthy (2003).Literature is scantly as to how different treatments control weight loss in banana fruits. However, it is supported by Rao and Chundawat (1986) and Partil and Hulamani (1998) also reported that GA_3treated banana reduced the physiological weight loss.

Table 1 Changes in skin color of two banana varieties (viz. Amritasagar and Sabri) as influenced by different storage treatment.

Varieties	Treatment	Different days				
		Initial	3	6	9	12
Amritasagar	T_o	Full green	Greenish	Yellowish green but tip of banana become green	Completely yellow	Completely yellow
	T_1	Full green	Yellow	Peel color yellow but crown in yellowish green	Yellowish green but tip of banana green	Completely green
	T_2	Full green	Greenish	Greenish yellow	Completely yellow	Completely yellow
	T_3	Full green	Green but tip of banana become greenish yellow	Slight yellow color developed in peel of banana but crowns are green	Completely yellow	Completely yellow
	T_4	Full green	Peel color greenish yellow but crowns are fully green	Peel color of banana become yellowish green but crowns are slightly green	Slight yellow color developed in peel of banana	Completely yellow
	T_5	Full green	Greenish yellow	Slightly yellowish green	Completely yellow	Completely yellow
Sabri	T_o	Full green	Peel color of banana become yellow but crown are yellowish green	Yellowish green tip of banana become green	Yellowish	Completely yellow
	T_1	Full green	Greenish	Peel color yellow but crown in yellowish green	Peel color of banana yellow but crown become slightly green	Completely green
	T_2	Full green	Yellow	Greenish yellow	Yellowish	Completely green
	T_3	Full green	Peel color greenish yellow but crowns are yellowish green	Slight yellow color developed in peel of banana but crowns are green	Peel of banana become yellow but crowns are yellowish	Completely green
	T_4	Full green	Green but tips of banana become yellow	Slight yellow color developed in peel of banana	Completely Yellow	Completely Yellow
	T_5	Full green	Greenish yellow	Slightly yellow green	Completely Yellow	Completely Yellow

Note: Treatment; To=Control, T_1=Paraffin, T_2=Hot water(52±2)°C, T_3=GA_3(400 ppm), T_4=Bavistin DF(750 ppm), T_5=Malic hydrazide(400 ppm)

The combined effects of varieties and treatments on physiological weight loss were found to be significant at6th, 9th and 12th days of storage. The highest physiological weight loss (27.37%) was obtained from the treatment combination of Amritasagar and control (V_1T_o) and the lowest physiological weight loss (15.92%) wasobtained from the combination of Sabri and 400 ppm of GA_3 (V_2T_3) at 12th day of storage. From 3rd to 12th days of storage, a sharp

increasing tendency in physiological weight loss was noticed from all the treatment combination (Table2).

Pulp to peel ratio

Varieties of banana means demonstrated significant variation in terms of pulp to peel ratio at different days of storage. The highest (2.39) and the lowest (1.40) pulp to peel ratio were observed from Amritasagar at 9th and 3rd days of storage, respectively. Similar trend was also observed in Sabri, where as the highest (3.08) and the lowest (1.88) pulp to peel ratio were found at 9th and 3rd days of storage respectively (Table 3). There appeared that pulp to peel ratio was increased up to the 9th day of storage and thereafter, it declined (Fig. 2). The results of the present investigation are supported by the findings of Krishnamurthy (1993). Variation among the treatments in relation to pulp to peel ratio were found to be statistically significant at different days of storage. The pulp to peel ratio was found to be an increasing trend from harvest to 9th day of storage and thereafter, it decreased. At 9th day of storage, the highest (2.99) was noticed from control (T_0) treatment whereas, the lowest (1.48) was observed in paraffin coating (T_1) at 3rd day of storage (Fig. 2).

Table 2. Combined effects of varieties and different storage treatments on physiological weight loss of banana at different days.

Variety× Treatment	Physiological weight loss (%)			
	3	6	9	12
V_1T_0	4.75	9.96a	14.66a	27.37a
V_1T_1	3.17	7.57c-d	11.89e	19.13e
V_1T_2	3.59	8.65b	13.83c	23.09c
V_1T_3	3.12	7.24d	11.15f	18.44f
V_1T_4	3.55	7.79c	13.75c	20.15d
V_1T_5	3.52	7.70c-d	12.67d	19.92d
V_2T_0	4.70	9.85a	14.25b	24.29b
V_2T_1	3.36	7.59c-d	11.85e	16.12h
V_2T_2	3.58	7.69c-d	12.80d	20.06d
V_2T_3	3.31	6.22e	10.30g	15.92h
V_2T_4	3.44	6.51e	12.85d	18.87e-f
V_2T_5	3.49	6.48e	12.54d	16.90g
Level of significances	NS	**	**	**
C.V.(%)	5.81	3.50	1.58	1.63

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 3. Combined effects of varieties and treatments on pulp to peel ratio of banana at different days.

Variety× Treatment	Pulp to peel ratio			
	3	6	9	12
V_1T_0	1.44de	1.99b	2.56e	2.52d
V_1T_1	1.33e	1.81d	2.25g	2.09f
V_1T_2	1.38e	1.91bc	2.35f	2.13ef
V_1T_3	1.35e	1.95bc	2.69d	2.28e
V_1T_4	1.45de	1.85cd	2.28g	2.19ef
V_1T_5	1.43de	1.92bc	2.23g	2.20ef
V_2T_0	2.15a	2.95a	3.42a	3.40a
V_2T_1	1.64bc	1.98b	2.98c	2.77c
V_2T_2	2.15a	2.90a	3.01c	2.89bc
V_2T_3	2.09a	2.92a	3.12b	2.98b
V_2T_4	1.70b	2.00b	2.97c	2.61d
V_2T_5	1.55cd	1.97b	3.02c	2.97b
Level of significances	**	**	**	*
C.V.(%)	5.25	2.62	1.01	3.32

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Variation among the interaction effect of different treatments and varieties in relation to pulp to peel ratio were observed to be statistically significant at different days of storage. At the 9th day of storage, the highest (3.42) pulp to peel ratio was found from the treatment combination of Sabri and control (V_2T_0) followed by the treatment combination of Amritasagar and control (V_2T_0) followed by the treatment combination of V_1T_0.

Table 4. Combined effects of varieties and treatments on dry matter content of banana at different days.

Variety× Treatment	Dry matter (%)			
	3	6	9	12
V_1T_0	25.48a-c	23.55c	24.14	24.30c
V_1T_1	24.46bc	24.50de	26.08	26.22ab
V_1T_2	26.29a	24.99cd	26.50	25.10bc
V_1T_3	26.08a	25.17a-d	26.84	24.56c
V_1T_4	25.90ab	25.58bc	26.69	24.62c
V_1T_5	24.28c	24.49de	25.06	24.02c
V_2T_0	24.49bc	25.08cd	25.17	24.70c
V_2T_1	25.47a-c	26.18ab	26.22	25.08bc
V_2T_2	26.48a	26.20ab	26.38	24.62c
V_2T_3	26.54a	27.04a	26.10	25.96ab
V_2T_4	25.04a-c	23.84c	26.48	26.92a
V_2T_5	26.20a	27.04a	26.22	25.98ab
Level of significances	*	**	NS	* *
C.V.(%)	3.13	2.25	2.53	2.71

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 5. Effect of varieties on moisture content of banana at different days.

Variety	Moisture content (%)			
	3	6	9	12
V_1	69.46a	71.04a	72.90	68.34a
V_2	68.46b	70.35b	72.69	66.60b
Level of significances	**	**	NS	* *
LSD (0.05)	0.86	0.69	0.44	0.81

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 6. Effect of different treatments on moisture content of banana at different days.

Treatment	Moisture content (%)			
	3	6	9	12
T_0	72.01a	74.14a	75.99a	70.47a
T_1	71.25a	73.15a	75.01b	69.05b
T_2	69.06b	71.39b	73.54c	67.90bc
T_3	65.90c-d	67.68e	69.45e	64.68e
T_4	68.34bc	69.82c	71.74d	66.73cd
T_5	67.17cd	68.58d	71.04d	65.98de
Level of significances	**	**	NS	* *
LSD (0.05)	1.50	1.20	0.77	1.41

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

The lowest value was obtained from the treatment combinations of V_1T_5. Again, at the 6th day of storage the highest (2.95) pulp to peel ratio was recorded from the treatment combination of V_2T_0which was statistical identical with the combination of V_2T_2 and V_2T_3 whereas the lowest pulp to peel ratio (1.81) was obtained from the treatment combinations of V_1T_1 which was also statistical at par to the combination of V_1T_4 (Table 3). Increase in pulp to peel ratio in bananas might possible due to be higher rate of

transpiration from peel over pulp which attributed to the increase of pulp to peel ratio.

Other causes might be the absorption of moisture in pulp which was derived from hydrolysis of carbohydrate and the osmotic pressure of water from peel to pulp. The results of the present investigation are strongly supported by the findings of Simmonds (1960).

Table 7. Combined effects of varieties and treatments on moisture content of banana at different days.

Variety × Treatment	Moisture content (%)			
	3	6	9	12
V_1T_0	72.52	74.12	76.12	71.70
V_1T_1	71.54	73.50	75.32	69.78
V_1T_2	69.29	71.82	73.46	68.44
V_1T_3	66.95	67.01	69.50	65.95
V_1T_4	68.72	70.51	72.06	67.38
V_1T_5	67.72	68.51	70.94	66.78
V_2T_0	71.51	73.42	75.86	69.24
V_2T_1	70.96	72.80	74.71	68.32
V_2T_2	68.82	70.96	73.62	67.37
V_2T_3	64.86	67.16	69.40	63.40
V_2T_4	67.96	69.12	71.42	66.08
V_2T_5	66.62	68.66	71.15	65.18
Level of significances	NS		NS	NS
C.V.(%)	1.56	1.43	0.89	1.75

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 8. Effect of varieties on pulp pH of banana at different days.

Variety	pulp pH at different days			
	3	6	9	12
V_1	4.64b	5.50b	6.33b	6.47
V_2	4.98a	6.00a	6.36a	6.59
Level of significances	**	**	*	NS
LSD (0.05)	0.24	0.27	0.30	0.24

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 9. Effect of different treatments on pulp pH of banana at different days.

Treatment	pulp pH at different days			
	3	6	9	12
T_0	4.57	5.35	6.27	6.49
T_1	4.93	6.11	6.63	6.80
T_2	4.82	5.46	6.20	6.45
T_3	4.88	5.82	6.18	6.34
T_4	4.86	5.79	6.37	6.55
T_5	4.81	5.99	6.41	6.55
Level of significances	NS	*	NS	NS
LSD (0.05)	0.43	0.47	0.52	0.43

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Dry matter content

Significant variation was found in respect of dry matter content of varieties were except 3rd and 9th days of storage. Dry matter content was recorded higher (25.90 % and 26.10%)Sabri at 6th and 9th days of storage whereas Amritasagar accumulated lower (25.41% and 25.89%) quantities at 3rd and 9th days of storage (Table 4).

Different treatments induced in the investigation on dry matter content were noticed to be significant. There appeared a smooth increasing tendency of dry

matter content in banana pulp during storage. Higher dry matters (26.11% and 26.58%) was obtained from the treatment of 400 ppm of GA_3 and 750 ppm of bavistin DF solution and lower (24.31% and 24.66%) were obtained from control at 6th and 9th days of storage, respectively.

Table 10. Combined effects of varieties and treatments on pulp pH of banana at different days.

Variety × Treatment	pulp pH at different days			
	3	6	9	12
V_1T_0	4.58	5.10d	6.23	6.42
V_1T_1	4.83	6.12a-c	6.79	6.70
V_1T_2	4.70	5.62b-d	6.27	6.51
V_1T_3	4.53	5.51c-d	6.13	6.27
V_1T_4	4.61	5.25d	6.25	6.39
V_1T_5	4.58	5.38c-d	6.29	6.41
V_2T_0	4.55	5.59b	6.31	6.56
V_2T_1	5.03	6.10a-c	6.46	6.79
V_2T_2	4.94	5.29d	6.13	6.39
V_2T_3	5.22	6.13a-c	6.23	6.41
V_2T_4	5.10	6.32ab	6.49	6.71
V_2T_5	5.03	6.59a	6.52	6.69
Level of significances	NS	*	NS	NS
C.V.%	7.51	6.95	6.95	5.53

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 11. Combined effects of varieties and treatments on shelf life of banana at different days.

Variety× Treatment	Shelf life(days)
V_1T_0	7.33g
V_1T_1	11.50bc
V_1T_2	9.50ef
V_1T_3	12.0b
V_1T_4	10.25c-f
V_1T_5	10.0d-f
V_2T_0	9.0f
V_2T_1	13.5a
V_2T_2	11.0b-d
V_2T_3	14.0a
V_2T_4	10.5c-e
V_2T_5	10.5c-e
Level of significances	**
C.V.(%)	1.31

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data ranges, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

The combined effects of varieties and different storages treatments in respect of dry matter content demonstrated significant variation during storage except at 9th day of storage. At 6th and 9th days of storage, the highest (27.04% and 26.84%) dry matter contents were observed from the treatment combination of V_2T_5 and V_1T_3 and the lowest (23.55 %and 24.14%) were found from the treatment combination of V_1T_0, respectively (Table 4).

Moisture content

Significant variation was found in moisture content between varieties means except 9th day of storage. Moisture content in pulp of banana of all the treatment was increased during storage period. Amritasagar retained higher moisture content (71.04%) where as Sabri retained lower amount 70.35% at 6th day of storage. Then after 9th day moisture content was declined gradually (Table 5).

Various treatments adopted in the present study also showed significant variation in relation to moisture content during storage. The maximum moisture

content (75.99%) was noticed from control at 9th day of storage which was statistical at par to T_1 (Table 6) and the lowest value (67.68%) was obtained from T_3 at 6th day of storage.

The combined effect of varieties and different treatments in terms of moisture content were found to be non significant at different days of storage (Table 7).Moisture content in the pulp of banana increased in the present study is in agreement with the findings of Mahmoudi and Eisawi (1968). The increase in moisture percent was probably due to (osmotic with drawl of water from peel to pulp) complete breakdown of starch to Co_2 and water. Total increase in this process was probably more than loss of water due to transpiration and starch hydrolysis.

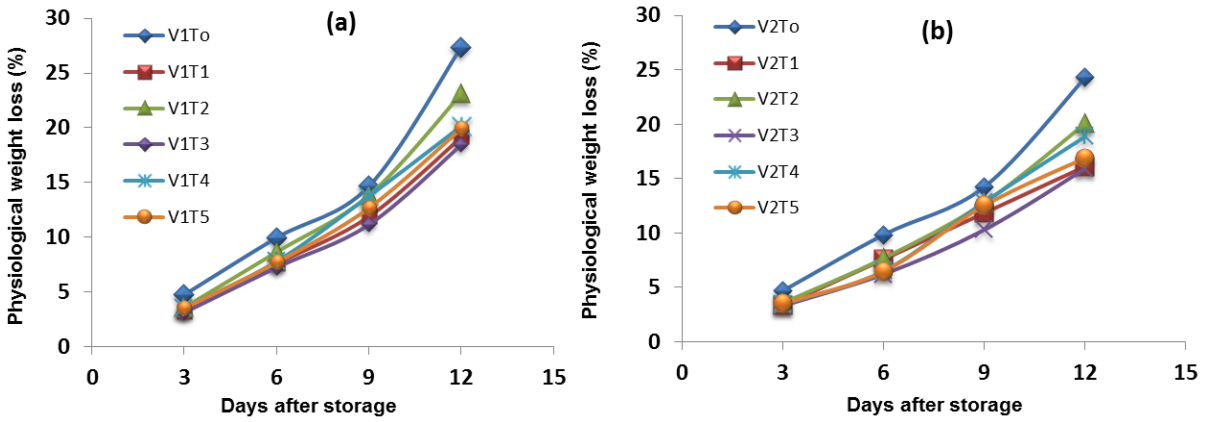

Fig. 1. Effect of different treatments on banana pulp of variety(a) Amritasagar, and (b) Sabrion their physiological weight loss at different days of storage. Vertical bars represent LSD at 0.5 levels.

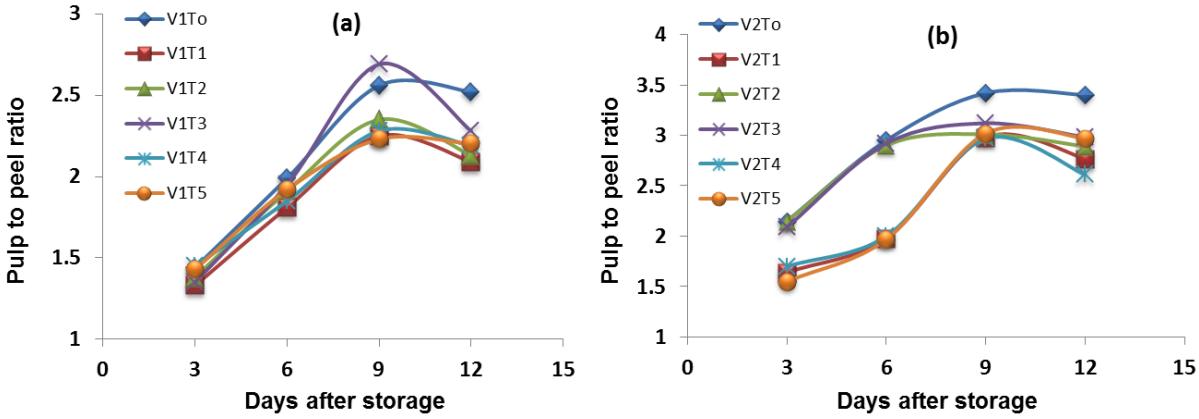

Fig. 2. Effect of different treatments on banana pulp of variety (a) Amritasagar, and (b) Sabri on their pulp to peel ratio at different days of storage. Vertical bars represent LSD at 0.5 levels.

Pulp pH

Significant variations in pulp pH were observed between varieties means at different days of storage except 12th days of storage. An increasing trend of pulp pH was exhibited in both the varieties with the augmentation of storage times. The maximum pulp pH (6.0 and 6.36) were Sabri recorded at 6th and 9th days of storage while the minimum values for Amritasagr were of (5.5 and 6.3) at the same days of storage, respectively (Table 8).

The effect of different treatments on pulp pH of postharvest banana pulp showed non-significant variation at different days of storage except 6th day. The fruit treated with paraffin coating solution gave comparatively higher pH value (6.1) at 6th days of

storage. On the other hand, lower pH values (5.3) were recorded from control at 6th day of storage (Table 9).The increase in pulp pH might be due to the continuous fall of acidity during ripening. In the present investigation, increase in pulp pH was recorded during storage and this result is in agreement with the findings of kumar and Sigh (1993), who observed that pulp pH of mango was increased during storage.

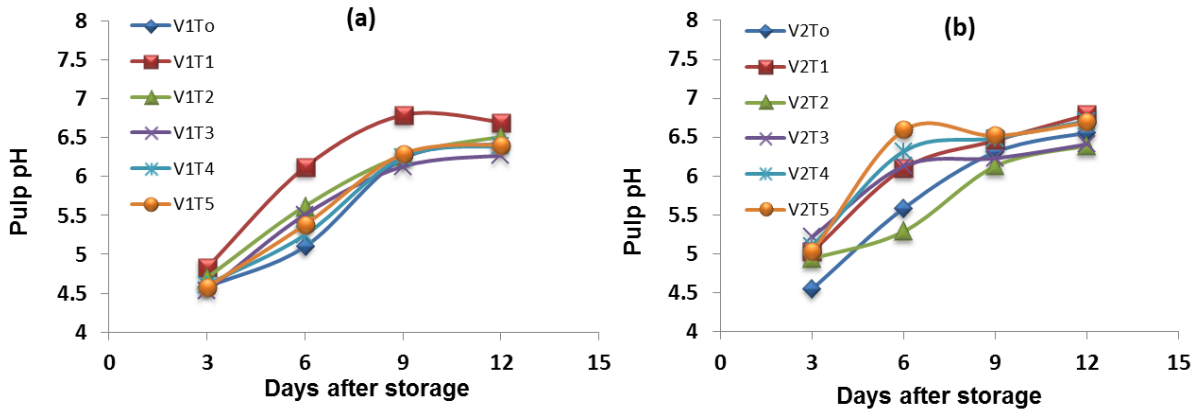

Fig. 3. Effect of different treatments on banana pulp of variety (a) Amritasagar, and (b) Sabri on their pulp pH at different days of storage. Vertical bars represent LSD at 0.5 levels.

The combined effect of different treatments and variety were noticed to be non-significant in relation to pulp pH except at 6th days of storage (Table 10). At 6th days of storage the highest value (6.5) was obtained from the treatment combination of V_2T_5 and the lowest 5.10 was recorded from the control V_1T_o (Fig. 3).

Shelf life of banana

Highly significant variations were observed in shelf life of two banana varieties means. Higher shelf life (11.41 days) was recorded in Sabri while lower shelf life (10.09 days) was recorded in Amritsagar (Fig.4).

The effect of different treatments used in the present investigations demonstrated highly significant variation in respect of shelf life of banana. The maximum shelf life (13.0 days) was observed in the fruits treated with 400 ppm of GA_3solution followed by (12.50 days) treated with paraffin coating and the minimum shelf life (8.16 days) was recorded in control. Rao and Rao (1979) also reported the same findings. GA_3 is also known to be maintained chlorophyll and thereafter, it would have maintained the green color of banana.

The combined effects of varieties and different treatments showed non-significant variation in case of shelf life of banana. The maximum shelf life (14.0 days) was observed in Sabri when treated with 400 ppm of GA_3 followed by Sabri using paraffin coating (V_2T_1). The minimum shelf life (7.33 days) was recorded in Amritasagar without treatment (Table 11).

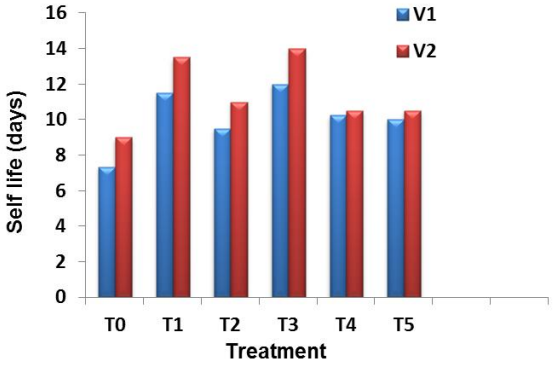

Fig. 4. Effect of different treatments on banana pulp of variety (a) Amritasagar, and (b) Sabri on their self life (days). Vertical bars represent LSD at 0.5 levels.

Conclusion

From our study and overall findings it can be concluded that, variety Sabri was found to be better in terms of qualities and extending shelf life. Among different treatments used in the experiments GA_3 using 400 ppm showed better performance in

retardation of ripening processes than that all other treatments namely, paraffin coating, hot water (52±2)°C, bavistin DF (750 ppm), maleic hydrazide (400 ppm). GA_3 using 400 ppm also appeared to be the more suitable method for extending of shelf life of banana. So, further investigation is required for comparing with other treatment which may retard the ripening process.

References

Amiruzzaman M. 1990. Post harvest handling and processing of fruits and vegetables. In kitchen gardening and homestead productive activities. CIRDAP Action Res. Ser. No. 11, pp. 22.

Assani AR, Haicour G, Wenzel F, Cote F, Bakry F, Foroughiwehr B, Ducreux G, Aguillar ME, Grapin A. 2001. Plant regeneration from protoplasts of dessert banana cv. Grande Naine (*Musa* spp., Cavendish sub-group AAA) via somatic embryogenesis.Plant Cell Reports **20(6)**, 482-488. http://dx.doi.org/10.1007/s002990100366

Baiyeri KP, Igbelina CC. 2002. The effect of storage media and fruit dip solution of hypochlorite on the shelf life of matured banana fruits. Molecular Journal of Agricultural Research **3(2),** 262-269.

Bhadra S, Sen SK. 1997. Post harvest storage of custard apple (Annonasquamosa L.) fruit var. local green under various chemical and wrapping treatments. Environmental Ecolology **1(4),** 322-328.

FAO (Food and Agricultural Organization) 2004.Production Yearbook 2003, Rome.

Gomez KA, Gomez AA. 1984. Statistical Procedure for Agricutural Research. John Weley and Sons. Inc., New York, ISBN: 978-0-471-87092-0, 2nd Edition, p. 67-256.

Haque MA.1988. Kallar Bagan (in Bengali), Banana Research project, BAU, Mymensingh, p. 1-4.

Kapoor JK, Turner JN. 1976. Plant growth regulators for tropical fruits. Outlook-on-Agriculture **9(2),** 52-56.

Kumar P, Singh S. 1993. Effect of GA_3 and ethrel on ripening and quality mango cv. Amrapali. Horticulture Journal **6(1),** 19-23.

Mahmoudi LT, Eisawi MT. 1968.Studies on the storage of bananas. Agricultural Research Revolution Cario **46(3),** 41-51.

Mary AE, Sathiamoorthy S. 2003.Effect of packing treatments on green life and peel split of banana cv. Rashali. Indian Journal of Agricultural Research 37(1), 72-75.

Patil SN, Hulamani NC. 1998. Effect of post harvest treatments on physical characters and shelf life of banana fruits. Karnataka Journal of Agricultural Sciences **11(2),** 535-537.

Prasad MM, Singh HNP. 1993. Effect of hormones on longevity of banana fruits. Natural Academic Scienes Letters **16(2),** 59-62.

Rao DVR, Chundawat BS. 1984. Chemical regulation of ripening in basrai banana at ambient temperature, Progressive Horticulture **16(1-2),** 58-68.

Rao DVR, Chundawat BS. 1988. Post harvest behavior of banana bunches of cv. Basrai in response to certain chemical and packing treatment. Gujrat Agricultural University Research Journal India **14(1),** 42-48.

Samson JA. 1980. Tropical fruits. Longman group limited, London, p. 121

Simmonds NW. 1960. Banias. Longman Green and Co. Lt. London p. 466.

Sudha R, Amutha R, Muthulaksmi S, Baby Rani W, Indira K, Mareeswari P. 2007. Influence of pre and postharvest chemical

treatments on physical characteristics of Sapota (*Achrassapota*L.) Var. PKM 1. Research Journal of Agricultural and Biological Sciences **3(5),** 450-452.

Sultana MS, Islam MZ, Shamim AHM, Mondal MF. 2012. Effect of growth regulators on physical changes and shelf life of banana during storage. International Journal of Sustainable Crop Production **7(3),** 31-35.

Vendrell M. 1969. Reversion of senescesnce: effects of 2,4-dichlorophenoxyacetic acid and indole acetic acid on respiration, ethylene production, and ripening in banana fruit slices. Australian Journal of Biological Sciences **22(3),** 601-610. http://dx.doi.org/BI9690601

Vendrell M. 1971. Relationship between internal distribution of exogenous auxin and accelerated ripening of banana, Australian Journal of Biological Sciences **23(5),** 1133-1142. http://dx.doi.org/10.1071/BI9701133

Weaver RJ. 1972. Plant growth substance in Agriculture, W. H. Freeman and Co. USA.