International Journal of Biosciences (IJB)
ISSN: 2220-6655 (Print) 2222-5234 (Online)
Vol. 2, No. 8, p. 83-94, 2012
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Status of the behavioral pattern of biochemical properties of banana in the storage condition

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Received: 02 July 2012
Revised: 12 August 2012
Accepted: 14 August 2012

Key words: Titratable acidity, vitamin C, total sugar, post harvest treatments, banana.

Abstract

A comparative study of two banana cultivars cv. Sabri and Amritasagor were performed upon the changing of biochemical components with different post harvest treatments at different storage periods as well as ripening period. The cultivars were treated with different chemicals and packed in polyethylene bags with ventilation and stored at cold storage (20 ± 2°C). Changes in storage characteristics were recorded at 3 days intervals till the condition of fruit turned to rejectable stage. For chemical analysis, pulp of each sample was ground in grinder (mixer). Known amount of these samples were weighed for determining titratable acids, vitamin C, total sugar, reducing sugar and non reducing sugar. Titratable acidity of banana fruit decreased as storage period increased. The maximum titratable acidity was noticed from GA_3 using 400 ppm at 3rd, 6th, 9th, and 12th days of storage. Vitamin C content of banana pulp gradually decreased in both varieties with the passing of storage period but the decreasing trend was found to be higher in Amritasagor than Sabri. The reducing sugar contents exhibited an increasing trend in both the varieties during storage but Amritasagor produced it more quantities than Sabri. The Sabri variety is better in terms of biochemical components and GA_3 using 400 ppm showed better performance in retardation of ripening processes than other treatments. These results will be beneficial for any commercial producers or marginal farmers who want to preserve the mentioned two banana cultivars for a time.

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Introduction

Banana *(Musa spp.* L) is one of the cheapest, most plentiful and important fruit crop in Bangladesh as well as all over the world (khader *at al.* 1996). From nutritional point of view, banana has high calorific and nutritional value (Anon, 1976). Its carbohydrate content in the pulp is 27% (Anon, 1976). It also contains nearly all other essential vitamins and minerals. The quality of banana fruits is largely dependent on the varieties and various post harvest treatments which are principally applied to increase the storability of fruits. Although banana is an important fruits of the sub tropics but considerable literature dealing with reducing of post harvest losses and biochemical changes after application of different treatments during storage is very limited under Bangladesh conditions.

Pesis *et al.* (1992) examined the fruits of cv. Sella, harvested at the colour break stage (>10% yellow), were untreated (controls), coated with wax or heat sealed in Cryovac polyethylene and stored at 17°C temperature. The controlled fruits showed a normal climacteric rise of CO_2 and ethylene but the coated and wrapped fruits did not do so. The wrapped and untreated fruits showed normal color development and softening but ripening was inhibited in the waxed fruit and the weight loss in fruits was in the order control>wax>plastic firm. Fonseca *et al.* (2001) found that partial ripening occurred in mango during storage. Waxing increased the general appearance of the fruits, mainly by maintaining them more turgid. Bekel *et al.* (1988) reported that hot water treatment of fruits at 54 ± 2°C for 2 minutes effectively controlled storage decay of papaya. Thangoraj and Irulappan (1988) mentioned that green mature mango fruits of cv. `Neelum' when treated with hot water at 52 ± 1° C temperature in different ways and stored in a cool chamber had least weight loss (2.3%) and the longest shelf life. Khumlert (1992) carried out an experiment to study some physico-chemical changes and physiological characteristics of "Kheaw and Sawoey" mango fruit as influenced by GA_3 application. Results showed that GA_3 (200 ppm) solution delayed ripening of mango via inhibition of some ethylene mediated ripening changes. The color of peel, pulp, pulp firmness, soluble solids, titratable acidity,conversion of starch to sugar, solubilization of pectic substances were also delayed. Among the fruit characters studied the delayed in peel color development was the most prominent for the effect of GA_3, both in mature and immature fruits. Khader, (1992) conducted an experiment on ripening and quality of 'fruits cv. "Mallika" influenced by GA_3 and vapor gard (di-1-P-methene). The fruits were treated with 200 mg/L GA_3 or 2.5% vapor gard or both and stored at an ambient temperature (34-37 °C) for 10 days or at 15°C for 20 days and found that GA_3 alone or with vapor gard significantly delayed fruit ripening, retarded ascorbic acid degradation in pulp and chlorophyll degradation in the peel, reduced x-amylase and peroxides activities during storage. He further observed that fruits dipped with vapor gard alone or with GA_3 reduced the percentage of weight loss during storage at both temperatures. Fruits dipped with vapor gard with GA_3 markedly delayed ripening in fruits stored at 15°C temperature. Finally, he concluded that mango could be successfully stored for up to 20 days at 15° C temperatures after treating with 200 mg/L GA_3 + 2.5% vapor gard.

To ensure the high numbers of green fruits, good marketability over a long period and to reduce a considerable weight loss, it is needed to determine storage characteristic of banana at different conditions. In this experiment, the efficiency of four post harvest treatments of banana fruits (Hot water at 52±2°C, Bavistin DF at 750 ppm, Gibberellic acid (GA_3) at 150 ppm, Maleic hydrazide at 400 ppm) and wrapping with paraffin were evaluated under ambient conditions.

Materials and methods

Titratable acidity of banana pulp

Ten gm of banana pulp was taken and homogenized with distilled water in a blender. The blended material was boiled for 1hour under refluxing. The whole mass was then transferred to a 100 ml

volumetric flask and the volume was made up to the mark with distilled water. Ten ml pulp solution was taken in a conical flask. Two or three drops of phenolphthalein indicator were added and then flask was shaken vigorously. It was then titrated immediately with 0.1 N NaOH solutions from a burette till a permanent pink color appeared. The volume of NaOH solution required for titration was noted and percent of titratable acidity was calculated.

Determination of vitamin C

Standard vitamin C solution was prepared by taking 10 mg of vitamin C in 100 ml of 3% metaphosphoric acid in 100 ml volumetric flask and 10 ml of standard vitamin C solution was taken in a conical flask and titrated it with prepared dye from a burette. The titration was terminated by the appearance of a permanent light pink color in the titration medium. The operation was repeated for two times and the burette reading was recorded for each time. The supplied sample was transferred in a 100 ml volumetric flask and made volume up to the mark by 3% metaphosphoric acid. 10 ml of this supplied was added into a conical flask and titrated it with the dye. This operation was repeated for two times and reading was taken for each time.

Extraction and determination of reducing and non reducing sugar from banana pulp

Extraction of sugar from banana pulp was done by using Loomis and shull (1937) method. Two banana pulps was cut into small pieces and immediately plunged into boiling ethylalcohol and was allowed to boil 5 to 10 minutes (10 to 20 ml of alcohol was used per gm of pulp). The extract was filtered through the two layers of cloths and the ground tissue was re-extracted for 3 minutes in hot 80% alcohols, using 2 to 3 ml of alcohol per gm of tissue. The second extraction was ensured complete removal of alcohol suitable substances. The extract was cooled and passed through the two layers of cloths. Both of the extracts were filtered through Whatman No. 41 filter paper. The volume of the extract was evaporated to about 25% of the volume over stem bath and cooled. This reduced volume of extract was transferred to a 100 ml volumetric flask and it was up to the mark with distilled water. Reducing sugar content of banana pulp was determined by dinitrosalicylic acid method (Miller, 1972) and non reducing sugar was calculated by subtracting reducing sugar from the total sugar.

Results and discussion

Titratable acidity

The varietal differences in terms of titratable acidity were observed to be statistically highly significant at different days of storage except at 3rd day. It was observed from fig 1 that Amritsagar produced higher titratable acid content over Sabri (Fig. 1). The amount of acid content decreased gradually with the passing of storage times.

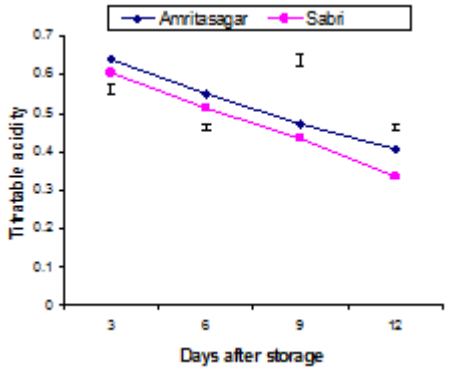

Fig. 1. Effect of varieties on titratable acid content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

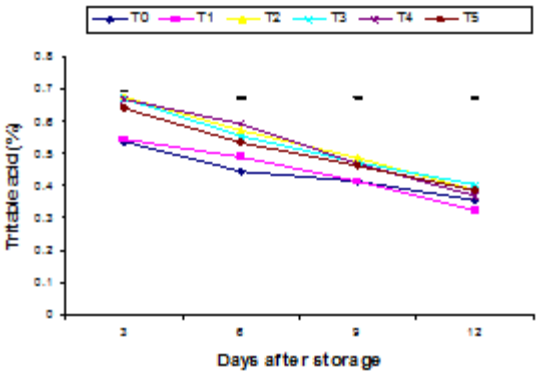

Fig. 2. Effect of treatments on titratable acid content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

Titratable acidity of banana fruits induced by different postharvest treatments exhibited

significant variation from all the storage periods. The maximum titratable acidity was noticed from GA_3 using 400 ppm at 3rd, 6th, 9th, and 12th days of storage followed by hot water treatment while the minimum titratable acidity was noticed at control followed by from the fruit treated with paraffin coating (Fig. 2).

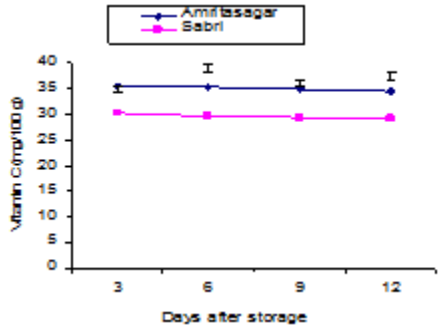

Fig. 3. Effect of varieties on vitamin C content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

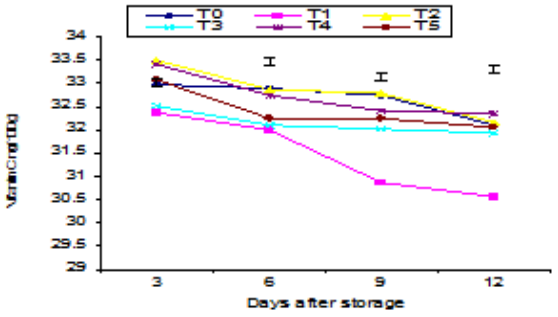

Fig. 4. Effect of treatments on vitamin C content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

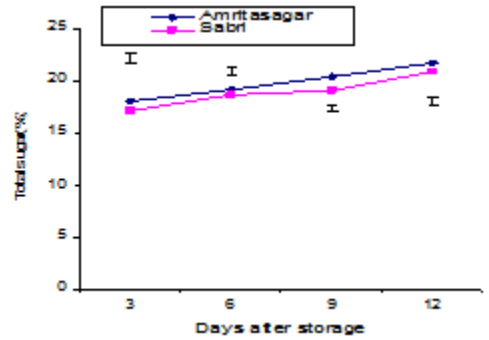

Fig. 5. Effect of varieties on percent total sugar content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

The combined effects of varieties and different treatments in respect of titratable acidity demonstrated significant variation at different days of storage except 3rd day. The highest titratable acidity was recorded from the treatment combination of Amritasagor and 400 ppm of GA_3 (V_1T_3) whereas the lowest were observed from the treatment combination of Amritasagor and control treatment (V_1T_0) at 3rd, 6th, 9th and 12th days of storage (Table 1).

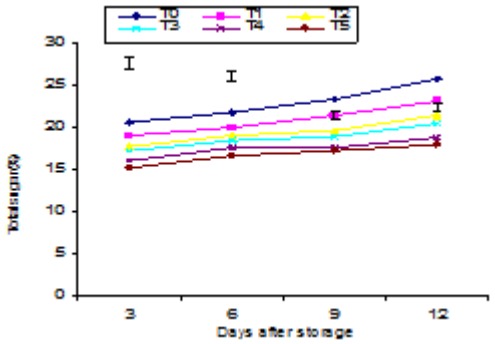

Fig. 6. Effect of treatments on percent total sugar content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

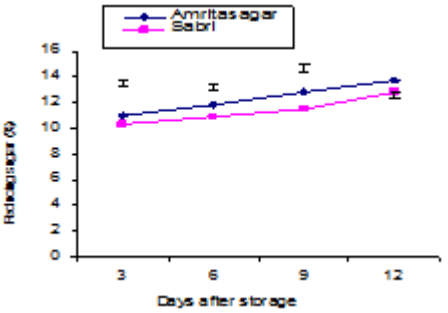

Fig. 7. Effect of varieties on reducing sugar content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

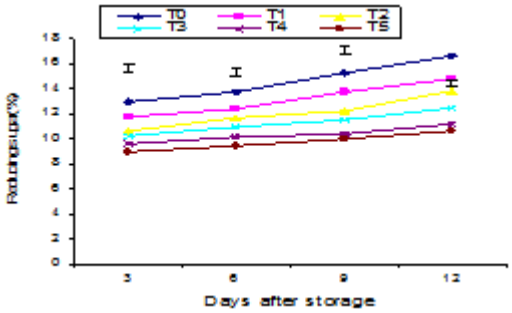

Fig. 8. Effect of treatments on reducing sugar content of banana pulp at different days of storage. Vertical bars represent LSD at 0.05 levels.

Table 1. Combined effect of varieties and storage treatments on titratable acidity (%) of banana pulp at different days.

Variety × Treatment	Titratable acidity (%)			
	3	6	9	12
V_1T_0	0.520	0.450 a-f	0.410 bc	0.390 bc
V_1T_1	0.570	0.490 d-f	0.400 c	0.320 de
V_1T_2	0.716	0.610 a	0.520 a	0.420 ab
V_1T_3	0.730	0.620 a	0.523 a	0.430 ab
V_1T_4	0.670	0.570 ab	0.470 ab	0.410 b
V_1T_5	0.630	0.550 bc	0.510 a	0.373 a
V_2T_0	0.556	0.440 f	0.420 bc	0.320 e
V_2T_1	0.520	0.490 c-f	0.430 bc	0.330 de
V_2T_2	0.630	0.520 b-d	0.450 bc	0.350 c-e
V_2T_3	0.610	0.500 c-e	0.420 bc	0.380 b-d
V_2T_4	0.660	0.613 a	0.470 ab	0.326 de
V_2T_5	0.650	0.520 bd	0.410 bc	0.300 e
Level of significance	NS	**	**	**
C.V (%)	9.49	5.97	6.71	6.58

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 2. Combined effects of varieties and different storage treatment on vitamin C of banana at different days.

Variety × treatment	Vitamin C content of different days			
	3	6	9	12
V_1T_0	35.92 a	35.87	35.74 ab	35.01 a
V_1T_1	34.52 b	34.49	32.47 d	32.11 b
V_1T_2	35.96 a	35.87	35.84 a	35.27 a
V_1T_3	34.99 b	34.92	34.92 c	34.69 a
V_1T_4	36.02 a	35.60	35.01 bc	34.98 a
V_1T_5	36.12 a	35.01	35.25 a-c	35.01 a
V_2T_0	30.02 e	29.92	29.78 e	29.22 c
V_2T_1	30.22 d-e	29.52	29.28 e	29.01 c
V_2T_2	31.02 c	26.87	29.76 e	29.05 c
V_2T_3	30.05 e	29.27	29.12 e	29.17 c
V_2T_4	30.81 d-e	29.92	29.82 e	29.71 c
V_2T_5	30.03 e	29.51	29.22 e	29.13 c
Level of significance	**	NS	**	**
C.V (%)	1.23	1.68	1.37	1.53

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 3. Combined effects of varieties and different treatments on total sugar (%) of banana at different days.

Variety × Treatment	Total Sugar (%)			
	3	6	9	12
V_1T_0	21.12	22.45	24.45 a	26.69 a
V_1T_1	19.49	20.19	22.12 b	23.71 c
V_1T_2	18.21	19.29	20.09 d	21.79 e
V_1T_3	17.54	18.92	19.67 de	20.20 g
V_1T_4	16.91	17.69	18.26 f	19.17 h
V_1T_5	15.47	16.72	17.66 g	18.72 hi
V_2T_0	20.00	21.29	22.41 b	24.92 b
V_2T_1	18.72	19.97	20.79 c	22.67 d
V_2T_2	17.29	18.79	19.26 e	21.29 ef
V_2T_3	17.03	18.02	18.29 f	20.79 f
V_2T_4	15.27	17.67	17.01 h	18.39 i
V_2T_5	15.02	16.70	16.97 h	17.27 j
Level of significance	NS	NS	**	**
C.V (%)	3.22	2.67	1.56	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 4. Combined effects of varieties and different treatments on reducing sugar content (%) of banana pulp at different days.

Variety × Treatment	Reducing sugar (%)			
	3	6	9	12
V_1T_0	13.63 a	15.02 a	16.76 a	17.43 a
V_1T_1	12.22 b	12.85 b	14.59 b	15.69 b
V_1T_2	10.97 c	11.99 c	12.64 d	14.41 c
V_1T_3	10.26 d	11.65 cd	11.92 e	12.29 g
V_1T_4	10.16 d	10.50 e	10.89 f	11.48 h
V_1T_5	8.95 e	9.19 g	10.24 g	11.15 hi
V_2T_0	12.23 b	12.55 b	13.79 c	15.91 b
V_2T_1	11.27 c	11.92 c	12.88 d	13.97 d
V_2T_2	10.30 d	11.31 d	11.79 e	13.25 e
V_2T_3	10.29 d	10.21 ef	11.08 f	12.75 f
V_2T_4	9.02 c	9.77 f	9.85 g	10.92 i
V_2T_5	9.01 e	9.72 f	9.79 g	10.07 j
Level of significance	**	**	**	**
C.V(%)	2.76	2.45	2.99	1.80

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 non-reducing sugar of banana at different days.

Variety	Non-reducing sugar (%)			
	3	6	9	12
V_1	7.047 a	7.610 a	7.671	8.146
V_2	6.347 b	7.343 b	7.535	8.072
Level of significance	**	**	NS	NS
LSD (0.05)	0.149	0.1071	0.1499	0.2004

Note: NS= None significant; **= Significant at 0.05 levels; a,b,c.. express the data range, 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 treatment on reducing sugar of banana at different days.

Treatments	Non-reducing Sugar (%)			
	3	6	9	12
T_0	7.54 a	8.09 a	8.29 a	9.18 a
T_1	7.29 ab	7.69 b	7.73 b	8.36 b
T_2	7.12 bc	7.34 c	7.46 c	8.01 c
T_3	6.97 c	7.27 c	7.55 bc	7.98 c
T_4	6.50 d	7.19 c	7.28 c	7.74 e
T_5	6.27 d	7.28 c	7.30 c	7.39 d
Level of significance	**	**	**	**
LSD (0.05)	0.2596	0.1855	0.2596	0.3470

Note: **= Significant at 0.05 levels; a,b,c.. express the data range, in a column values having the same letter(s) do not differ significantly as per DMRT at 0.05 levels.

Table 7. Combined effects of varieties and treatment on non-reducing sugar of banana pulp at different days.

Variety×Treatment	Non-reducing Sugar (%)			
	3	6	9	12
V_1T_0	7.79 a	8.74 a	8.90 a	9.10
V_1T_1	7.31 b	8.05 b	7.94 b	8.70
V_1T_2	6.99 bc	7.38 cd	7.47 cd	8.04
V_1T_3	6.73 cd	7.27 c-e	7.34 cd	8.04
V_1T_4	6.25 ef	7.19 de	7.19 d	7.80
V_1T_5	6.010f	7.030e	7.18d	7.20
V_2T_0	7.29 b	7.43cd	7.69 c-e	9.26
V_2T_1	7.27 b	7.34 cd	7.53 cd	8.02
V_2T_2	7.24 b	7.30 c-e	7.45 cd	7.98
V_2T_3	7.21 b	7.27 c-e	7.75 bc	7.91
V_2T_4	6.75 cd	7.19 de	7.37 cd	7.69
V_2T_5	6.52 de	7.53 c	7.42 cd	7.57
Level of significance	**	**	**	NS
C.V (%)	3.12	2.09	2.84	3.56

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

Tripathi *et al.,* (1981) reported that titratable acidity was increased during ripening. Simmonds (1960) mentioned initial rise in acidity to a peak level and its later decline during ripening. Wyman and Palmer (1964) conducted an experiment on changes in organic acids in ripening Gros Michel bananas. 'They found 14 organic acids, other than keto acids, in the banana pulp at greater than the concentration of 0.0005 meq/100 gm fresh weight. Presence of many other acids below that level was also hinted. Along with maleic and citric acid, oxalic acid proved to be a major acid. Concentration of major acids changed markedly during early stages of ripening at about the time of climacteric and then trended to remain constant or to increase slowly thereafter. In unripe fruit, oxalic acid was the predominant acid. As ripening progressed, maleic and citric peak acidity increased 3 to 4 fold while oxalic acid dropped to about 60% of its original value. The net result was a doubling of the organic acidity during ripening with maleic acid becoming the predominant acid in ripe bananas. Total acidity increased from 4.43 meq/100 gm fresh weight in pre-climacteric to 8.74 meq/100 gm in climacteric and 10-90 meq/100 gm in post climacteric bananas. Munasquc and Mendoza (1990) reported that titratable acidity increased until color index 3 (more green than yellow) and then declined as the fruit turned yellow in color. Barker and Solomos (1962) reported a six fold increase in malate during ripening. Evaluating the work of several scientists, Loesecke (1950) commented that maleic acid was the chief acid in banana pulp while Steward *et al.* (1960) reported both citric and maleic acid predominate.

Estimation of vitamin C

The variation between varieties means on vitamin C content of banana pulp was found to be significant at different days of storage except 3rd day of storage. Vitamin C content of banana pulp gradually decreased in both varieties with the passing of storage period but the decreasing trend was found to be higher in Amritasagor than sabri. Higher vitamin C contents were obtained from Amritasagor over sabri at 6th and 9th days of storage (Fig. 3).

Variation among the treatmenst in relation to vitamin C content exhibited statistically significant at different days of storage. The maximum vitamin C contents were found in control and the minimum was obtained from 400 ppm of GA_3 at 9th days of storage. Vitamin C content was gradually decreased with the progresses of storage period (Fig 4).

The combined effect of varieties and treatments were also found to be significant and the highest vitamin C content was observed from the treatment combination of Amritasagor and control (V_1T_o) at 3rd day of storage. The lowest were found from the treatment combination of V_1T_3 (Table 2). The vitamin C content of banana pulp was changed slowly from 3rd to 9th days of storage but it decreased rapidly after 9th days of storage. This result is similar to Ghanta (1994). He reported that ascorbic acid content declined from 33.30 mg/100 gm (10 days anthesis) to 10.64 mg/100gm (60 days after anthesis). Tripathi (1988) also noticed that the percentage of ascorbic acid was the highest at 6th day of storage. He also noted that fruit quality and flavor in banana remained better at the same day.

Estimation of total sugar

Varietal differences in terms of total sugar content were found to be significant during storage. The total sugar contents of Amritsagar and Sabri increased with the progress of storage times (Fig. 5). The total sugar content was gradually increased and reached the pick point at 12th day of storage in both varieties. But Amritsagor accumulated higher quantities of total sugar over Sabri.

The most striking postharvest chemical changes which occur during postharvest ripening of banana that is the hydrolysis of starch and accumulation of sugar i.e. sucrose, glucose and fructose which is responsible for the sweetness of the fruits (Palmer, 1971). The main changes in fruit pulp during ripening are the conversion of starch to sugars. Starch

declines from 20 to 23% at harvest and 1 to 2% in the ripe fruits. Sugar increases about the same proportion. According to Robinson (1996), during the early stage of ripening of banana the ratio of different sugars (sucrose: glucose: fructose) is about 65:20:15 and this ratio became decrease with the increase of storage time. Total sugar content in green and ripe banana were reported as 1-2% and 15-20% (Simmonds, 1960), 0.5% and 19% (Anon., 1972); 1-2.0% and 19.0-19.5% (Purseglove, 1983) respectively. Chacon *et al.* (1987) mentioned the total sugar content in green bananas as 13.2% and in ripe bananas as 19.7%. Stratton and Loesecke (1930) conducted an experiment with banana and reported that total sugar content increased progressively from 0.86% to 17.9%. Abdullah *et al.* (1985) conducted an experiment on physicochemical changes during maturation and after ripening of banana and reported that total sugar content increased during ripening. Tripathi *et al.* (1981) also found the similar result.

The different treatments involved in the investigations were also found to be highly significant in relation to total sugar content. The maximum and the minimum sugar content were obtained from control and maleic hydrazide (400 ppm) respectively at 6th, 9th and 12th days of storage (Fig 6). So, Maleic hydrazide significantly retarded the accumulation of total sugar content followed by other treatments such as GA_3 (400 ppm). During ripening of banana fruits undergo physiological changes. The most striking chemical changes which occur during the postharvest ripening of banana fruits were hydrolysis of starch and accumulation of sugars. Lower accumulation of total sugar caused by maleic hydrazide might be perhaps due to acting better enzymatic inhibitor which restricted the ripening process.

The combined effect of varieties and treatments on total sugar content of banana pulp was also noticed to be statistically significant at 9th and 12th days of storage and the highest quantities of total sugar contents were found from the combination of Amritasagor and Control (V_1T_0) while the minimum was found from the treatment combination of Sabri and Maleic hydrazide (V_2T_5) at 6th, 9th and 12th days of storage. (Table 3)

Estimation of reducing sugar (%)

Statistically highly significant variation was observed in reducing sugar content between two varieties means at different days of storage. The highest amount of reducing sugar contents were found from Amritasagor whereas the lowest was noticed from Sabri at 6th and 9th days of storage respectively (Fig.7). The reducing sugar contents exhibited an increasing trend in both the varieties during storage but Amritasagor produced it more quantities than Sabri.

The increase in reducing sugar with the progress of ripening as well as storage time was due to the degradation of starches to glucose and fructose by the activities of amylase and maltase (Wills *et al. I981).* Tandon *et al.* (1985) mentioned that fructose content was increased during ripening. Joshi and Roy (1988) also reported that percentage of reducing sugars increased gradually up to 25 days in the fruits held in cold room and declined sharply after because of the onset of senescence. Chacon *et al.* (1987) mentioned the total reducing sugar in green and ripe bananas were 0.52% and 10.3%, respectively. Stratton and Loesecke (1930) reported that reducing sugar content increased progressively from 0.24% to 15.3%

Different treatments showed a significant effect on reducing sugar content of banana pulp at different days of storage. The maximum reducing sugar contents were found in control while the minimum were obtained from maleic hydrazide (400 ppm) at 6th and 9th days of storage, respectively (Fig 8). Islam (1998) narrated that increase in reducing sugar could be attributed to enzymatic conversion of starch to reducing sugar.

The combined effect of varieties and different treatments in respect of reducing sugar content demonstrated significant variation at different days

of storage. The highest reducing sugar contents were recorded from the combination of Amritasagor with control (V_1T_0)) while the lowest reducing sugar contents were recorded from the combination of Sabri and 400 ppm of maleic hydrazide (V_2T_5) at 6th and 9th days of storage respectively (Table 4).

Estimation of non-reducing sugar (%)

Varieties means in terms of non-reducing sugar content were found to be significant at different days of storage except 3rd and 12th days of storage. Higher non-reducing content were observed in Amritasagor while Sabri produced lower quantities at 6th and 9th days of storage respectively (Table 5). It was also noticed that non-reducing sugar content gradually increased in both the varieties during storage but increasing trend was higher in Sabri over Amritasagor.

Stratton and Loesecke (1930) conducted an experiment with banana and stated that non reducing sugar content was initially very low. It then increased to a peak value after 5 days of harvesting and then again dropped drastically. Muthuswamy *et al.* **(**1971**)** conducted an experiment with Dwarf Cavendish and found that non-reducing sugar were very less at the initial stage of fruit development and with the advanced of fruit maturity non-reducing sugar increased.

Variation among the treatment means in relation to non-reducing sugar content showed statistically significant at different days of storage. The maximum non-reducing sugar contents were noticed in control (T_0) at 6th and 9th days of storage while the minimum values of non-reducing sugar content were recorded from using 750 ppm of bavistin DF (Table 6).

The overall findings recorded in the present investigation are that the Sabri variety was found to be better in terms of biochemical components and 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. So, further investigation is required for comparing with other varieties and treatments which may retard the ripening process.

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