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Artificial ripening of banana by application of heat

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Abstract:

An experiment was conducted to find out a suitable method for ripening and to analyze the nutritional qualities of artificially ripened banana. Two varieties of banana viz., Amritasagar and Sabri were exposed separately to four different durations of heat such as 12, 18, 24 and 30 hrs along with control. The two-day interval data on physico-chemical characteristics revealed that in both the variety faster changes in physico-chemical qualities occurred in heat treated bananas than that of untreated ones and an improvement in the quality characters was found with the increase in the duration of exposure to heat. Among the quality parameters investigated pulp to peel ratio (6.02), total sugar (24.41%), reducing sugar (12.81%), non-reducing sugar (11.59%) and TSS (29.11) was observed to be the maximum in variety Sabri while total weight loss (23.22%) and titratable acidity (0.69%) were found to be the highest in Amritasagar and all were in 30-hr heat exposure. Whereas in untreated banana total weight loss (%), pulp to peel ratio, total sugar (%), reducing sugar (%), non-reducing sugar (%), titratable acidity (%) and TSS (%) contents were 18.72 and 12.77, 3.74 and 4.19, 18.47 and 20.30, 9.92 and 10.92, 8.54 and 9.38, 0.62 and 0.58 and 20.95 and 22.09 in Amritasagar and Sabri, respectively at the final day of investigation

after 8 days of treatment. Fruits exposed to 30-hr heat attained full ripe stage within 3.4 and 3.8 days in Sabri and Amritasagar, respectively while untreated fruits required at least 10 days to ripen fully. Maximum shelf life was observed in Sabri (11.4 days) in control while in 30-hr heat exposure it was found 8 and 8.4 days in Amritasagar and Sabri, respectively. Now, it can be concluded that artificial heat brings about rapid ripening with no deterioration rather improvement in the quality of banana provided that the bananas are in proper stage of maturity.

Key words: Banana, artificial ripening, heat, physico-chemical qualities.

INTRODUCTION

Banana (*Musa sapientum* L.) is a crop of major economic importance in the world. It constitutes the 4th largest food crop of the world after rice, wheat and maize (Arias *et al.*, 2003). Among the fruit crops grown in Bangladesh, banana ranks first in terms of production comprising nearly 20% of total fruits production with 36% share in area (BBS, 2010) producing 7.46 thousand metric tons of bananas from 1.22 thousand acres of land (BBS, 2012). The consumption of banana cuts across every age group from little children to adults as it supplies necessary calories and essential micronutrients and contains considerable amount of carbohydrate, crude fiber, protein, fat, ash, phosphorus, calcium, iron, ß-carotene, riboflavin, niacin and ascorbic acid (Tran, 2011; Khader *et al.*, 1996). In the nature, banana ripens easily showing changes in skin color, flavor and texture of the flesh during ripening (Botondi *et al.*, 2014). But natural ripening may result in softening with non-uniform, dull, pale yellow and unattractive color (Eduardo, 2012). Besides, due to slow ripening natural process leads to high weight loss, splitting fruit's peel (Subbaiah *et al.*, 2013). The small and large scale farmers use ripening agents to overcome

these disputes. But most of the ripening agents are toxic and their consumption can cause serious health problems, such as heart disease, skin disease, lung failure and kidney failure (Siddiqui and Dhua, 2010; Hoque, 2012). In many developing countries like Ethiopia, wholesalers ripen bananas with smoke for 24-72 hours (Berhe *et al.*, 2010). In some areas of Bangladesh, artificial heat from burning rice husk, wood litters etc. is used to ripen banana but with little or even no knowledge of quality change with the duration of heat exposure. Prolonged smoke treatment is crude and ineffective and also evolution of carbon monoxide is hazardous to health. Improper smoke treatment leads to uneven ripening and also poor external colour development (Kulkarni *et al.*, 2004). Thus both eating and marketable qualities of ripened banana are in the face of question! Hence, the present study was undertaken to find out a suitable and efficient method for ripening of banana and to analyze nutritional qualities of the artificially ripened bananas.

MATERIALS AND METHODS

The present research was conducted in the laboratory of Department of Horticulture, Bangladesh Agricultural University, Mymensingh, during the period from June 2015 to September 2015. Mature green bunches of two varieties of banana viz., Sabri and Amritasagar were collected directly from farmer's field and pre-cooled in the laboratory to remove the field heat and thereafter exposed to four different durations of rice-husk burnt heat such as 12, 18, 24 and 30 hrs along with control and the treated bananas were then kept on the brown paper placed on the table in the laboratory at ambient conditions for analysis. The experiment was carried out in completely randomized design with five replications. Quality characters such as percent total weight loss, pulp to peel ratio, chemical characters viz., total sugar content, reducing sugar content, non-reducing sugar content, titratable acid content and

total soluble solids (TSS) content (% Brix) of banana pulp was determined according to Ranganna (1979) and time taken to ripen and shelf life was estimated according to Mondal (2000). Data were collected at an interval of two days. The parameters were analyzed statistically using MSTAT-C statistical package program and significant differences among the means, if any, were compared by LSD test at 1% and 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Total weight loss

Total weight loss of both treated and untreated banana increased with the advancement of storage after treatment which differed significantly. It was higher in Amritasagar than Sabri (Fig. 1). Following the trend, maximum weight loss after 8 days of treatment was found 22.64% in T_4 (Heat; 30 hrs) treatment while the minimum weight loss after 8 days of treatment was observed (17.96%) in T_0 (Control) treatment (Fig. 2). The highest total weight losses after 4, 6 and 8 days of treatment were observed to be 13.74, 18.78 and 23.22% in V_1T_4 (Amritasagar with Heat; 30 hrs) while the lowest weight losses were observed 8.70, 12.77 and 17.21% in V_2T_0 (Sabri with control) (Table 1). Total weight loss increased with increase in heating duration and prolongation of storage. The results have got support of Waskar and Roy (1992) who said that the loss of weight in fruits increased with advancement of storage period both in treated and control fruits.

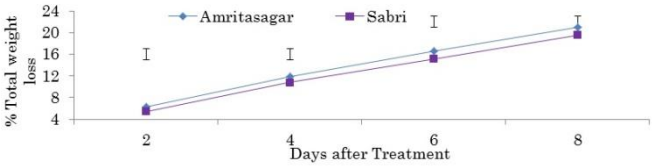

Fig. 1. Main effect of varieties on percent total weight loss of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

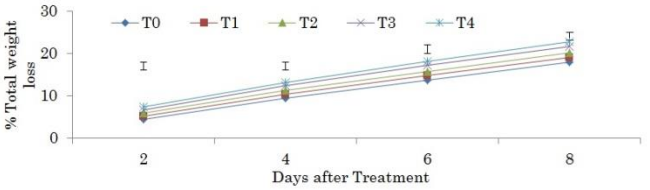

Fig. 2. Main effect of treatments on percent total weight loss of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

Pulp to peel ratio

An increase in the pulp to peel ratio in both treated and untreated banana of each variety was observed with the increase in storage period and duration of exposure to heat and the variation was found significant being higher in Sabri and lower in Amritasagar (Fig. 3). Following the trend, after 8 days of treatment the maximum pulp to peel ratio (5.88) was in T_4 (Heat; 30 hrs) treatment (Fig. 4). Again in interaction, the highest pulp to peel ratios were recorded 3.61, 4.17, 4.99 and 6.02 after 2, 4, 6 and 8 days of treatment in V_2T_4 (Sabri with Heat; 30 hrs) treatment while the lowest ratios were observed 1.40, 1.96, 2.62 and 3.74 in V_1T_0 (Amritasagar with control) treatment, respectively (Table 1). The faster changes and higher values of pulp to peel ratio were observed from smoke treatment and related to water loss from the peel to the pulp and to the atmosphere which derive support of Dadzie and Orchard (1997) and Tripathi *et al.* (1981).

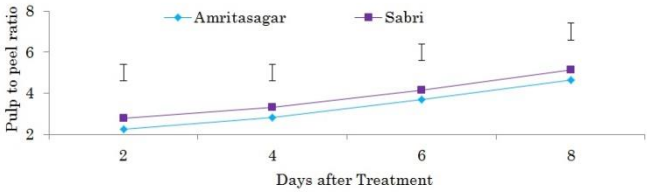

Fig. 3. Main effect of varieties on pulp to peel ratio of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

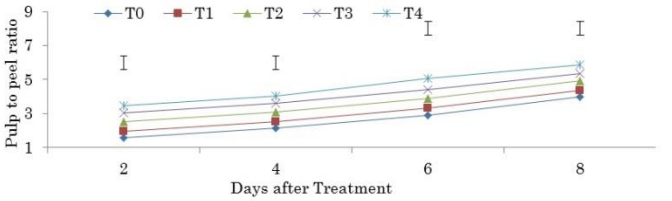

Fig. 4. Main effect of treatments on pulp to peel ratio of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

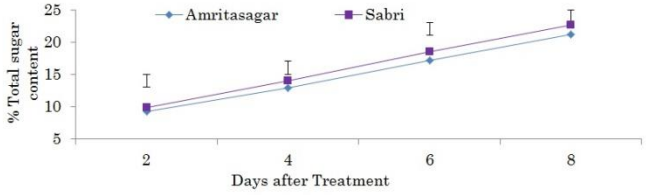

Fig. 5. Main effect of varieties on percent sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

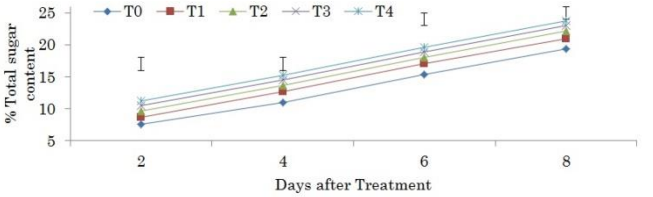

Fig. 6. Main effect of treatments on percent sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

Total sugar content

Total sugar content was recorded higher in Sabri and lower in Amritasagar during storage and it increased with the progress of time (Fig. 5). Thus, the maximum level of total sugar content was found in T_4 (Heat; 30 hrs) treatment while the minimum in T_0 (Control) treatment (Fig. 6). According to the trend of

increase in total sugar content, after 8 days of treatment it was found to be the highest (24.41%) in V_2T_4 (Sabri with Heat; 30 hrs) treatment while the lowest total sugar content was observed to be 18.47% in V_1T_0 (Amritasagar with control) treatment (Table 1). Simmonds (1960) and Purseglove (1983) had the same opinion. Changes in fruit pulp during ripening are the conversion of starch to sugars i.e. sucrose, glucose and fructose which is responsible for the sweetness of the fruits (Palmer, 1971).

Reducing sugar content

An increasing trend in the reducing sugar content was found in both the varieties during ripening period. It increased gradually from 2 to 8 days after treatment. Thus, after 8 days of treatment the maximum level was recorded (12.77%) in T_4 (Heat; 30 hrs) treatment (Fig. 8). Following the similar trend the maximum reducing sugar contents were recorded to be 7.17, 9.31, 10.63 and 12.81% after 2, 4, 6 and 8 days of treatment in V_2T_4 (Sabri with Heat; 30 hrs) treatment while the minimum reducing sugar contents were 4.36, 6.62, 7.82 and 9.93% after 2, 4, 6 and 8 days of treatment in V_1T_0 (Amritasagar with control) treatment (Table 2) which have got support of Stratton and Loesecke (1930) who reported that reducing sugar content increased progressively from 0.24% to 15.3%.

Table 1. Combined effect of varieties and treatments on percent total weight loss, pulp to peel ratio and total sugar content of banana at different days after treatment

Variety x Treatment	%Total weight loss at DAT				Pulp to peel ratio at DAT				% Total sugar content at DAT			
	2	4	6	8	2	4	6	8	2	4	6	8
V_1T_0	5.12	10.23	14.43	18.72	1.40	1.96	2.62	3.74	7.32	10.17	14.52	18.47
V_1T_1	5.41	10.61	15.05	19.40	1.81	2.37	3.19	4.22	8.38	12.23	16.43	20.26
V_1T_2	6.29	11.78	16.44	20.80	2.12	2.68	3.50	4.53	9.38	13.23	17.43	21.48
V_1T_3	7.15	13.16	18.17	22.69	2.67	3.23	4.05	5.08	10.22	14.07	18.27	22.38
V_1T_4	7.70	13.74	18.78	23.22	3.32	3.88	5.14	5.73	11.04	14.89	19.09	23.18
V_2T_0	3.85	8.708	12.77	17.21	1.78	2.34	3.16	4.19	7.92	11.77	16.25	20.30
V_2T_1	4.93	10.13	14.37	18.60	2.12	2.68	3.50	4.53	9.06	13.21	17.71	21.80
V_2T_2	5.46	10.76	15.06	19.31	2.92	3.48	4.30	5.33	10.08	14.23	18.73	22.89
V_2T_3	6.18	11.64	16.18	20.51	3.41	3.97	4.79	5.59	10.91	15.06	19.56	23.80
V_2T_4	6.93	12.69	17.47	22.07	3.61	4.17	4.99	6.02	11.42	15.57	20.07	24.41
LSD0.05	0.43	0.39	0.39	0.37	0.19	0.19	0.30	0.23	0.19	0.19	0.19	0.19
LSD0.01	0.57	0.52	0.52	0.49	0.25	0.25	0.40	0.31	0.25	0.25	0.25	0.26
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**

ns Not-significant (p>0.05), * p<0.05, ** p<0.01; V_1= Amritasagar, V_2= Sabri; T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs; DAT= Days after treatment

Table 2. Combined effect of varieties and treatments on percent reducing sugar, non-reducing sugar, titratable acid and total soluble solids content of banana after different days of treatment

Variety x Treatment	% Reducing sugar content at DAT				% Non-reducing sugar content at DAT				% Titratable acid content at DAT				% Total soluble solids content at DAT			
	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
V_1T_0	4.36	6.62	7.82	9.92	2.9	3.55	6.70	8.54	0.32	0.42	0.51	0.61	12.26	16.46	18.85	20.95
V_1T_1	4.69	6.89	8.29	10.37	3.7	5.34	8.14	9.90	0.37	0.50	0.59	0.68	17.49	21.49	23.33	26.43
V_1T_2	5.29	7.49	8.89	10.98	4.1	5.74	8.54	10.50	0.38	0.52	0.62	0.69	18.19	22.39	24.23	27.33
V_1T_3	5.93	8.13	9.53	11.79	4.3	5.94	8.74	10.60	0.41	0.58	0.66	0.66	19.05	23.25	25.14	28.29
V_1T_4	6.63	8.83	10.23	12.43	4.4	6.05	8.84	10.74	0.47	0.62	0.69	0.67	19.63	23.65	25.37	28.59
V_2T_0	5.26	7.46	8.71	10.92	2.6	4.31	7.53	9.38	0.30	0.39	0.48	0.58	13.69	17.59	19.99	22.09
V_2T_1	5.80	7.94	9.26	11.49	3.3	5.27	8.44	10.31	0.33	0.42	0.52	0.63	18.00	22.20	24.73	26.83
V_2T_2	6.64	8.78	10.10	12.36	3.4	5.45	8.63	10.53	0.35	0.45	0.54	0.66	18.80	23.00	25.53	27.63
V_2T_3	6.91	9.05	10.37	12.63	3.4	6.01	9.19	11.17	0.38	0.51	0.61	0.66	19.28	23.38	26.05	28.15
V_2T_4	7.17	9.33	10.63	12.81	4.2	6.25	9.43	11.59	0.43	0.55	0.65	0.63	20.24	24.34	27.01	29.11
LSD0.05	0.08	0.08	0.08	0.09	0.2	0.21	0.21	0.21	0.04	0.04	0.04	0.04	0.37	0.37	0.37	0.37
LSD0.01	0.11	0.11	0.11	0.12	0.3	0.28	0.28	0.28	0.05	0.05	0.05	0.05	0.50	0.49	0.49	0.49
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

ns Not-significant (p>0.05), * p<0.05, ** p<0.01; V_1= Amritasagar, V_2= Sabri; T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs; DAT= Days after treatment

Non-reducing sugar content

Non-reducing sugar content of bananas also followed the similar trend as per reducing sugar content and the variations observed during the ripening period were significant (Fig. 9, 10). Following the trend, the highest non-reducing sugar contents after 2, 4, 6 and 8 days of treatment were recorded to be 4.24, 6.25, 9.43 and 11.59% in V_2T_4 (Sabri with Heat; 30hrs) treatment and the lowest in V_1T_0 (Amritasagar with control) (Table 2) as reported by Stratton and Loesecke (1930).

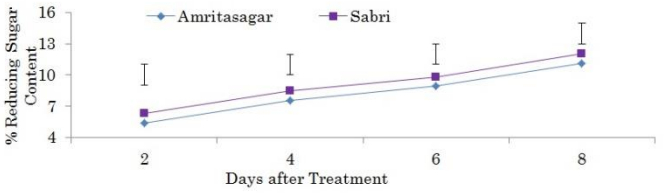

Fig. 7. Main effect of varieties on percent reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

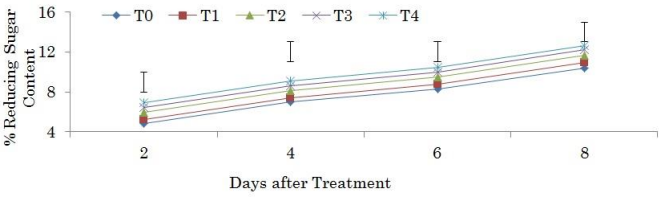

Fig. 8. Main effect of treatments on percent reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

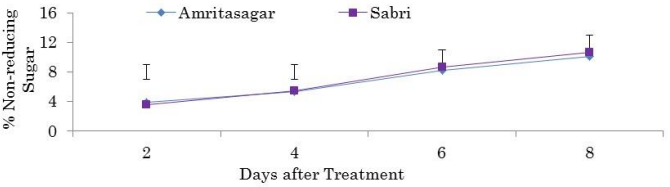

Fig. 9. Main effect of varieties on percent non-reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

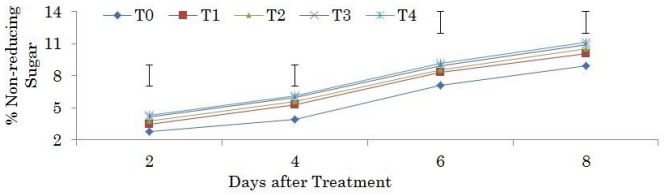

Fig. 10. Main effect of treatments on percent non-reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

Titratable acid (TA) content

From the results of the experiment it was found that titratable acidity increased with the increase in duration of exposure of banana to heat and with progress in ripening up to a limit. It was observed that Amritasagar had higher titratable acid

content than Sabri (Fig. 11). The maximum titratable acidity after 2, 4 and 6 days of treatment were found to be 0.47, 0.62 and 0.69%, respectively in V_1T_4 (Amritasagar with Heat; 30 hrs) and at 8 days after treatment it was found highest (0.69%) in V_1T_2 (Amritasagar with Heat; 18 hrs) while minimum was found in untreated Sabri (Table 2). It declined after reaching its peak in 30-hr heat. Tan *et al.* (2014) mentioned that acid levels increased slowly during the preservation time from 0 to 60 hours and similar results were reported by Dadzie and Orchard (1997) who stated on the increase in TA over the ripening.

Total soluble solids (TSS) content

Total solids contents were found higher in Sabri than in of Amritasagar. The maximum TSS contents were recorded to be 19.93, 23.99, 26.19 and 28.85% in T_4 (Heat; 30 hrs) treatment while the minimum values were recorded 12.98, 17.02, 19.42 and 21.52% in T_0 (Control) treatment after 2, 4, 6 and 8 days of treatment, respectively (Fig. 14). Again, after 2, 4, 6 and 8 days of treatment, the highest values were observed to be 20.24, 24.34, 27.01 and 29.11% in V_2T_4 (Sabri with Heat; 30 hrs) treatment and the lowest values were 12.26, 16.46, 18.85 and 20.95% in V_1T_0 (Amritasagar with control) (Table 2). The report of with Tapre and Jain (2012) agree with the results. Mondal and Rakib (2014) also expressed similar opinion.

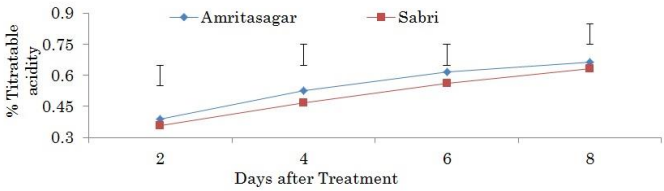

Fig. 11. Main effect of varieties on percent titratable acidity content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

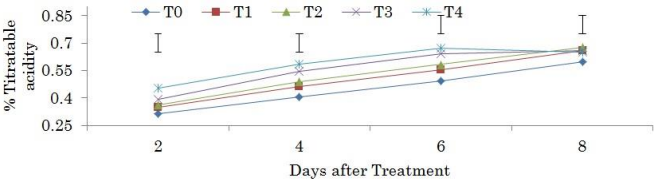

Fig. 12. Main effect of treatments on percent titratable acidity content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

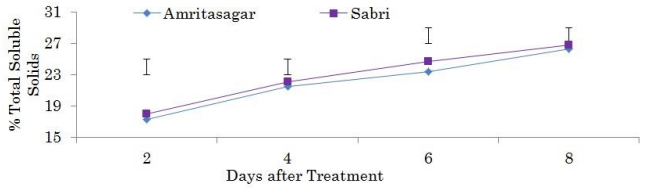

Fig. 13. Main effect of varieties on percent soluble solids content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

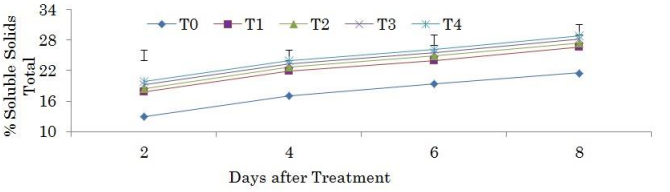

Fig. 14. Main effect of treatments on percent soluble solids content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

Time taken to ripen banana

Ripening is a biochemical process which involves a series of physiological changes in colour, aroma, flavor and texture (Sogo-Temi *et al.*, 2014). Between the two varieties Sabri (5.40 days) ripened faster than Amritasagar (5.72 days) (Fig. 15). Bananas under T_4 (Heat; 30 hrs) treatment attained at full ripe stage within minimum number of days (3.60 days) while

bananas from T_0 (Control) treatment took maximum 8.2 days to ripen fully (Fig. 16). Again in combination, the lowest number of days required to ripen banana was recorded 3.4 days in V_2T_4 (Sabri with Heat; 30 hrs) while the maximum number of days taken to ripen banana was observed 9.4 days in V_1T_0 (Amritasagar with control) treatment (Fig. 17). The reduced ripening time of smoke treated fruits is also in agreement with the previous findings of Maerere *et al.* (2008).

Shelf life of banana

Shelf life of any fruits calculated from the period of harvest up to rotting. Mondal (2000) reported that the shelf life was the period of time which started from the time of harvesting and extended up to the start of rotting of fruit. Shelf life was higher in the variety Sabri and lower in Amritasagar (Fig. 18). Maximum shelf life (11.1 days) was observed in control (T_0) treatment and minimum (7.6 days) in T_4 (Heat; 30 hrs) treatment (Fig. 19). In combination maximum shelf life was observed 11.4 days in V_2T_0 (Sabri with control) and minimum in V_1T_4 (Amritasagar with Heat; 30 hrs) (Fig. 20). The results of the present experiment have got support of Maerere *et al.* (2008) who reported shorter shelf life of less than 8 days for smoke treated bananas (Grand Naine) which was also in line with the opinion of Le *et al.* (2008). Similar results also observed by Mondal and Rouf (2011).

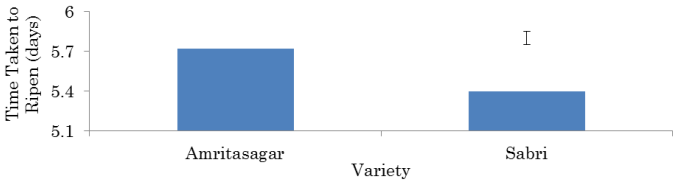

Fig. 15. Main effect of varieties on time taken to ripen banana. Vertical bar represent LSD at 5% level of significance.

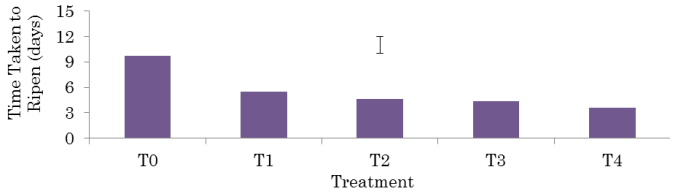

Fig. 16. Main effect of treatments on time taken to ripen banana. Vertical bar represent LSD at 1% level of significance.

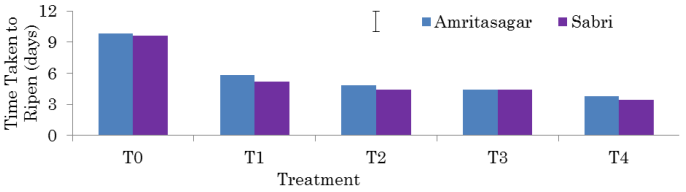

Fig. 17. Combined effect of variety and treatment on time taken to ripen banana. Vertical bar represent LSD at 1% level of significance.
T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

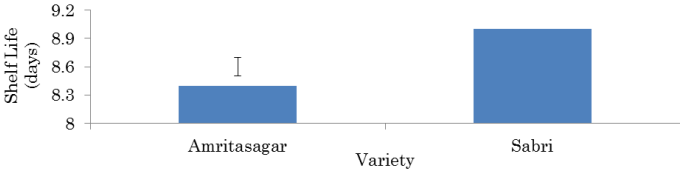

Fig. 18. Main effect of varieties on shelf life of banana. Vertical bar represent LSD at 5% level of significance.

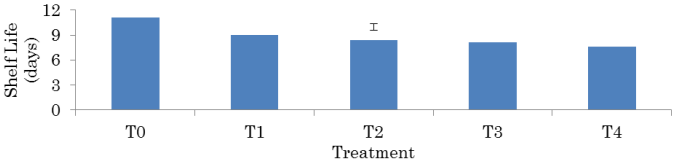

Fig. 19. Main effect of treatments on shelf life of banana. Vertical bar represent LSD at 1% level of significance.

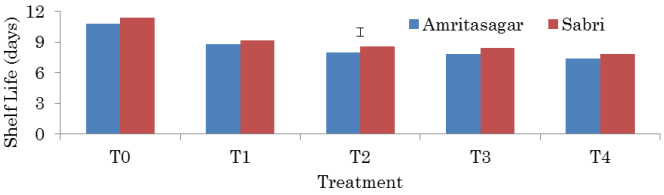

Fig. 20. Combined effect of variety and treatment on shelf life of banana. Vertical bar represent LSD at 1% level of significance.
T_0= Control, T_1= Heat; 12 hrs, T_2= Heat; 18 hrs, T_3= Heat; 24 hrs, T_4= Heat; 30 hrs

CONCLUSION

Thus, from this present investigation it can be concluded that heat is an important agent for ripening banana with no deterioration rather positive changes in the quality provide that the bananas are in the proper stage of maturity.

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