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Original Research Article

Effects of Hot Water Treatment and Immersion Period on Total Soluble Solids of Different Banana

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Abstract: An experiment was carried out to determination of different effects of hot water and immersion on Total Soluble Solids (TSS) of Different Banana Varieties. The experiment comprised three factors, namely hot water treatments (control, 45°C, 50°C, and 55°C), times of immersion (five minutes and ten minutes) and varieties (Mehersagar and Sabri). The experiment was laid out in completely randomized design with three replications. Main effect of hot water treatments, immersion periods and varieties were showed significant on percent total soluble solid. An increasing trend in TSS contents was observed in all treatments at all stages of ripening. Incase of main effect maximum TSS was found in Control temperature, Sabri variety and five minutes immersion periods respectively. Between two Banana varieties Sabri showed maximum TSS than Mehersagar in all treated conditions. The control treatments consistently showed higher TSS than the treated bananas, although none remained fresh by the 9th day. Five minutes immersed fruits showed maximum TSS than ten minutes in main and combined treatments. Longer immersion period had significantly effects and less increase TSS of the bananas than shorter immersion period. Among the treatments, both varieties showed lowest TSS in five minutes immersion at 50°C temperature than other treatments. Hot water treatment is better than untreated banana for storage and quality of banana.

Keywords: Hot Water, Immersion, Varieties, Total Soluble Solids, Post-Harvest and Shelf Life.

INTRODUCTION

Banana is the most important fruit in Bangladesh considering its year round availability, popularity and production. According to BBS, 2023 total production of banana was 840362.67 metric tons in Bangladesh. But non-availability of adequate postharvest storage facilities has posed a great threat to the commercial cultivation of banana. Therefore, reduction in postharvest losses should be considered as a strategic requirement in our country. In Bangladesh a considerable amount of banana is being spoiled due to prevailing high temperature and humidity during main harvesting period. There is a lack of appropriate storage facilities and the knowledge about storage is also insufficient. The increase in yield and productivity without reducing postharvest losses, will not be sufficient in securing the availability of food in the world. The postharvest losses is a major problem from harvesting to consumption and the gross postharvest losses of banana was 21.67% of total production. (C.K. Saha *et al.*, 2021). Recently, a number of chemicals have been withdrawn from the market upon report of health hazards. After hot water treatment is easy and effective for farmers, and safe for human. Hot water treatment maintains firmness, inhibits ripening and reduces weight loss, decay, and mold growth of fruits (Suparlan *et al.*, 2003). Proper temperature and immersion period should consider to improve quality and shelf life. Chemical changes especially TSS is very important for quality and storage. With these points in view, the present experiment was undertaken to find out effects of hot water treatment and time of immersion period on TSS of banana for best storage.

MATERIALS AND METHODS

Banana fruits were harvested and transported carefully from field to lab. Banana fingers were separated from brunches, graded according to size and

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sort out injured, disease/insects symptoms fingers. The experiment comprised three factors as follow: Factor A: Hot water (T_1=Control, T_2=Fruits treated with hot water at 45°C, T_3= Fruits treated with hot water at 50°C, T_4= Fruits treated with hot water at 55°C) Factor B: Time of immersion period (I_1= 5 minutes and I_2=10 minutes) Factor C: Varieties (V_1=Mehersagar and V_2=Sabri). According to the treatment, randomly selected banana fingers from both verities were separately immersed into hot water (45°C, 5 0°C and 55°C) for five and ten minutes respectively. Immersion time was counted when water bath indicate constant temperature. Before placing them on the brown paper placed on the table in the laboratory at ambient atmospheric conditions. For hot water treatment, a hot water bath was used. Total soluble solids (TSS) content of banana fruit pulp was estimated by using Abbe's refractometer. A drop of banana juice squeezed with cloth from the fruit pulp on the prism of the refractometer at three day intervals. Percent TSS was obtained from direct reading of the instrument. Temperature corrections were made by using the methods described by Ranganna (1979).

RESULTS AND DISCUSSION

Main effect of hot water treatments, times of immersion & variety.

Main effect of hot water treatments on percent total soluble solid (TSS) was significant during the storage which was similar to Oluwafemi *et al.*, (2016) findings. Hot water treatment resulted in lower total soluble solids (TSS) compared to control that was similar to Anwar, (2007) findings. Total soluble solids was increased rapidly in control up to 9th days and it damaged due to high respiration of fruits (Singh *et al*., 2009). On the other hand among the treated treatments maximum TSS showed in T_4

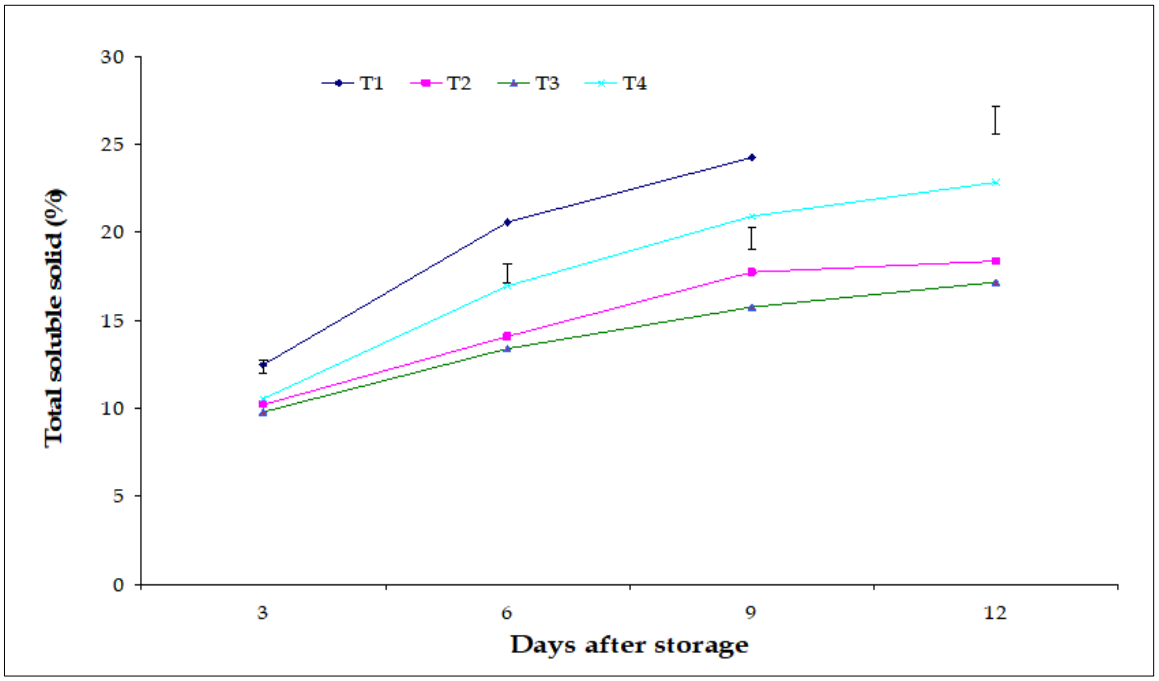

Figure 1: Main effect of hot water treatment on percent total soluble solids (TSS) of banana. The vertical bars represents LSD at 1 % level of significance.

Main effect of times of immersion on percent total soluble solids (TSS) was significant during storage. Five minutes immersed fruits showed maximum total soluble solid (TSS) than ten minutes during the storage. In case of I_1 total soluble solids increase sharply first nine days but after nine days TSS increase in a stable form. (Fig. 2). Longer immersion period had significantly effects and less increase TSS of the bananas than shorter immersion period. In case of mango, Anwar & Malik (2007) found similar result that prolonged immersion prevent decay and not consistently improves TSS.

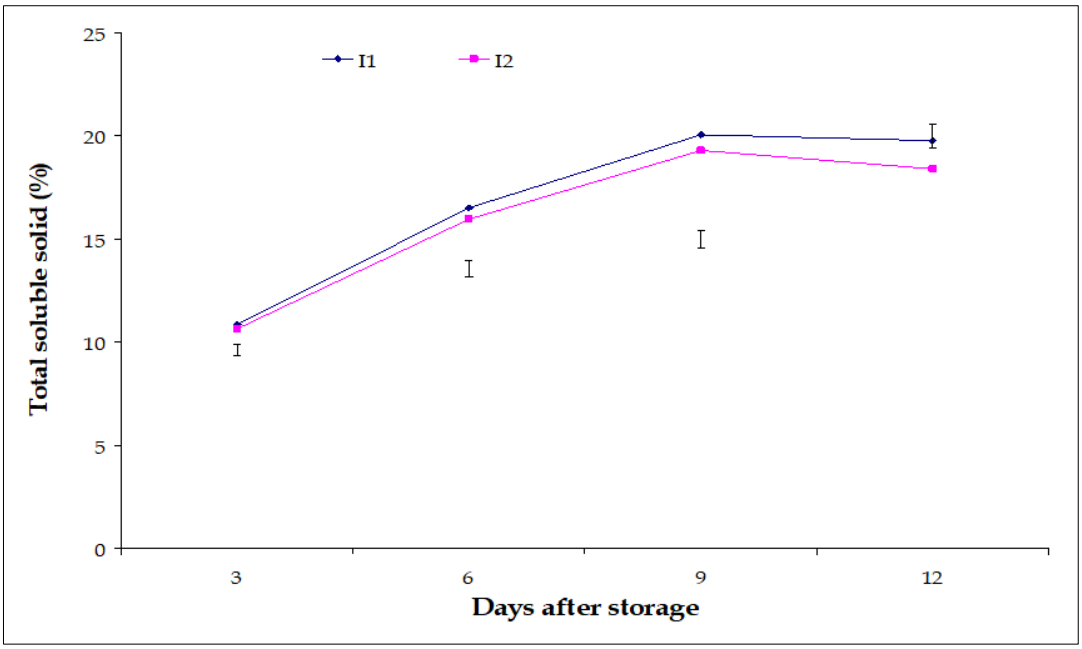

Figure 2: Main effect of times of immersion on percent total soluble solid (TSS) of banana. The vertical bar represents LSD at 1 % level of significance

Main Effect of variety on percent total soluble solids (TSS) of banana showed significant during storage. Higher amount of total soluble solid was recorded in Mehersagar variety than Sabri during storage (Figure 3). Mehersagar is naturally quick ripening variety it is another reason for higher TSS. Hibler and Hardey (1994) also found similar results in their research which support our findings.

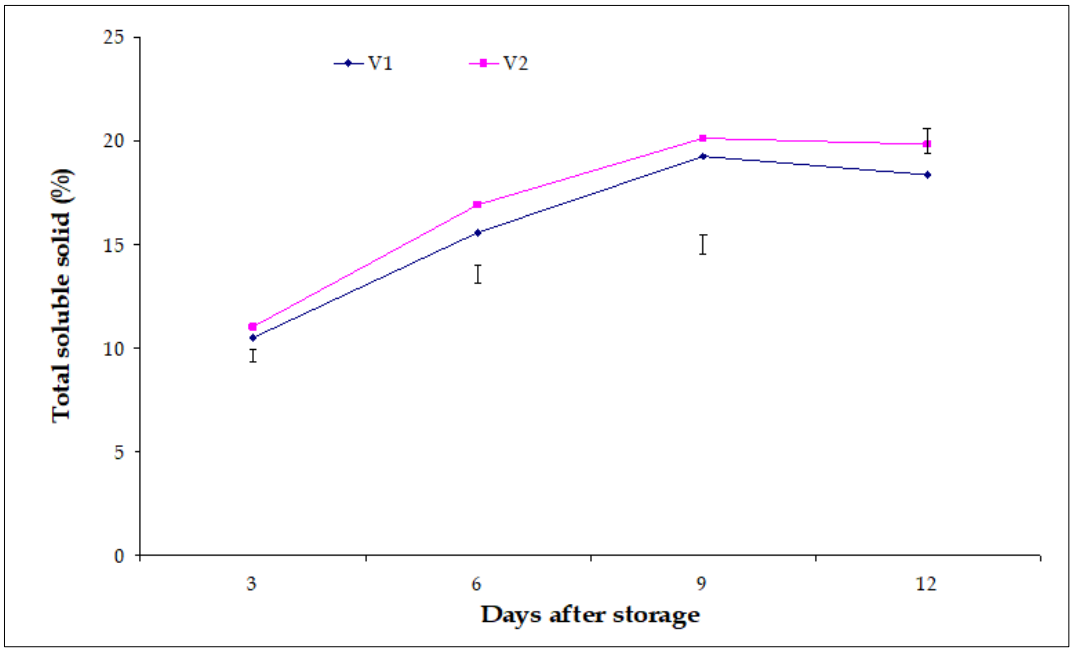

Figure 3: Effects of varieties on percent total soluble solids (TSS) of banana. The vertical bars represents LSD at 1 % level of significance

Combined Effects between Two Factors

Combined effect of hot water treatments and times of immersion on percent total soluble solid (TSS) showed significant result (Table 1). TSS of all treatments increase day after storage period. Long immersion period showed less TSS than short immersion period. Except control, the maximum TSS (23.11%) was found in five minutes immersion at 55°C hot water and minimum total soluble solids (17.14%) was recorded in five minutes immersion at 50°C hot water at 12th day after storage (Table 1).

Table 1: Combined effects of hot water treatments and times of immersion on percent total soluble solids (TSS) of banana

Treatment combination	% Total soluble solid (TSS) at DAS			
	3	6	9	12
T_1I_1	12.57	20.70	24.44	-
T_1I_2	12.37	20.44	24.10	-
T_2I_1	10.27	14.44	18.10	19.05
T_2I_2	10.16	13.74	17.40	17.70
T_3I_1	10.07	13.54	16.24	17.19
T_3I_2	9.55	13.24	15.27	17.14
T_4I_1	10.60	17.40	21.43	23.11
T_4I_2	10.54	16.47	20.44	22.37
$LSD_{0.05}$	0.053	0.075	0.084	0.113
$LSD_{0.01}$	0.071	0.100	0.112	0.150
Level of significance	**	**	**	**

**Significant at 1% level of probability, T_1: control; T_2: Fruits treated with hot water at 45°C T_3: Fruits treated with hot water at 50°C; T_4: Fruits treated with hot water at 55°C; I_1: Five minutes immersion; I_2: Ten minutes immersion.

Combined effects of hot water treatments and varieties on percent total soluble solids (%) were highly significant and TSS gradually increased. All treated combination showed lower TSS than control in combined effect of hot water and verities. During 3th days of storage, the highest total soluble solid (12.99%) and lowest (9.56%) were observed in T_3V_1 and T_1V_2 respectively. At 12th days, TSS increased along with increased of water temperature but at 50^{0}C temperature both varieties showed lowest TSS.

Table 2: Combined effects of hot water treatments and varieties on percent total soluble solids (TSS) of banana

Treatment combination	% Total soluble solids (TSS) at DAS			
	3	6	9	12
T_1V_1	11.95	20.14	23.34	-
T_1V_2	12.99	21.00	25.20	-
T_2V_1	10.10	13.40	17.44	17.85
T_2V_2	10.32	14.77	18.07	18.89
T_3V_1	9.56	12.67	15.54	16.79
T_3V_2	10.06	14.10	15.97	17.54
T_4V_1	10.44	16.10	20.67	22.47
T_4V_2	10.70	17.77	21.20	23.06
$LSD_{0.05}$	0.053	0.075	0.084	0.113
$LSD_{0.01}$	0.071	0.100	0.112	0.150
Level of significance	**	**	**	**

**Significant at 1% level of probability

Percent total soluble solids showed significant results in combined effects of times of immersion and varieties. Non significant also found in 3rd day during storage. The five minutes immersed Sabri showed maximum (20.48%) total soluble solid and ten minutes immersed Mehersagar showed minimum (17.25%) total soluble solid (Table 3). The five minutes immersed banana showed maximum tss than ten minutes in both varieties.

Table 3: Combined effects of time of immersion and variety on percent total soluble solids (TSS) of banana

Treatment combination	% Total soluble solids (TSS) at DAS			
	3	6	9	12
I_1V_1	10.62	15.89	19.57	19.08
I_1V_2	11.13	17.14	20.53	20.48
I_2V_1	10.40	15.26	18.92	17.25
I_2V_2	10.90	16.68	19.68	19.18
$LSD_{0.05}$	0.037	0.053	0.059	0.079
$LSD_{0.01}$	0.501	0.708	0.792	1.063
Level of significance	NS	**	**	**

**Significant at 1% level of probability; V_1: Mehersagar; V_2: Sabri variety; I_1: Five minutes immersion; I_2: Ten minutes immersion

Combined Effects between Three Factors

The combined effects of hot water treatment, times of immersion, and varieties of percent total soluble solids were statistically significant during storage. In all treatment combination total soluble solids (TSS) was increased the day after storage. In all combinations, the V_1 variety showed lower TSS than V_2 variety on the final days of storage. Both varieties expressed higher TSS in five minutes of immersion at all treated temperatures. Maximum (25.20%) total soluble solids (TSS) was found in $T_1I_1V_2$ Treatment combination at 9th DAS and no sample of the control combination remained after the 9th day due to fungal infection.

On the other hand all treated combinations showed long storage period upto 12th days. The maximum (23.74%) and minimum (16.57%) total soluble solid were observed in $T_4I_1V_2$ and $T_3I_1V_1$ treatment at 12th day (Table 4). Similar trend of TSS during banana ripening is reported in literature (Salvador *et al*., 2007). In both varieties lowest TSS was observed in five minutes immersion at 50°C temperature than other treatments. Das *et al*., 2021 also found better physic-chemical characteristics at 50^0C for 5 min treated fruits than 55^0C for 5 min treated fruits at 12 days after storage.

Table 4: Combined effects of hot water treatments, times of immersion and varieties on percent total soluble solids (TSS) of banana

Treatment combination	% Total soluble solids (TSS) at DAS			
	3	6	9	12
$T_1I_1V_1$	12.03	20.37	23.67	-
$T_1I_1V_2$	13.10	21.03	25.20	-
$T_1I_2V_1$	11.87	19.90	23.00	-
$T_1I_2V_2$	12.87	20.97	25.19	-
$T_2I_1V_1$	10.13	13.60	17.60	18.20
$T_2I_1V_2$	10.40	15.27	18.60	19.89
$T_2I_2V_1$	10.07	13.20	17.27	17.50
$T_2I_2V_2$	10.27	14.27	17.53	17.89
$T_3I_1V_1$	9.83	12.87	15.87	16.57
$T_3I_1V_2$	10.27	14.20	16.60	17.27
$T_3I_2V_1$	9.27	12.47	15.20	17.00
$T_3I_2V_2$	9.83	14.00	15.33	17.81
$T_4I_1V_1$	10.47	16.73	21.13	22.47
$T_4I_1V_2$	10.73	18.07	21.73	23.74
$T_4I_2V_1$	10.40	15.47	20.20	-
$T_4I_2V_2$	10.67	17.47	20.67	22.37
$LSD_{0.05}$	0.075	0.106	0.118	0.158
$LSD_{0.01}$	0.100	0.141	0.158	0.212
Level of significance	*	**	**	**

**Significant at 1% level of probability, T_1: control; T_2: Fruits treated with hot water at 45°C; T_3: Fruits treated with hot water at 50°C; T_4: Fruits treated with hot water at 55°C; V_1: Mehersagar variety; V_2: Sabri variety; I_1: Five minutes immersion; I_2: Ten minutes immersion

CONCLUSION

Among the treatments, 50°C temperature & five minutes immersion period were showed lowest TSS in both banana varieties. Sabri variety showed higher TSS than Mehersagar variety. Control treatments always showed higher TSS than treated banana but no banana remained fresh at 9th days. Hot water treatment is better than untreated banana for storage and maintain quality of banana.

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