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Effects of neem leaf extract and hot water treatments on shelf life and quality of banana

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Abstract

A huge loss of banana occurs due to its shorter shelf life and inappropriate postharvest handling. There is a scarce of effective postharvest practices to combat this situation in Bangladesh. In this context, the current experiment was conducted to assess the effects of hot water (45°C for 2 or 5 minutes) and neem leaf extract (20% or 40%) on quality and shelf life of banana (cv. Sabri). The experiment was carried out in completely randomized design with three replications. Data on physico-chemical properties of banana were collected during storage in ambient conditions for two weeks. After two weeks of storage, the banana treated with 40% neem leaf extract showed longest shelf life (8.33 days), minimum change in color (score 4.88), minimum disease incidence (33.33%) and severity (score 2.23), lower reduction of titratable acidity (0.12%) and lower level of total soluble solid (6.90%). While the banana were treated with hot water at 45°C for 2 min, the treated banana also showed lower color change (score 4.53), longer shelf life (8.33 days), minimum loss of firmness (score 4.67), minimum change in vitamin C content (2.17mg/100g) and lower reduction in titratable acidity (0.11%). Among the combined treatments, the banana treated with the combination of hot water (at 45°C for 5 minutes)and 40% neem leaf extract also exhibited considerably longer shelf life (8.17 days), lower change in color (score 5.00), lower disease incidence (46.67%) and lower reduction in titratable acidity (0.15%). From the study it could be concluded that the fruit treated with 40% neem leaf extract retained the majority of the quality parameters for considerably longer period and thereby it could be recommended for practical use to ensure better and longer storage of banana (cv. Sabri).

Introduction

Banana (*Musa sp.*) is a popular fruit belonging to the family Musaceae is a high quality tropical fruit having high calorific and nutritional value (Habiba, 2012). Banana is produced in every tropical country (FAOSTAT, 2013) and widely consumed both as food and medicine (Kumar *et al*., 2012). It is an economically important fruit available throughout the year. Bangladesh produces 0.78 million tons of bananas from 0.12 million acres of land (BBS, 2016). However, Bangladesh losses a huge amount of money every year due to shorter shelf life of bananas (Almamun, 2014) and inappropriate postharvest handling (Islam, 2012; Basel *et al*., 2002).Molla *et al*. (2012) reported postharvest loss of banana in urban areas of Bangladesh at different levels of supply chain as growers (2.13%), *Beparies* (11.75%), *Arathdars* (7.25%), retailers (3.0%) and consumers (2.5%). According to Hassan (2010), postharvest loss of banana is 24.62% which accounts for 56.7 crore taka in Bangladesh.

It is necessary to treat the banana fruit for extending their shelf life in storage and during transportation. The use of synthetic chemicals for the reduction of postharvest losses and extension of shelf life of perishables is a threat to human health and environment (Habiba, 2012). In this regard, the fruit exporting countries apply hot water treatment to reduce pest or disease causing organism (Sivakumar and Falik, 2013; Theodosy and Kimaro, 2011). However, further efforts needed to optimize or develop suitable alternatives such as application of different plant extracts for reducing postharvest loss of banana and extend shelf life with retained quality (Habiba, 2012). Treatment with plant extracts as aloe vera, garlic, neem, onion etc. (Anjum *et al*., 2016) and hotwater (Thi-Nghiem *et al*., 2010) are popularly practiced abroad but rare use of plant extracts and hot water is noticed and very little research has been done on this issue in Bangladesh. For these reasons the current study has been designed to evaluate the effectiveness of hot water and plant extract on shelf life and postharvest quality of banana in ambient conditions.

Materials and Methods

Four bunches of the fresh mature banana (cv. Sabri) free from any kind of injury were harvested in the morning from farmers field in Noapara, Jessore, Bangladesh. The study was carried out in the ambient conditions.

Design of experiment and treatments: The experiment was conducted by following Completely Randomized Design (CRD) with three replications for the treatments having 10 banana fruits in each replication. The postharvest treatments used in the current study included

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as T_1 = Control, T_2 = Hot water (HW) at 45°C for 2 minute**,** T_3 = HW at 45°C for 5 minute, T_4 = 20% neem leaf extract (NLE)**,** T_5 = 40% neem leaf extract (NLE)**,** T_6 = HW at 45°C for 2 minute + 20% NLE**,** T_7 = HW at 45°C for 2 minute + 40% NLE**,** T_8 = HW at 45°C for 5 minute + 20% NLE**,** T_9 = HW at 45°C for 5 minute + 40% NLE. For hot water treatment, selected bananas were immersed into hot water (45°C) for 2 or 5 minutes before placing them to treat with 20% or 40% neem extract by spraying.

Fresh green leaves of neem (about 250g) were collected from Khulna University campus and blended with 500 ml of distilled water. Then 20% or 40% neem leaf extract solution was prepared by taking 60 ml or 120 ml raw neem leaf extract in 500 ml beaker with the addition of 240 ml or 180 ml distilled water separately to make a final volume of 300 ml (Mia, 2003). Finally the extracts solutions were filtered before use and stored in refrigerator at 5°C.

Data collection: During the storage period, the treated banana samples were observed everyday for physical changes, but chemical changes were measured at one day interval using standard procedures for two weeks.

Determination of Weight loss (%): Weight loss of fruit was calculated by following the formula of Enab (2013) as follows-

$$\text{Percent Weight Loss (WL)} = \frac{W - Fw}{IW} \times 100$$

Where, IW = Initial weight (g), FW = Final weight (g)

Changes in color and firmness: The changes of fruit peel color and firmness was determined on the basis of eye estimation by using a numerical scale of 1-7 for color (Dadzie and Orchard, 1997) where 1 = 100% green, 2 = 1-25% yellow, 3 = 26-50% yellow, 4 = 51-75% yellow, 5 = 76-100%, 6 = fully yellow, 7 = rotten and 1-5 for firmness (Dang et al., 2008) where 1 = Hard, 2 = Sprung, 3 = slightly soft, 4 = Eating soft and 5 = Over soft.

Disease incidence and severity: The percent of infected area on banana fruit was determined by visual observation and following a numerical scale of 1-5 for disease severity (Ullah, 2007). The percentage of disease infected banana is called disease incidence which was calculated by using the following equation as suggested by Ullah (2007).

$$\text{Disease Incidence} = \frac{\text{Number of infected banana}}{\text{Total number of banana}} \times 100$$

Shelf life: Shelf life of banana treated with different treatments was calculated by counting the number of days until the score for firmness and disease severity retains less than or equal to 3 and color score attains less than or equal to 5. The number of days for attaining a loss of 25% weight was also considered to calculate shelf life. The average of the days required to reach at the mentioned level of the considered parameters was recorded as the shelf life of fruits.

Total Soluble Solids (TSS) (% Brix) and Titratable acidity (TA): Total soluble solid of banana was estimated by using Abbe's refract meter (REF 10/111). A drop of banana juice squeezed from the banana was dropped on the prism of the refract meter. Percent of TSS was obtained as the direct reading from the instrument (Ranganna, 1979). Titratable acidity was determined by using the following formula (Khan and Singh, 2008).

$$\text{Malic acid (\%)} = \frac{0.0067 \times \text{Vol. of NaOH} \times 30 \times 100}{5 \times 10}$$

Here, 0.0067 = Milli-equivalent weight of malic acid, 30 = Total volume (ml), 5 = Extracted juice sample (ml), 10 = Volume of aliquot (ml)

Determination of vitamin C content: Vitamin C content in the sample was determined by the following formula as suggested by Majumdar and Majumder (2003).

$$\text{Vitamin C} = \frac{e \times d \times b}{c \times a} \times 100$$

Where, a = weight of sample, b = volume made with metaphosphoric acid, c = volume of aliquot taken for estimation, d = dye factor, e = average burette reading for sample

Determination of Reducing sugars (RS): Reducing sugar content was determined according to AOAC (2005) and the results were expressed in percentage.

$$\text{RS (\%)} = \frac{\text{Fehlings Factor (0.05)} \times \text{Volume of filtrate used} \times \text{Dilution made} \times 100}{\text{Dilution used} \times \text{Volume of juice}}$$

Microbial examination: Fruit samples from infected fruit were taken in different sterilized petridishes and examined under microscope to identify the casual organism (Pervin, 2016).

Statistical analysis: The collected data on various parameters were statistically analyzed by using Statistical Tool for Agricultural Research (STAR), Version 2.0.1 (IRRI, 2013). The means for all the treatments were calculated and analyses of variances (ANOVA) for all the parameters were performed by F-test. The significance of differences between the pairs of means was compared by least significance difference (LSD) at the 5% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Color change of banana

A significant ($P \leq 0.05$) rapid change in color of banana was observed from the current study (Fig. 1). The increase of color was 85.69%from 1 DAT (Days after Treatment) (score 1) to 12 DAT (score6.99). However, the increase in color change on 3 DAT was pretty sharp in T_1 than all other treatments. The acceptable color limit (1-5) was noticed in T_1 until 4 DAT while it remained4 days more in all other treatments. Lower color score was observed in T_2 (score 4.53), T_5 (score 4.88), T_8 (score 5) and T_9 (score 5) than T_1 (score 6.10) on 8 DAT. Abd El-Naby (2010) and Habiba (2012) also reported that hot water treatment and neem leaf extract delayed color development of banana fruit in storage period.

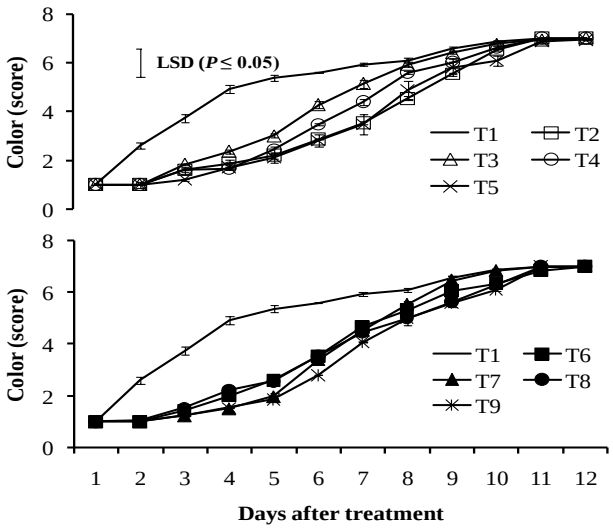

Fig. 1. Change in color of banana due to different postharvest treatment

Reduction of banana firmness

A clear rapid reduction (79.72%) in firmness was noticed for banana from 1 DAT to 12 DAT (Fig. 2). Highest reduction for firmness was observed in T_1 (from 1 to 5) which was pretty sharp than all other treatments on 6 DAT (3.73). The acceptable score for firmness (3.00) retained until 4 DAT in T_1 treated fruit but in all other treatment it retained for four more days than T1. Moreover, lowest reduction for firmness was noticed in T_2 (hot water at 45°C for 2 min) treated fruit (score4.67) which showed 1.07-part lower reduction than T_1 (score 5) at 12 DAT. Hot water treatment delayed the ripening of mature banana fruit as reported by Abd El-Naby (2010) and Mimi (2013). These findings support the finding of the current study.

Weight loss of banana

A higher rate of cumulative weight loss (97.75%) was observed during storage period from 1 DAT to 12 DAT (Fig. 3). The acceptable weight loss limit (1-25%) was crossed in T_1 and T_3 treated fruits (31.33% and 32.49% respectively) on 6 DAT than all other treatments. On 12 DAT, the highest weight loss was recorded in T_1 (43.18%) but it was low (33.02%) while neem leaf extract (20%) (T_4) was used. The findings of Habiba (2012) exhibited that neem extract is effective for reduction of weight loss of bananas which supports the findings of the current study.

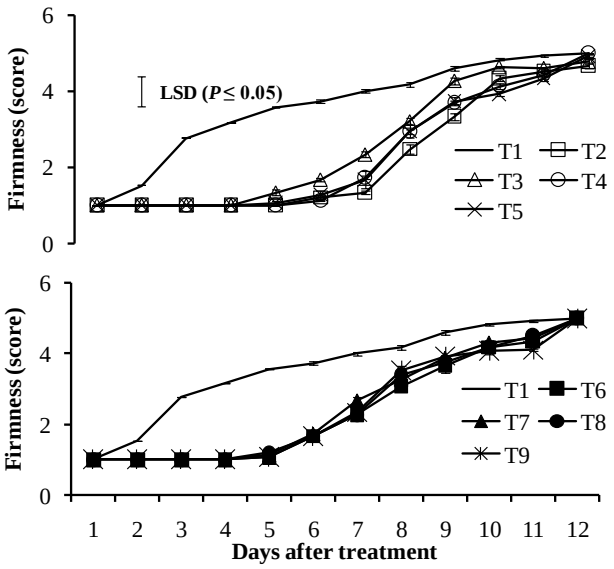

Fig. 2. Change in firmness of banana treated by postharvest treatment

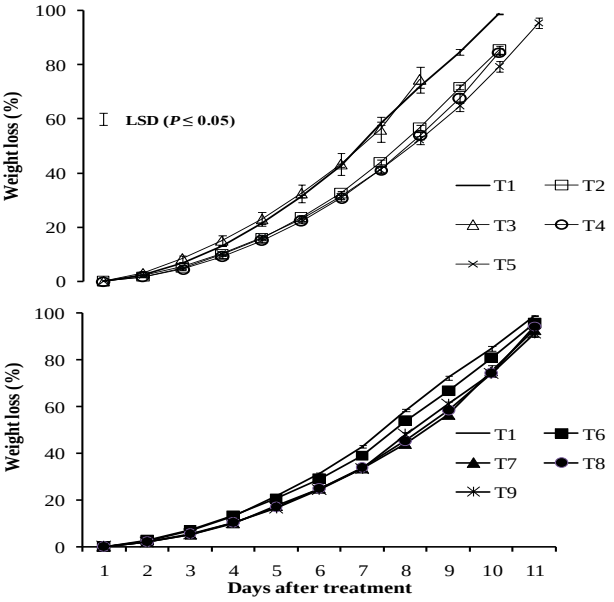

Fig. 3. Change in weight of banana due to postharvest treatment

Disease incidence in banana

The postharvest treatments in this study showed significant variations in respect of percent disease incidence at storage period of banana (Fig. 4). The increase of disease incidence was 88.26% from 1 DAT to 12 DAT. Acceptable limit of disease incidence (1-50%) was crossed in T_1 treated fruit (53.33%) on 5 DAT while it retained 4 days more in T_5. The disease incidence rate in T_5, T_6 and T_9 was 33.33%, 40.00% and

46.67% respectively while it was 73.33% in control at 9 DAT. Anthracnose (*Colletotrichum musae*) disease was found from the test of infected banana. Neem (*Azadirachta indica*) extract has good capacity in controlling various postharvest diseases of fruits (Brahmachari, 2004 and Bagwan, 2001) which supports the findings of current study.

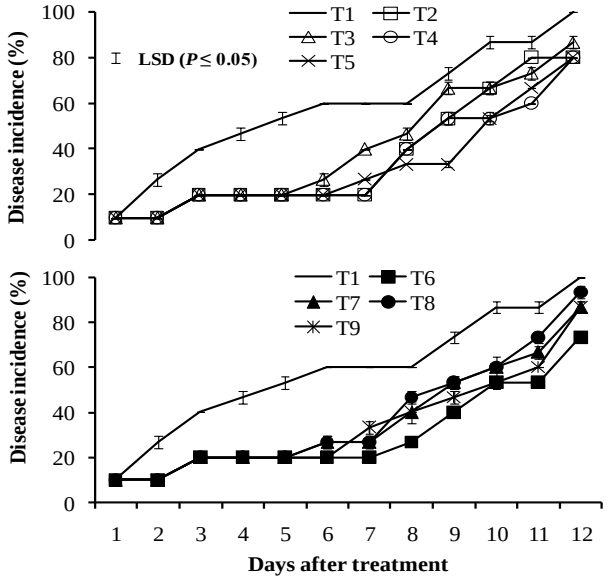

Fig. 4. Percent disease incidence of banana in different treatment group

Disease severity of banana

The disease severity score increased (77.87%) from 1 DAT to 12 DAT (Fig. 5). Acceptable disease severity score (1-3) was noticed in T_1 treated fruit until 5 DAT while T_5 and T_6 treated fruit remained in this limit for 5 more days. Lowest disease severity score (2.23) was observed in T_5 and T_6 which was 0.57-part less than T_1 (3.93) at 9 DAT. Obilo *et al.* (2005) observed highest percentage (36.3%) of inhibition of fungi by applying neem extracts which supports the current study.

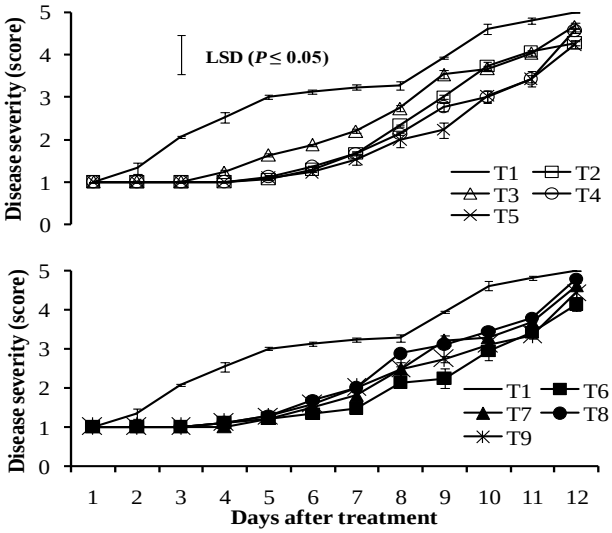

Fig. 5. Percent disease severity of banana in different treatment group

Shelf life of banana

Significantly longest shelf life was showed by T_2 and T_5 treated fruit (8.33 days) and shortest by control fruits (4.33 days). A considerable extension of shelf life (8.17 days) was also observed in T_6 and T_9 treated fruit (Fig. 6). According to Almamun (2014), plant extracts and hot water treatment and their combination show significant result but neem leaf extract extend the shelf life of banana (16.25 day) mostly in comparison to other plant extracts.

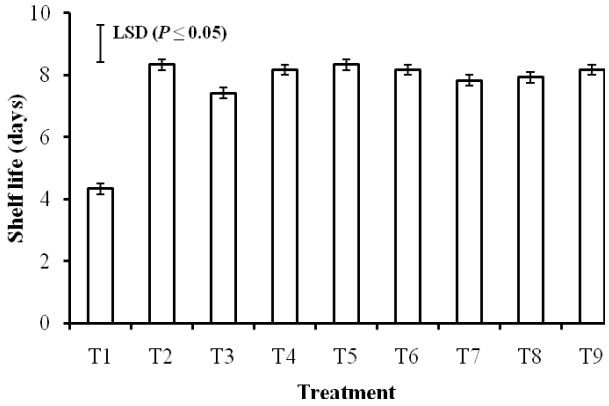

Fig. 6. Influence of postharvest treatments on shelf life of banana

Vitamin C content in banana

A higher rate of reduction in vitamin C content was observed from the study (Fig. 7). Significant reduction (38.89%) of vitamin C content was observed during the storage period from 3 DAT (2.16 mg/100g) to 13 DAT (1.32 mg/100g). Higher reduction (63.54%) in vitamin C content was noticed in case of T_1 (1.20 mg/100g) and lowest reduction (57.45%) in T_2 treated fruit (2.17 mg/100g) when averaged over DAT. Significant interaction ($P \leq 0.05$) was recorded between the treatments (T) and days after treatments (DAT) with the lowest reduction in vitamin C content on 13 DAT for T_2 (1.8-fold than T_1). Vitamin C content significantly decreased with increasing the storage duration in hot water treated lime fruits as reported by Obeed and Harhash (2006) which supports the findings from the current study.

Titratable acidity (TA) in banana

Titratable acidity decreased with the postharvest treatment in storage period (Fig. 8). About 41.67% reduction in titratable acidity was observed from 3 DAT (0.12) to 13 DAT (0.07). Lower reduction of titratable acidity was recorded in T_2, T_3, T_5 and T_6 (0.11%, 0.10%, 0.12% and 0.15% respectively) where T6 showed 0.08-fold higher acidity than T_1 (0.07%) at 11 DAT. Similarly, Rashid (2013) found highest titratable acidity in neem extract + perforated polythene treated banana fruits at 12 day of storage.

Total soluble solids (TSS) in banana

Different postharvest treatments used in the study significantly influenced the TSS during storage period

(Fig. 9).After two weeks of storage the lowest TSS was noticed in T_4 (7.24% Brix) and T_5 (6.90% Brix)treated banana fruits where T_5 treated fruit showed 0.77-part lower TSS than T_1 (9.00% Brix). However, the treatment T_2, T_3 and T_9 showed highest TSS content (10.95%, 10.20% and 11.46% Brix respectively) than T_1 (9.00% Brix). Similar result was observed by Habiba (2012) who reported that the lowest TSS (10.82%) retains in neem treated banana fruits than control (23.48%) during storage.

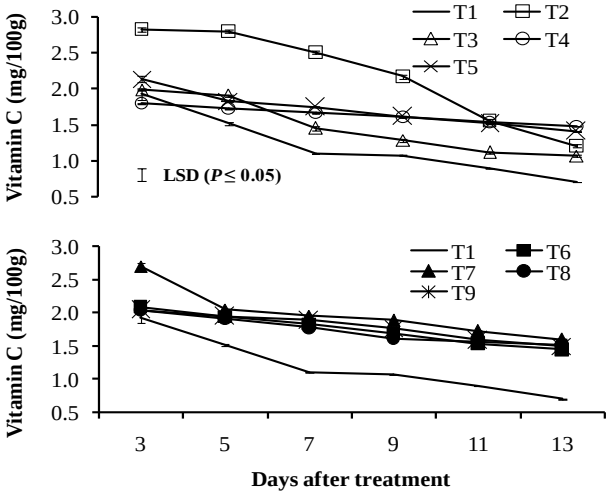

Fig. 7. Change in vitamin C content of banana

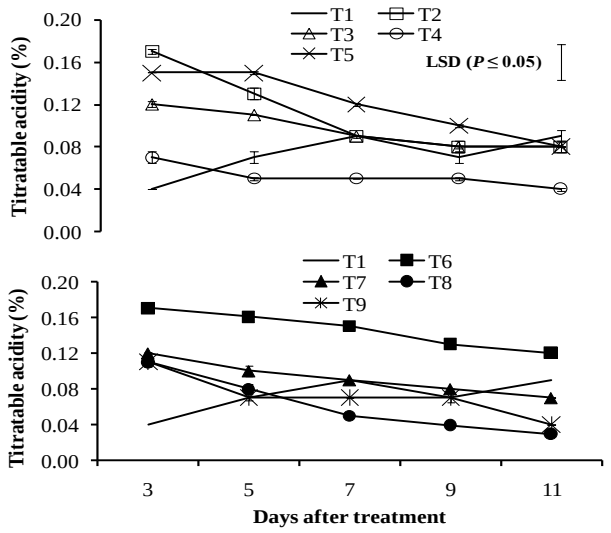

Fig. 8. Change in titratable acidity of banana

Content of reducing sugar in banana

Reducing sugar content of banana pulps increased in this study with the progress of time during storage period (Fig. 10). The highest content of reducing sugar was observed in T_2, T_8 and T_6 (11.16%, 11.56% and 11.69% respectively) and the lowest in T_1 (6.31%) at 13 DAT. The highest reducing sugar content showed by T_6 (11.69%) which was 1.85-fold higher than the T_1 (6.31%) after two weeks of storage. However, Almamun (2014) observed higher reducing sugar content in control than hot water treated banana fruits at storage period. The finding of the current study is supported by Habiba (2012) who reported increased level of sugar in banana fruits treated with neem extract in comparison to control during postharvest period.

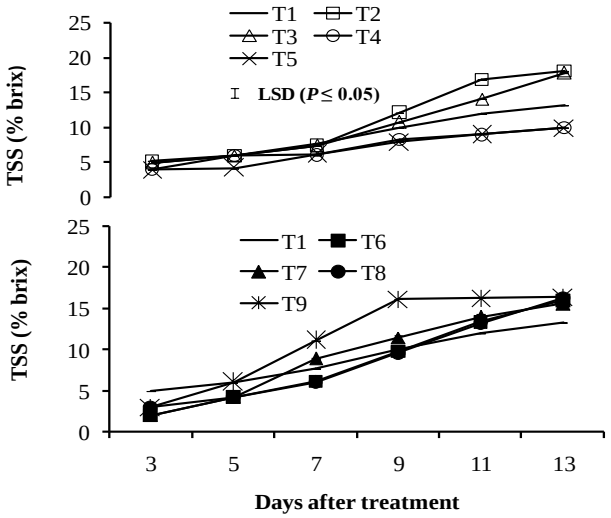

Fig. 9. Change in TSS in banana treated with postharvest treatment

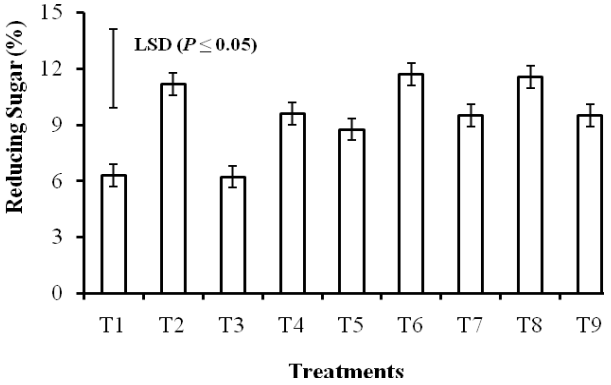

Fig. 10. Influence of postharvest treatments on reducing sugar content of banana

Conclusion

Postharvest treatments showed significant effect on the physico-chemical parameters after two weeks of storage where T_5 recorded highest desired result for the color change (3.65), TSS (6.90% Brix), TA (0.12%) than all other treatments. Microbial infection or disease incidence was lowest in T_5 (33.33%) in comparison to control (73.33%) at 9 DAT. Moreover, the lowest disease severity score (2.23) was observed in T_5 than T_1 (3.93) at 9 DAT.

Though all postharvest treatments showed effectiveness for the shelf life of banana, the T_5 showed longer shelf life (8.33 days) than control (4.33 days) during storage period. From the current experiment it could be inferred that postharvest treatments with 40% neem leaf extract (T_5) significantly influence the physico-chemical, disease incidence, disease severity and shelf life of

banana in ambient conditions. Therefore, the postharvest treatment of banana with 40% neem leaf extract (T_5) could be recommended as a suitable postharvest treatment in maintaining most of the postharvest qualities and extending shelf life of banana during storage in ambient conditions.

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