EFFECT OF MODIFIED AND ACTIVE PACKAGING ON SHELF LIFE AND QUALITY OF BANANA CV. GRAND NAINE

TAPAS SARKAR¹, SAYAN SAU¹*, VEENA JOSHI², TANMOY SARKAR¹ AND SUKAMAL SARKAR¹
¹Department of Fruits and Orchard Management, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal - 741 252, INDIA
²Department of Fruits and Orchard Management, College of Horticulture, Dr. Y.S.R Horticultural University - 500 030 (Hyderabad)
³Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal - 741 252, INDIA
e-mail: sayan.bckv@yahoo.com

INTRODUCTION
Banana (Musa sp.), the “Poor man’s apple” is grown throughout the tropics, subtropics and plays a key role in the economy of developing countries (Mulagund et al., 2015) for its higher production potentiality from unit area in a short period of time. Banana fruit is a good source of vitamin A, C, B1, B2 and minerals like, magnesium, sodium, potassium, phosphorus and a fair source of calcium and iron. The sugar rich and low fat bananas have diverse uses as infant food, functional food, dessert and carbohydrate based staple foods (Mohapatra, 2009). India is the largest producer of banana (Musa sp.) in the world with a production of 28.45 million tonne from an area of 802.6 thousand ha and productivity of 37 mt/ha (NHB, 2015). Maximum production and productivity of banana acquired from Southern states in India due to presence of favourable climatic conditions (Kumbargire et al., 2016). Out of large number of varieties grown in India, due to introduction of high yielding varieties like Grand Naine, the area of indigenous cultivar shrivelled to a great extent (Bhalerao et al., 2011) and makes this new cultivar popular and dominant one for domestic and export trade in India. Besides the increasing production, major constraints and problems associated with post harvest handling of fresh banana are short shelf life under tropical climate (6–10 days) and lack of appropriate post harvest technologies for storage (Anon, 2007). Banana is a climacteric fruit with typical ethylene dependent ripening for which the shelf life of the banana deteriorates as soon as the climacteric peak is reached. Unlike many other fruits, banana is not a seasonal fruit in nature and is available in fairly large quantities throughout the year and records a post harvest losses as high as 30-40% (Patil and Hulmani, 1998). The benefits of increased production will not be realized unless it is duly accompanied by advanced storage, packaging and transport techniques. So, there is a need to find appropriate storage method to extend the storage life of banana to maintain the fruit quality for long distance transportation for domestic and export markets. Modified atmosphere packaging (MAP) is one of the potential preservation techniques (Mangaraj and Goswami, 2009) and is known to have great potentiality to extending the post harvest life of fruits and vegetables (Thompson, 1998). In recent time, as an innovative concept ‘Active Packaging’ is exceedingly accepted by food industry in which the package, the product, and the environment interact to prolong shelf life or enhance safety or sensory properties, while maintaining the quality of the product (Bhat, 2013). Components included in active packaging are capable of scavenging oxygen, absorbing carbon dioxide, ethylene and moisture and also remove unpleasant flavour. Active packaging perform traditional functions of packaging such as providing barriers to gases, moisture and vapour, preventing product contamination from

KEYWORDS
Active packaging
Banana
Ethylene absorbent
Fruit quality
Shelf-life

ABSTRACT
The present experiment was conducted at Post Harvest Laboratory, College of Horticulture, Dr. Y.S.R Horticultural University, Hyderabad during the year 2014 and 2015 with banana cv. Grand Naine where fruits were subjected to nine different treatments [T₁: Low density poly Ethylene (LDPE) film 150 gauge; T₂: LDPE + Ethylene Scrubber (K₂MnO₄) 5g Sachet; T₃: LDPE + Humidity scrubber (silica gel) 2g sachet; T₄: LDPE + Ethylene Scrubber (K₂MnO₄) 5g Sachet + Humidity scrubber (silica gel) 2g sachet; T₅: Poly propylene (PP) film 150 gauge; T₆: PP + Ethylene Scrubber (K₂MnO₄) 5g Sachet; T₇: PP + Humidity scrubber (silica gel) 2 g sachet; T₈: PP + Ethylene Scrubber (K₂MnO₄) 5g Sachet + Humidity scrubber (silica gel) 2 g sachet and T₉: Control (Fruits kept in open air)], each replicated thrice. All the fruits kept in different active packaging system delayed colour, texture, pulp to peel ratio and total soluble solids (TSS) content as compared to openly kept control banana. But, fruits packed with (LDPE + K₂MnO₄) recorded significantly lowest PLW (1.11 %) by maintaining significant amount of TSS (17.03 °B), sugars (reducing, non reducing and total) in longest storage observation (on day 24) with a maximum shelf life up to 26.05 days compared to 9 days only for untreated fruits.
outside, and making food handling and identification easy (De Kruijf et al., 2002). Thus, with an objective of curtailing post-harvest losses and extending availability of the fruit, an attempt was made in this experiment to evaluate the effectiveness of modified and active packaging system on fruit quality attributes and shelf-life extension of unripe green ‘Grand Naine’ banana fruits under ambient condition.

MATERIALS AND METHODS
Sample preparation, experimental design and treatments
The present experiment on active packaging of banana cv. Grand Naine was carried out for two consecutive seasons of 2014-15. Mature banana fruits were obtained from farmers field located at Peddapur village of Medak district in Telangana, wherein pre-harvest spray schedules for effective control of major pests and diseases were strictly followed during fruit development and maturation up to the harvest of fruits. The fruit used for experiment were harvested after 110–115 days of inflorescence emergence. Selected fruits were then delatedexed, water washed, sorted and graded by size, colour and weight. The individual hands were surface disinfected with Benomyl fungicide solution (1,000 ppm) for 5 min and dried under shade. The hands were randomly divided into different treatment groups. Each treatment group consisted of five uniform hands (15 to 18 fingers per hand). The experiment was designed in completely randomized design (CRD) at Post Harvest laboratory, College of Horticulture, DR. Y.S.R Horticultural University, Rajendranagar, Hyderabad, during the year 2014 and 2015 with following nine treatments [T1: Low density poly Ethylene (LDPE) film 150 gauge; T2: LDPE + Ethylene Scrubber (Kmno4) 5g Sachet; T3: LDPE + Humidity scrubber (silica gel) 2g sachet; T4: LDPE + Ethylene Scrubber (Kmno4) 5g Sachet + Humidity scrubber (silica gel) 2g sachet; T5: Poly propylene (PP) film 150 gauge; T6: PP + Ethylene Scrubber (Kmno4) 5g Sachet; T7: PP + Humidity scrubber (silica gel) 2 g sachet; T8: PP + Ethylene Scrubber (Kmno4) 5g Sachet + Humidity scrubber (silica gel) 2 g sachet and T9: Control (Fruits kept in open air)] replicated thrice. Ethylene was determined with ATAGO, RX 5000, Tokyo, Japan and expressed as °Brix. Titrable acidity were determined by titrating 5 mL of juice against 0.1 N NaOH and expressed as % value. Total sugars, reducing sugars and non-reducing sugars were determined according to the method explained by Khan et al. (2009) and were expressed as %.

Statistical analysis
The collected data were analyzed statistically by the analysis of variance (ANOVA) technique using the SAS 9.3 version (SAS Institute Inc., 2011). The ANOVA of different quality parameters of banana across the years revealed a non-significant variation within the years as well as year × quality parameters interactions at p ≤ 0.05. The homogeneity of error variance was tested using Bartlett’s ‘chi-square’ test. As the error variance was homogeneous, pooled analysis was done. For comparison of ‘F’ values and computation of critical difference (CD) at 5% level of significance, Fisher and Yates’ table were consulted.

RESULTS AND DISCUSSION
Physiological loss in weight (%)
The data on physiological loss in weight (PLW) as significantly influenced by various treatments and is presented in Table 1. PLW in banana fruit packed following active packaging methods was lower compared to unwrapped and openly kept control fruits (Table 1). It is evident from the Table 1 that during the storage period of 3rd, 6th, 9th and 12 day lowest PLW was recorded in T1 (0.06, 0.13 and 0.18 and 0.41 %) followed by T4 (0.08, 0.16, 0.23 and 0.50 %) while highest PLW was recorded in T9 i.e
colour control (8.53, 14.94, 18.17 % and nil). The reduction in PLW among treated green banana could be due to the selective permeability characteristics of LDPE packaging films against water vapour (Kudachikar et al., 2011) and efficacy of KMnO4 as an ethylene scrubber to prevent injury from high levels of CO2 or depletion of O2 (Borkar et al., 2008). A similar trend in changes of PLW in banana treated with active...
**Table 1: Effect of active packaging methods on pulp to peel ratio and spoilage (%) of banana cv. Grand Naine**

| Treatments | PLW % | 3rd day | 6th day | 9th day | 12th day | 15th day | 18th day | 21st day | 24th day | Fruit firmness (kg/cm²) | 3rd day | 6th day | 9th day | 12th day | 15th day | 18th day | 21st day | 24th day |
|------------|-------|--------|--------|--------|----------|----------|----------|----------|----------|------------------------|--------|--------|--------|----------|----------|----------|----------|----------|----------|
| T1        | 1.61  | 2.14   | 2.62   | 3.14   | *        | *        | *        | 0        | 5.11     | 12.84     | 49.05   | 73.35   | *        | *        |
| T2        | 1.32  | 1.37   | 1.42   | 1.54   | 2.00     | 2.21     | 2.45     | 2.70     | 0        | 0        | 4.12     | 11.02   | 23.00   | 45.00   |
| T3        | 1.58  | 1.75   | 1.92   | 2.15   | 2.82     | 3.12     | *        | 0        | 5.01     | 12.55     | 26.00   | 49.05   | 71.00   |
| T4        | 1.41  | 1.67   | 1.75   | 1.90   | 2.12     | 2.30     | 2.60     | 0        | 0        | 5.10     | 12.00   | 27.05   | 48.50   | 74.00   |
| T5        | 1.73  | 2.16   | 2.67   | 3.15   | *        | *        | *        | 0        | 4.11     | 12.85     | 49.95   | 74.05   | *        | *        |
| T6        | 1.35  | 1.42   | 1.54   | 1.82   | 2.02     | 2.27     | 2.50     | 2.90     | 0        | 0        | 5.35     | 13.05   | 28.00   | 48.00   |
| T7        | 1.63  | 1.77   | 1.97   | 2.20   | 2.87     | 3.17     | *        | 0        | 5.10     | 12.56     | 27.02   | 50.00   | 76.00   |
| T8        | 1.41  | 1.72   | 1.83   | 1.92   | 2.17     | 2.32     | 2.68     | 0        | 0        | 5.03     | 12.55   | 27.50   | 50.00   | 76.00   |
| T9        | 1.94  | 2.25   | 3.08   | *        | *        | *        | *        | 0        | 5.35     | 27.38     | 47.56   | 76.02   | *        | *        |
| S.Em ±    | 0.08  | 0.01   | 0.02   | 0.05   | 0.01     | 0.01     | 0.02     | 0.05     | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     |
| CD @ 0.05%| 0.02  | 0.04   | 0.08   | 0.01   | 0.07     | 0.05     | 0.02     | NS       | 0.15     | 0.07      | 0.08     | 0.06     | 0.03     | NS       |

1. PLW - polymer layer width. 2. NS - not significant. 3. * denotes differences from previous date within the same storage period. 4. All treatments were compared using Tukey’s Honestly Significant Difference (HSD) test. 5. Asterisks (*) denote differences from previous day within the same storage period.

**Table 2: Effect of active packaging methods on pulp to peel ratio and spoilage (%) of banana cv. Grand Naine**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Pulp to peel ratio (%)</th>
<th>3rd day</th>
<th>6th day</th>
<th>9th day</th>
<th>12th day</th>
<th>15th day</th>
<th>18th day</th>
<th>21st day</th>
<th>24th day</th>
<th>12th day</th>
<th>15th day</th>
<th>18th day</th>
<th>21st day</th>
<th>24th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.008</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>T2</td>
<td>0.08</td>
<td>0.16</td>
<td>0.23</td>
<td>0.50</td>
<td>0.65</td>
<td>0.98</td>
<td>1.16</td>
<td>1.30</td>
<td>5.25</td>
<td>5.05</td>
<td>4.67</td>
<td>4.05</td>
<td>3.45</td>
<td>2.76</td>
</tr>
<tr>
<td>T3</td>
<td>0.08</td>
<td>0.18</td>
<td>0.27</td>
<td>0.39</td>
<td>0.80</td>
<td>1.15</td>
<td>1.32</td>
<td>*</td>
<td>5.06</td>
<td>4.65</td>
<td>3.61</td>
<td>3.00</td>
<td>2.46</td>
<td>1.32</td>
</tr>
<tr>
<td>T4</td>
<td>0.08</td>
<td>0.13</td>
<td>0.23</td>
<td>0.34</td>
<td>0.57</td>
<td>0.79</td>
<td>1.16</td>
<td>1.39</td>
<td>*</td>
<td>5.11</td>
<td>4.70</td>
<td>3.60</td>
<td>3.35</td>
<td>2.51</td>
</tr>
<tr>
<td>T5</td>
<td>0.85</td>
<td>14.94</td>
<td>18.17</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>3.50</td>
<td>1.95</td>
<td>0.87</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

1. PLW - polymer layer width. 2. NS - not significant. 3. * denotes differences from previous day within the same storage period. 4. All treatments were compared using Tukey’s Honestly Significant Difference (HSD) test. 5. Asterisks (*) denote differences from previous day within the same storage period.

**Packaging practices**

Packaging practices was also reported by Kudachikar et al. (2007).

**Fruit firmness**

A significant variation in fruit firmness of banana was observed that received different post-harvest treatments (Table 1). The result showed reduction in fruit firmness steadily over the period of storage. Fruits kept in perforated polyethylene bag along with KMnO4 treatment (T2) remained the most firm (4.73 kg/cm²) followed by fruits packed in Polypropylene + KMnO4 (T1), while minimum value (0.87 kg/cm²) of firmness recorded for control fruits at 9th day of storage. The steady reduction in fruit firmness during the storage period is a complex natural process of ripening of almost all fleshy fruits as a result of biochemical changes of the cellular structure (Dharmasena and Kumari, 2005). With advance in ripening, the cell walls broken, reduction in the cohesion of the middle lamella due to the solubilization of the pectic substance (Smith et al., 1989) all of which result in softening of the fruits. Accordingly, the variation observed in fruit firmness in this study could be attributed to the direct and indirect effects of the treatments on the rate of respiration and ripening. The effect of polyethylene or polypropylene bag in delaying loss of firmness compared to the open air could be due to modified atmospheric created by using these packaging materials that reduced the rate of respiration and retarded tissue break down during slow ripening (Kotecha and Babasaheb, 1995). The effects of Polyethylene and KMnO4 on fruit firmness coincide with the results obtained by Jobling (2000) and Shashirekha et al. (2007). The delay in firmness of fruit stored in polyethylene bag in combination with ethylene absorber KMnO4 may be due to reaction of KMnO4 with ethylene which produces carbon dioxide and water, thus limiting the role of ethylene on ripening (Jobling, 2000).

**Pulp to peel ratio**

There was significant ($P \leq 0.05$) variation in pulp to peel ratio of the banana fruits subjected to different postharvest treatments throughout the storage period (Table 2). Gradual increase of this ratio was recorded for banana treated with T1 (LDPE + KMnO4) and T9 (PP + KMnO4) up to 24th day of storage but at 12th day of storage maximum value (3.15 and 3.14) of this ratio was showed by fruits kept in Polypropylene (T2) followed by LDPE (T1) films, respectively. For untreated fruits a steady uplift of pulp to peel ratio from 1.94 to 3.08 recorded during 3rd and 9th day; but during same period of storage lowest increment of (1.32 to 1.42) recorded in T1. Our results are in conformity of the results reported by Borkar et al. (2008) and Kudachikar et al. (2007) in active packaging of different varieties of banana. This sudden and slow rise in pulp to peel ratio in untreated and treated fruits could be due to osmotic transfer of moisture from peel to pulp at a faster and comparably.
Colour development

The colour change in banana peel during storage has shown significant difference among the treatments on each sampling date (Table 3). Initially, the banana fruits were greenish but subsequently they turned greenish yellow with green tips, uniform yellow, yellow with small spots and finally yellow with black spots during the storage. In this experiment, the control treatment showed a faster colour change on the second day of storage than other treated fruits. Late stage of storage marks the transition to final stage i.e. yellow with black spots.

Table 3: Effect of active packaging methods on shelf life and peel colour of banana cv. Grand Naine

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shell life (days)</th>
<th>Peel colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3rd day</td>
<td>6th day</td>
</tr>
<tr>
<td>T1</td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>T2</td>
<td>26.05</td>
<td>Green</td>
</tr>
</tbody>
</table>
| T3         | 19.08    | Green    | Green   | Greenish yellow   | Yellow with green tip | Greenish yellow | Yellow with small spots | Uniform yellow | Yellow with small spots | * | *
| T4         | 22.06    | Green    | Greenish yellow | Yellow with green tip | Yellow with small spots | * | * | * | *
| T5         | 12.00    | Green    | Greenish yellow | Yellow with green tip | Yellow with small spots | * | * | * | *
| T6         | 25.07    | Green    | Greenish yellow | Yellow with green tip | Yellow with small spots | * | * | * | *
| T7         | 18.00    | Green    | Greenish yellow | Yellow with green tip | Uniform yellow | Uniform yellow | Uniform yellow | Uniform yellow | Uniform yellow | *
| T8         | 21.00    | Green    | Greenish yellow | Yellow with green tip | Uniform yellow | Uniform yellow | Uniform yellow | Uniform yellow | Uniform yellow | *
| T9         | 9.00     | Greenish yellow | Yellow with green tip | Yellow with small spots | Yellow with black spot | * | * | * | *

Means ± S.E.M. of 3 replications. *CD at 0.05% 1.29

Figure 1 (A-C): Effect of active packaging methods on reducing sugar (%), non-reducing sugar (%) and total sugar (%) of banana cv. Grand Naine.
development of consumer’s preferred greenish yellow colour in fruit obtained from banana packed with T₆ (LDPE + KMnO₄) and T₇ (PP + KMnO₄) followed by T₅ (LDPE + KMnO₄ + Silica gel) on 15th and 12th day of storage, respectively. Good marketable colour for long period of time upto 21st day of storage also maintained in the above two treatments i.e. T₅ and T₆. Same pattern of peel colour development of banana in modified atmospheric storage reported by Zewter et al. (2012) and Salvador et al. (2006). Delay in colour development and retention of chlorophyll could be due to decreased metabolic processes responsible for chlorophyll pigments degradation and biosynthesis of carotenoids pigments in the peel portions of green banana treated with treatments LDPE/ PP, KMnO₄ and Silica gel, under elevated CO₂ levels due to active storage conditions (Kudachikar et al., 2011).

**Spoilage (%) and shelf life**

The data presented in Table 2 and 3 indicates the significant difference in percent spoilage and shelf life of banana fruits stored in different packaging materials. At 12th day storage untreated fruits attained 100% spoilage followed by T₁ (LDPE film) and T₂ (LDPE + KMnO₄) with 49.95% and 49.05% fruit spoilage respectively, while on the same day no fruits spoiled in T₅ (LDPE + KMnO₄) and T₆ (PP + KMnO₄). Minimum spoilage in banana even in storage of 24th day found in T₆ (45%) followed by T₅ (48%). In accordance with the above result for spoilage percent of fruit, extended shelf life of banana also observed in case of T₁ (26.05 days) which was statistically at par with T₃ (25.07 days) followed by T₄ (22.06 days) and T₅ (21.00 days).

Significant change in TSS and titratable acidity was observed in banana treated with different packaging materials and chemicals (Table 4). Fruits kept in open air showed a faster increment in their TSS content of 14.5 °Brix on day 3 to 18.18 °Brix on day 9 whereas banana treated with T₁ was slowest to reach the TSS peak (increment from 4.02 °Brix on day 3 to 22.10 °Brix on day 24) followed by T₆ (increment from 4.32 °Brix on day 3 to 20.10 °Brix on day 24). But, titratable acidity content decreased gradually with the passage of the storage period in all the treatments (Table 4). More rapid decline in acidity content observed in untreated fruits (declining from 0.73% on day 3 to 0.40% on day 9) whereas fruits treated with T₆ took longest time to reach minimum acidity (0.40% on day 24) followed by T₄ (0.44% on day 24).

The observed increment in TSS and rapid fall off acidity content of fruits placed in open air is an indication of high respiration rate and ripening thereby resulting in quality deterioration with the onset of senescence (Pal and Roy, 1988). On the other hand, delay in the increment of TSS and reduction of acidity content of fruits stored in LDPE or PP with KMnO₄ treatment could be due to slow down of ripening as a result of apparent delay in the onset of elevated ethylene evolution in respiration (Jiang et al., 1999). Moreover, active packaging may able to create such microenvironment inside the package with changed gaseous concentration that leads to result in marked reduction in rate of conversion of starch to sugars as compared to openly kept fruit control (Kudachikar et al., 2011).

**Reducing, Non-reducing and Total sugar content (%)**

During postharvest ripening of banana, the most striking postharvest chemical changes occur 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 different treatments involved in this investigation were also found to be highly significant in relation to reducing, non-reducing and total sugar content [Fig. 1 (A-C)]. All the three types of sugar (total, reducing and non-reducing) showed a gradual increment over the advancement of storage period. Minimum time (9th day) to reach the peak of increment for total and reducing sugar executed by untreated fruits with a lowest value of 14.46% and 8.96%, respectively. Maximum time (24th day) to attain the peak value of both total and reducing sugar were required by T₇ (17.62% and 12.00%, respectively).

---

**Table 4: Effect of active packaging methods on TSS (°B) and Acidity (%) of banana cv. Grand Naine**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>TSS (°B)</th>
<th>Acidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3rd day</td>
<td>6th day</td>
</tr>
<tr>
<td>T₁ (LDPE)</td>
<td>6.13</td>
<td>14.40</td>
</tr>
<tr>
<td>T₂ (LDPE + KMnO₄)</td>
<td>4.02</td>
<td>5.02</td>
</tr>
<tr>
<td>T₃ (LDPE + KMnO₄ + Silica gel)</td>
<td>6.03</td>
<td>7.12</td>
</tr>
<tr>
<td>T₄ (LDPE + KMnO₄ + Silica gel)</td>
<td>5.32</td>
<td>5.45</td>
</tr>
<tr>
<td>T₅ (PP + KMnO₄)</td>
<td>6.17</td>
<td>14.67</td>
</tr>
<tr>
<td>T₆ (PP + KMnO₄ + Silica gel)</td>
<td>4.32</td>
<td>5.12</td>
</tr>
<tr>
<td>T₇ (LDPE + KMnO₄)</td>
<td>6.12</td>
<td>7.22</td>
</tr>
<tr>
<td>T₈ (LDPE + KMnO₄ + Silica gel)</td>
<td>5.34</td>
<td>5.38</td>
</tr>
<tr>
<td>T₉ (Control)</td>
<td>14.50</td>
<td>20.13</td>
</tr>
</tbody>
</table>

T₁ – Low density poly Ethylene (LDPE) film 150 gauge, T₂ – LDPE + Ethylene Scrubber (KMnO₄) 5g sachet, T₃ – LDPE + Humidity scrubber (silica gel) 2 g sachet, T₄ – LDPE + Ethylene Scrubber (KMnO₄) 5g sachet + Humidity scrubber (silica gel) 2g sachet, T₅ – PP + Ethylene Scrubber (KMnO₄) 5g Sachet , T₆ – PP + Humidity scrubber (silica gel) 2g sachet, T₇ – PP + Ethylene Scrubber (KMnO₄) 5g Sachet + Humidity Scrubber (silica gel) 2g sachet, T₈ – Control (without any treatment); Asterisk marks (*) denotes the end of shelf life in that particular date.
and $T_6$ (16.50% and 11.50%, respectively). Similar trend of increment observed in non-reducing sugar also, but increment value was very less for all treatments as in case of untreated fruits, it was only 3.35% on day 3 to 5.50% on day 9. Highest value of non reducing sugar i.e. 5.66% obtained from banana treated with $T_6$ (on day 18) followed by $T_5$ (5.62% on day 24). Rapid increment in the total and reducing sugar contents of fruits stored in open air could be due to faster ripening process which converts starch into sugar, while the slower rate in the rest of the treatments could be due to the effects of the treatments in delaying the ripening process (Golding et al., 2005). The more delay in increase of the sugars by inclusion of KMnO$_4$ in the polyethylene could be attributed to the ethylene removal effect of KMnO$_4$ (Jobling, 2000).

REFERENCES


Shashirekha, S., Scott, K. J. and Graham, D. 2007. Storage of banana in sealed polyethylene tubes. CSIRO, Food Researche Laboratory, North Ryde Australia.


