EFFECT OF TEMPERATURE AND PERIOD OF STORAGE ON PHYSICAL, BIOCHEMICAL AND TEXTURAL PROPERTIES OF BANANA DURING RIPENING

Sonali C. Khanbarad, Indrajit D. Thorat, Debabandya Mohapatra*, R. F. Sutar and D.C. Joshi
Anand Agricultural University,
Anand-388 110, India.

ABSTRACT
A study on the ripening behavior of Grand Naine variety of banana was conducted under controlled conditions. Green matured banana fruits treated with 100 ppm ethylene were stored at 15±1°C and 30±2°C, for different storage periods to study the physical, biochemical and textural changes associated with the ripening process. Ethylene treated bananas ripened at low temperature (15±1°C), had a firmer pulp, while those stored at higher temperature (30±2°C) had softer pulp. Total soluble solids, reducing sugars, total sugars, pulp to peel ratio and weight loss increased significantly, while acidity and firmness/hardness decreased with increase in the storage temperature and days. Higher temperature and longer storage time resulted in lower shelf life of the fruits.

Key words: Banana, Ripening, Storage temperature, Storage period and Weight loss.

INTRODUCTION
Bananas are climacteric fruits and mostly harvested while still green and firm. The harvested bananas pass through three physiological development stages, namely the pre-climacteric or ‘green life’ stage, the climacteric or ripening stage which covers the eat-ripe, and finally the senescence stage when the fruits are over-ripe and dying. Technically, ripening process can be induced by introduction of ethylene gas (Nootruddee & Propapan, 2004).

Storage conditions such as relative humidity and temperature are very crucial in deciding the final quality of fresh fruit as they influence the physiological and chemical activity in the live biological commodities. It is reported that the relative humidity of about 80 % and temperature of about 20°C are the ideal storage conditions for banana (Broughton & Wu, 1979). Storage temperature is an important parameter that influences the ripening process in bananas by catalyzing the enzymatic activity (Esguerra et al., 1992). An increase in storage temperature from 14 to 30°C enhances the rate of ripening and the fruit softens at a faster rate (Smith, 1989). Storing bananas at high temperature causes extensive tissue damage due to higher rate of biochemical reaction (Smith & Thompson, 1987; Semple & Thompson, 1988). Further, storage of bananas below 14°C imparts chilling injuries and uneven ripening (Stover & Simmonds, 1987). Since temperature and period of storage are the important factors in deciding the quality and the marketable life of banana fruit, this research was initiated to investigate the effect of different temperatures and period of storage on the ripening behavior and shelf life of ethylene treated bananas.

MATERIALS AND METHODS
Freshly harvested pre-climacteric (Grand Naine) banana fruits used for this study were obtained from horticulture farm of Anand Agricultural University, Gujarat, Bananas were immediately washed with clean tap water to remove the field heat and wrapped with tissue paper to remove the excessive surface moisture. The selected hands with 6-8 fingers were kept in plastic crates and stored in temperature controlled ripening chambers maintained at 15±1°C and 30±2°C. Bananas were treated with ethylene gas @ 100 ppm for 24 hours in the chamber (Ahmad et al., 2006a). The fruits were allowed to ripen and stored at above conditions

*Corresponding author’s address : IDMC, Vidya Nagar, Anand-388 110, India
for five days. Various physical, biochemical, hardness and organoleptic parameters were evaluated for 0, 3\textsuperscript{rd} and 5\textsuperscript{th} day of storage using standard methodology described hereunder. All trials were conducted in triplicate.

Weight loss was calculated by weighing the bananas before and after storage. The selected fruits were washed, and the skin was peeled off to separate out the pulp. Pulp and peel were then weighed individually for calculating pulp to peel ratio (Ahmad \textit{et al.}, 2006b). Total soluble solids (TSS) in the pulp of ripe banana were measured using refractometer (Atago, Japan).

Total acidity was calculated by titrating the diluted (10 g/100 ml) banana pulp with 0.1 N NaOH using 0.3 ml phenolphthalein as indicator till the pH became 8.1. The acidity was expressed in terms of percentage malic acid equivalent (Ranganna, 2000).

Reducing sugar and total sugar were determined with Lane and Eynon method by titrating centrifuged (Micro Scientific Works, Delhi) banana pulp with Fehling solutions A and B against the sample solution already prepared (Ranganna, 2000).

Hardness/firmness was determined on whole, unpeeled fruits using Texture Analyzer (TA-HDi, Stable Microsystems, UK) fitted with stainless steel cylindrical 5 mm probe (P/5) and 50 kg load cell, at pre-, post and test speeds of 2, 2, 1 mm/s, respectively, in the compression mode. The depth of penetration was maintained at 0.5 cm for each trial.

Five panelists, who were familiar with the quality of ripe banana, were selected for evaluation of samples for color and taste, using 9 point hedonic scale. 9 point was given for ‘like extremely’ and 1 point for ‘dislike extremely’.

\textbf{Statistical analysis}: Experiment was conducted in four replications for statistical analysis and the data were subjected to analysis of variance (ANOVA) using Microsoft Excel 2007.

\textbf{RESULTS AND DISCUSSION}

The weight loss of bananas increased with the increase in the storage temperature as well as storage days. The maximum and minimum weight loss was found to be 8.33 \% and 5 \% for storage condition at 30±2°C and 15±1°C temperature on 5\textsuperscript{th} day respectively. It was also found that on 1\textsuperscript{st} day, there was no significant difference (p < 0.05) in the weight loss between the samples stored at different temperatures. The values were, however significantly different as storage period progressed (Table 1). The excess energy produced from the respiration process is released from the tissue by the vaporization of water, which will subsequently be transpired from the fruit, causing weight loss. Some of the moisture loss through the peel could be observed through shrinkage on the peel. This observation substantiate to the earlier reports by Nootrudee (2004).

As observed from table 1 Pulp to peel ratio steadily increased with the increase in both the storage temperature and period. The ratio was the maximum (2.24 \%) at 15±1°C and was the minimum (2.06\%) at 30±2°C on 5\textsuperscript{th} day. Changes in pulp to peel ratio were not significant (p>0.05) for storage temperature and periods. The greater pulp/peel ratio at higher temperatures could be due to the greater weight loss. The pulp mass of banana fruit increased during ripening; the reason could be due to the movement of water from peel to pulp and to the surrounding air (Ahmad \textit{et al.}, 2001).

A change in total soluble solid (TSS) followed the same trend as the weight loss (%), with a sharp rise for all days of storage (Table-1). The TSS was the minimum (18\%) at 15±1°C and the maximum (19.32 \%) at 30±2°C temperature on 5\textsuperscript{th} day of storage. TSS was found to increase significantly with storage time; the effect of storage temperature was, however found to be insignificant. This may be due to conversion of complex polymers into simple substance according to the finding of Sarode \textit{et al.} (2009).

Total acidity steadily decreased with the increase in both storage temperature and period. Total acidity was the maximum (0.29 \%) and minimum (0.24 \%) at 30±2°C and 15±1°C on the fifth day of storage (Table-1). The total acidity decreased insignificantly with the storage temperature and period. As the fruit ripened up to the 5\textsuperscript{th} day, acidity was reduced and the taste changed to a sweet during the hydrolyzed sugar from the starch degradation. Similar results were reported by Nootrudee (2004). Reducing sugar was the maximum (7.18\%) and minimum (6.08\%) at 30±2°C and 15±1°C on 5\textsuperscript{th} day. Total sugar was the maximum (12.78\%) and minimum (11.66\%) at 30±2°C and 15±1°C on 5\textsuperscript{th} day. Reducing sugar and
total sugar increased significantly both with storage temperature and period, implying the conversion of starch into sugar. Similar results were reported by Sarode et al., (2009) for the sugar conversion from starch at faster rate at high temperature.

Maximum textural firmness as measured by puncture test 47.1 N at 15±1°C and 46.3 N at 30±2°C on 1st day while, minimum hardness/firmness was 19.1 N at 15±1°C and 16.7 N at 30±2°C on 5th day. Firmness of banana decreased as the storage temperature increased significantly (p<0.05). The firmness, however decreased steadily as the storage period progressed, which could be attributed to decrease in cell pectin degradation and conversion of starch into sugar (Seymour et al., 1993).

**CONCLUSIONS**

Physical, mechanical and chemical properties of banana fruits stored at different temperatures were significantly different. Bananas stored at (15±1°C) temperature got ripened in 5 days with acceptable marketable quality while, those stored at (30±2°C) had ripened earlier with greater effect on appearance. Bananas ripened at lower temperature were firmer but still had acceptability in terms of total soluble solids, reducing sugar, acidity and total sugar. Therefore, it is postulated that bananas stored at low temperature would have firmer texture which might withstand rough handling during marketing.

**REFERENCES**


**TABLE 1: Effect of temperature and period of storage on different quality parameters of banana fruit.**

<table>
<thead>
<tr>
<th>Storage temperature</th>
<th>Storage Period</th>
<th>Weight loss, %</th>
<th>Pulp to peel ratio</th>
<th>Total soluble solids, %</th>
<th>Total Acidity, %</th>
<th>Reducing sugar, %</th>
<th>Total Sugar, %</th>
<th>Hardness, N</th>
</tr>
</thead>
<tbody>
<tr>
<td>15±1°C</td>
<td>0 Day</td>
<td>-</td>
<td>1.05±0.025**</td>
<td>1.56±0.32†*</td>
<td>0.44±0.031**</td>
<td>0.67±0.26†*</td>
<td>2.58±0.38†**</td>
<td>50.45±0.32†**</td>
</tr>
<tr>
<td></td>
<td>1 Day</td>
<td>2.54±0.64†**</td>
<td>1.63±0.25**</td>
<td>3.31±1.12†*</td>
<td>0.34±0.11†*</td>
<td>0.82±0.21†*</td>
<td>5.08±0.71†**</td>
<td>47.1±0.35†**</td>
</tr>
<tr>
<td></td>
<td>3 Day</td>
<td>3.26±0.34†*</td>
<td>1.70±0.20†**</td>
<td>16.93±1.40†**</td>
<td>0.33±0.04†*</td>
<td>2.76±0.82†*</td>
<td>6.08±0.86†*</td>
<td>23.7±0.25†*</td>
</tr>
<tr>
<td></td>
<td>5 Day</td>
<td>5.0±0.96†*</td>
<td>2.06±0.32†**</td>
<td>18±0.64†**</td>
<td>0.24±0.02†*</td>
<td>6.08±0.54†*</td>
<td>11.66±0.99†**</td>
<td>19.1±0.06†*</td>
</tr>
<tr>
<td>30±2°C</td>
<td>0 Day</td>
<td>-</td>
<td>1.06±0.015**</td>
<td>2.66±0.25†*</td>
<td>0.42±0.053†*</td>
<td>1.04±0.19†*</td>
<td>2.74±0.30†**</td>
<td>50.38±0.27†**</td>
</tr>
<tr>
<td></td>
<td>1 Day</td>
<td>3.22±1.18†**</td>
<td>1.62±0.21†**</td>
<td>5.91±0.63†*</td>
<td>0.35±0.08†*</td>
<td>2.54±0.69†*</td>
<td>4.74±0.60†**</td>
<td>46.3±0.30†**</td>
</tr>
<tr>
<td></td>
<td>3 Day</td>
<td>4.33±0.54†*</td>
<td>1.925±0.14†**</td>
<td>18.43±0.91†**</td>
<td>0.31±0.05†*</td>
<td>5.08±0.34†*</td>
<td>7.86±0.83†*</td>
<td>16.7±0.30†*</td>
</tr>
<tr>
<td></td>
<td>5 Day</td>
<td>8.33±1.13†*</td>
<td>2.24±0.47†**</td>
<td>19.32±0.75†*</td>
<td>0.29±0.05†*</td>
<td>7.18±0.65†*</td>
<td>7.2±0.11†**</td>
<td>7.2±0.11†**</td>
</tr>
</tbody>
</table>

* Significant at 5 % level between storage temperatures, † Significant at 5% level between storage days and ns non-significant


