Studies on storage behavior of Assam Lemon (Citrus limon Burm)

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ABSTRACT

Assam lemon is one of the most important fruit of Assam and it is used for culinary purpose due to its fragrance and acidic content. Though Citrus fruits are non-climacteric in nature, depending on the temperature and storage duration, chemical composition of fruits may change. In this experiment different treatments viz. T₀: Control, T₁: Chlorination (4%), T₂: Chlorination (4%) + Polyethylene (300 gauge thickness), T₃: Chlorination (4%) + perforated polythene (with pinholes), T₄: Chlorination (4%) + individual shrink wrapping, T₅: Chlorination (4%) + tray packaging were used to study the storage life and post harvest quality of Assam Lemon fruits. The effect of these treatments on citric acid, respiration, fruit texture and colour were studied. Among all the treatments, individual shrink wrapping (T₄) of Assam Lemon fruit stored at ambient temperature (30-32°C and 80–85% RH) was found to be beneficial because it helped to extend the shelf life without deterioration in quality of fruit. Shrink wrap packaging retained the freshness, colour and firmness of the fruit up to 1 month without any decay.

Key words: Assam Lemon, Chroma, Hue angle, Respiration, Shrink wrapping.

INTRODUCTION

Citrus fruits are well known for their dietary, nutritional, medicinal and cosmetic properties and are also good sources of citric acid, flavonoids, phenolic, pectin, limonoids, ascorbic acids etc. (Dugo and Di Giacomo, 2002; Kumar et al., 2010). Citrus fruits are non-climacteric but compounds in fruits depending on the temperature and storage duration may change appreciably (Lester and Hodges, 2007). Among the citrus, lemon is the third most important citrus species after orange and mandarin (Porat et al., 2000). In Assam, lemon covers an area of 0.13 lakh hectar with 1.04 lakh MT production (Indian Horticulture Database, 2015). Assam Lemon is one of the most important varieties of lemon, which is valued for fragrance, acidic content and mainly used in green matured stage for culinary purposes. Citrus fruits do not undergo rapid chemical or physical changes, after harvest lemons are the only citrus fruits held in prolonged storage. Commercially, the duration of holding depends on the fruit colour at the beginning of storage-such as yellow and green. Thus, the knowledge of the biochemical changes during storage is essential to extend storage life and improve keeping quality of a fruit. Various workers have reported about the storage behavior of many citrus species. But limited post-harvest studies on the cultivar Assam Lemon has been carried out with reference to prolonging the shelf life and thereby, stretching the period of fresh fruit and availability.

MATERIALS AND METHODS

The experiment was undertaken during 2014-15 in the quality control and PHT Laboratory of the Department of Horticulture, Jorhat. The fruits were collected from the Experimental plot, Department of Horticulture, AAU, Jorhat. Uniformly matured Assam Lemon fruits were harvested at marketable stage and immediately brought to the Laboratory. The fruits were kept in departmental laboratory in open condition at temperature 30-32°C and relative humidity 80-85 %. The fruits were kept for 28 days and changes in respiration, color, texture and citric acid level were observed at weekly interval.

RESULTS AND DISCUSSION

Colour development: The results revealed that (Table 1) brightness or lightness (L) value of fruit continued to increase during storage in all the treatments, but in treatment 4 (T₄), the lightness value was observed to be significantly lowest, whereas, control recorded highest value of lightness during all the storage days. There was consistent decrease in the...
greenness value (-a) and increase in the yellowness value (+b) for all the treatments. But, treatment 4 (shrink wrapping) recorded highest average value (-12.69) of greenness (-a) and lowest average value (26.48) of yellowness (+b), whereas, lowest mean value (-7.14) of greenness and highest mean value (31.14) of yellowness were recorded in control. (Table 1).

Values of hue angle near 90° represent yellow colour, while values near 120° represent green colour Minolta, (2008). In our present study, the value of hue angle was found to be decreasing indicating yellowing of the fruit during storage. But, among all the treatments, treatment 4 (T4) showed significantly highest mean value (116.70) of hue angle than the other treatments with a range between 124 to 105 during 28 days of storage and control showed the lowest mean (103.75) value of hue angle (Table 2).

Chromaticity (Chroma) defines colour vividness or clearness. Present study revealed that chroma value increased with storage days. Among all the treatments, treatment (4), recorded lowest mean value of chroma (29.78), whereas, control recorded the highest mean value (33.35).

As the fruit ripen and chlorophyll disappears, the carotenoids gradually increase their concentrations, as they are synthesized during ripening but these changes are not to a great extent in lemons Kato et al., (2004). The loss of chlorophyll coincides with decrease in the coordinate a’ (green), decrease in hue angle and rise in chroma in our study. The present study revealed that, with increase in storage days, negative values of coordinate a’ decreased, indicating degradation of chlorophyll (lemons become less green) and appearance of carotenes (colour coordinate b’). These findings were in accordance with the reports of Tietel et al., (2010); on storage of Satsuma mandarins. These authors found decrease in hue angle (from 118 to 88), increase in lightness (from 56 to 67) and increase in colour saturation (from 31 to 42), characterizing peel colour change from dark green to bright yellow.

Thus, as indicated by the significant decrease in hue angle values, increase in color saturation or vividness, and increase in brightness; it may be inferred that, all the treatments and control promotes the de-greening of Assam Lemon during storage but significantly lower rate was observed in treatment 4 (T4) compared to others treatments and control. Wrapping of Nagpur mandarin fruit with heat-shrinkable polyolefin Cryovac films D-955 and BDF-2001 minimized water loss and retained fruit colour and freshness, up to 3 weeks at 30-35°C and 25-40% RH ( NRCC).

Respiration rate (mg CO₂/kg Fruit/hr): Citrus fruits have a relatively low respiration rate, which decline with time after harvest. The treatments were found to be significant for rate of respiration (Table 3). The rate of respiration in Assam lemon fruits showed declining trend as storage days
Table 2: Colour parameters (Hue and chroma) of Assam Lemon fruit stored under ambient temperature 30-32°C and RH, 80-85%

| Treatment          | Hue angle | Chroma |
|--------------------|-----------|--------|
|                    | Storage days |       | Storage days |       |
|                    | 7          | 14     | 21          | 28      | Mean  | 7          | 14     | 21          | 28      | Mean  |
| T₀                 | 117a       | 108ab  | 97a         | 93a     | 103.75a | 27.03a | 30.92d     | 33.78c  | 37.63d | 33.35c |
| T₁                 | 118a       | 110b   | 101b        | 98b     | 106.75b | 26.86a | 29.73b     | 32.97c  | 35.84b | 31.24b |
| T₂                 | 118a       | 111b   | 100b        | 98b     | 106.91b | 27.20a | 30.11bc    | 33.79c  | 37.44cd | 32.04c |
| T₃                 | 121b       | 115c   | 110c        | 102c    | 112c    | 27.30a | 28.40c     | 29.32b  | 35.93bc | 30.23b |
| T₄                 | 124c       | 121d   | 113d        | 105d    | 115.75d | 27.96b | 28.32a     | 28.74a  | 34.13a | 29.78a |
| T₅                 | 116a       | 106a   | 100b        | 97b     | 104.75a | 26.84a | 34.11d     | 34.11c  | 36.31bcd | 32.10c |
| Mean               | 119a       | 111.8b | 103.5c      | 98.83d  |         | 27.19a | 30.26c     | 32.11d  | 36.14d |        |

*Means within the same column followed by the same small letters are not significantly different (level of significance 5%) according to Duncan multiple range test.

Initial value of chroma = 26, Hue angle: 125

T₀: Control, T₁: Chlorination (4%), T₂: Chlorination (4%) + Polyethylene (300 gauge thickness), T₃: Chlorination (4%) + perforated polythene (with pinholes), T₄: Chlorination (4%) + individual shrink wrapping, T₅: Chlorination (4%) + tray packaging

Table 3: Rate of respiration (mg CO₂/kg/hr) of Assam lemon fruit stored under temperature 30-32°C and RH, 80-85%

| Treatments          | Storage days |       |       |
|---------------------|--------------|-------|-------|
|                     | 7            | 14    | 21    | 28    | Mean |
| T₀                  | 23.50a       | 22.50b| 21.55b| 20.51b| 22.43b|
| T₁                  | 23.40a       | 22.15b| 21.44b| 20.38b| 22.29b|
| T₂                  | 23.45a       | 22.25b| 21.47b| 20.41b| 22.33b|
| T₃                  | 23.35a       | 22.15b| 21.38b| 20.35b| 22.26b|
| T₄                  | 23.00a       | 21.76a| 20.00a| 19.00a| 21.57a|
| T₅                  | 23.45a       | 22.25b| 21.67b| 20.25b| 22.34b|
| Mean                | 23.35d       | 22.17b| 21.25c| 20.15a|        |

*Means within the same column followed by the same small letters are not significantly different (level of significance 5%) according to Duncan multiple range test.

Initial value of respiration = 24.10 mg CO₂/kg hr

T₀: Control, T₁: Chlorination (4%), T₂: Chlorination (4%) + Polyethylene (300 gauge thickness), T₃: Chlorination (4%) + perforated polythene (with pinholes), T₄: Chlorination (4%) + individual shrink wrapping, T₅: Chlorination (4%) + tray packaging

In the present investigation shrink wrapping significantly reduced the rate of respiration. This might be due to the fact that, shrink wrapping arrested the process of respiration and transpiration by creating modified atmosphere. Individual shrink wrapping has also been reported to reduce the respiration rate of ‘Nagpur’ mandarins by 47% as compared with unwrapped fruits at 30°C storage Nanda et al., (2001). This reduction in the respiration rates of fruits could be due to exposure to high concentrations of CO₂ and low concentrations of O₂ in the individual wrapping Rouyi et al., (2005).

Citric acid: Different treatments during storage showed significant effect on citric acid content of the Assam Lemon fruit. The citric acid content of the fruit was found to be decreased with increase in storage days (Table 4) for all the treatments, but highest loss of citric acid was recorded in control, whereas, lowest loss was recorded in treatment 4. Treatment (4) recorded highest content of citric acid during all the storage days, which ranged between 0.98 to 0.63 % with a mean value 0.80 % and the lowest acid content (0.58%) was recorded in control. The decrease of acid content during storage indicates the disappearance of astringency which might be due to the use of the acids present, as respiratory materials. In shrink wrapped fruits the lowering of acidity was delayed which might be due to the effect of shrink packaging film in delaying the respiratory and ripening process Mahajan et al., (2013). The results are in conformity with the findings of Mahajan and Singh (2014), who reported highest average acidity (0.54 %) in
shrink wrapped fruit and lowest average acidity in (0.48 %) in control fruit of kinnow mandarin under ambient storage condition.

**Fruit firmness:** The effect of treatments on firmness was found to be significant (Table 5) during all the storage days. In the present investigation, fruit firmness, followed a declining trend commensurate with advance in storage period. The individually shrink wrapped fruits maintained higher firmness as compared to control at all storage intervals. The highest mean fruit firmness (7.84 kg forces) was observed in individually shrink wrapped fruits. The individually shrink wrapped fruits maintained higher fruit firmness throughout the stipulated storage period of 28 days which ranged between 10.05 to 5.35kg force as compared to other treatments. On the other hand, the control fruits showed significantly the faster loss of firmness during storage and ranged between 9.16 to 1.65kg force, thereby leading to excessive softening and shriveling of fruits.

Fruit firmness is one of the most important attributes in determining the post harvest quality (Lachapella et al., 2013). Softening of fruits is caused by loss of pectic substances in the middle lamella of the cell wall that leads to the loss of cell wall integrity, thus causes loss of firmness leading to shriveling and softening (Solomos and Laties 1973). The maintenance of higher firmness in shrink film packed fruits during storage could be due to the reduction in moisture loss, respiratory activity and thus maintained the turgidity of the cells. Pongener et al., (2011) observed higher firmness in shrink film packed peach fruit.

The minimum loss in firmness and freshness of shrink wrapping might be due to maintaining a modified atmosphere (MA) around each piece of fruit, which reduces senescence process and thus, help in retention of fresh surface appearance even at ambient storage condition. Similar results were reported by Ben et al., (1983) in Lemon, Dhall et al., (2011) in cucumber under ambient condition.

The above results revealed that, shrink wrapping of Assam Lemon fruit stored at ambient temperature (30-32°C) with relative humidity 80-85 % was beneficial as it helped to extend the shelf life by retaining freshness, color and firmness of the fruit. The results were in conformity with Sharma et al., (2010), who reported that, shrink wrapping of fruits in polymeric films creates modified atmosphere resulting in reduced rate of respiration, transpiration and retention of colors and texture. Malik et al., (2002); reported that firmness and freshness of shrink wrapped kinnow fruits treated with chlorinated water were found to be better than seal and tray packaging stored under ambient condition.

**CONCLUSION**

It can be concluded from the experiment that, individual shrink wrapping affects positively on different parameters of Assam Lemon fruits. The shrink wrap fruits

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**Table 4:** Citric acid content (%) of Assam lemon fruit stored under temperature 30-32°C and RH, 80-85%

| Treatment                  | 7      | 14     | 21     | 28     | Mean  |
|----------------------------|--------|--------|--------|--------|-------|
| T<sub>0</sub>              | 0.67a  | 0.61a  | 0.56a  | 0.5a   | 0.58a |
| T<sub>1</sub>              | 0.75c  | 0.71d  | 0.65c  | 0.56c  | 0.66c |
| T<sub>2</sub>              | 0.71b  | 0.67c  | 0.62b  | 0.54b  | 0.63b |
| T<sub>3</sub>              | 0.93d  | 0.81e  | 0.72d  | 0.58d  | 0.76d |
| T<sub>4</sub>              | 0.98e  | 0.85f  | 0.77e  | 0.63e  | 0.80e |
| T<sub>5</sub>              | 0.72b  | 0.66b  | 0.62b  | 0.53b  | 0.63b |
| Mean                      | 0.79b  | 0.71d  | 0.65c  | 0.55a  | 0.56c |

*aMeans within the same column followed by the same small letters are not significantly different (level of significance 5%) according to Duncan multiple range test.*

Initial value of Citric Acid = 1.66

**Table 5:** Firmness (Kg.force) of Assam lemon fruit stored under temperature 30-32°C and RH, 80-85%

| Treatments                  | 7      | 14     | 21     | 28     | Mean  |
|-----------------------------|--------|--------|--------|--------|-------|
| T<sub>0</sub>               | 9.16a  | 5.56a  | 3.84a  | 1.65a  | 5.05a |
| T<sub>1</sub>               | 9.2b   | 5.61b  | 4.51b  | 1.69b  | 5.25b |
| T<sub>2</sub>               | 9.46c  | 5.73d  | 4.75d  | 2.35c  | 5.57c |
| T<sub>3</sub>               | 9.7d   | 5.81e  | 4.8e   | 2.43d  | 5.68d |
| T<sub>4</sub>               | 10.05e | 8.5f   | 7.5f   | 5.35e  | 7.85e |
| T<sub>5</sub>               | 9.45c  | 5.71c  | 4.73c  | 2.37e  | 5.56c |

*aMeans within the same column followed by the same small letters are not significantly different (level of significance 5%) according to Duncan multiple range test.*

Initial value of firmness = 10.50 kg.f.
show significant differences for all the parameters as compared to control sample. Individual Shrink wrapping retained the freshness, color and firmness of the fruit preserving the quality of the fruit during storage.

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