Effect of Storage System and Packages Type on The Self life and Quality of okra

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Abstract

The main aim of this work was to study the effect of storage system (traditional, ventilated and cold) and package type on the quality of okra during storage. The results indicated that, the total accumulated weight loss increases with increasing the storage period. Storage system had a great effect on the losses, where, the traditional storage system recorded was 86.00 % compared with 84.37 and 68.68 % for the okra stored in the ventilated and cold systems. The okra stored without packages recorded the highest accumulated weight loss (86.00%) when stored at traditional storage system while the lowest accumulated weight losses (33.03%) for the okra stored in the clothes packages when stored in the cold storage. The highest value of moisture loss was recorded by the okra pods stored without packages, while the lowest value of moisture loss was recorded for the okra stored in without packages. The ash, protein, nitrogen and fat composition were increased with increasing storage period for different storage system and package types, while, the fiber composition was decreased with increasing storage period for the same conditions.

Keywords: okra storage – ventilated storage – cold storage – chemical composition

Introduction

Okra (Abelmoschus esculentus L. Moench) is one of the most important vegetables produced in Egypt. However, production of the crop has been constrained by the short shelf life of its pods. Okra pods lose quality through blackening, shriveling and decaying within two days under room temperature conditions leading to heavy postharvest losses. To reduce these losses, traders disinfect fresh produce against decay-causing microorganisms using chlorine solution. However, chlorine has an unpleasant smell and is easily vaporized. Moreover, there is a growing consumer concern on the use of chemicals to manage infections (Salunkhe and Desai, 1984). There has been a strong move towards the use of non-chemical methods, such as packaging and right storage temperature in managing postharvest pathogens (Bauchmann and Earles, 2000).

Okra is highly perishable because of its high moisture content and respiratory activities (Boonyaritthongchai et al., 2013), then the okra is highly susceptible to water loss, color fading and decay, resulting in loss of commercial value and become squasy and not easy to consume fresh (Huang and Jiang, 2012). The ridges of okra easily caused mechanical injuries and these pods become blacken on ridges and calyx disc after post-harvesting, resulting in value deletion and unsaleability in quality conscious markets (Anonymous, 2004). Therefore, there is urgent need to develop suitable method to reduce the postharvest losses in okra and maintain high quality from harvesting to the entire supply chain.

Temperature management is the most effective tool for extending the shelf life of fresh horticultural produce. Exposure of okra pods to undesirable temperatures will result in bleaching, surface burning or scalding, shrivelling, excessive softening and desiccation (Cantwell and Trevor, 2002). Temperature also influences the effect of ethylene, reduces oxygen, and elevates carbon dioxide levels; affect pathogen spore germination and growth rate. Low temperature will reduce the effects of pathogens on fresh produce. For instance, cooling commodities below 5°C immediately after harvest reduces the incidence of Rhizopus rot. However, extremely low storage temperatures can also affect the quality of certain vegetables. Okra is rapidly chill damaged when stored at temperatures less than 7°C for an extended period (Perkin-Veazie and Collins, 1992). The symptoms of chilling injury include surface and internal discoloration (browning), pitting, water soaked areas, off-flavour development, and accelerated incidence of surface moulds and decay especially organisms not usually found growing on healthy tissue (Ngure et al., 2009).

Storage temperature and humidity are most important as they influence the senescent phases of fresh vegetables by regulating the rate of all associated physiological and biochemical processes. Similar findings have been made with bell peppers stored in perforated packaging which had a lower decay incidence than in non-perforated packaging (Ngure et al., 2009). It was also found that pods in perforated packaging had less off odour than those in non-perforated packaging. This finding is also similar to a study carried out on parsley where perforated packaging retained flavour and aroma better than in non-perforated packaging (Heyes, 2004). In storage, ventilation is very important to avoid build-up of carbon dioxide and heat as non-perforation permits...
slow gas exchange combined with vapour and heat build-up leading to rapid deterioration.

Okra is a perishable commodity, susceptible to unsuitable environmental conditions, which cause high water losses, color fade and high decay percentages. To overcome these problems, sound storage system and suitable packages types should be used to prolong shelf life, reduce losses and keep the quality, therefore, the main aim of this investigation is to study the effect of storage system and type of packages on the quality and shelf life of okra.

Materials and Methods

The main objective of the present study is to study the effect of storage conditions and package type on the quality of okra during storage. The experiment was carried out at Agricultural and Bio-Systems Engineering Department Faculty of Agriculture Moshtohor, Benha University, Egypt, during 2020 season.

2.1. Materials

2.1.1. Okra

The Okra was brought from the local market, at the beginning of the season, 2020.

2.1.2. Storage conditions

The okra was stored using different systems as follows:-
- Traditional system

Okra was folded into different packages in room at ambient temperature.
- Ventilated storage system

Okra was folded into different packages in room at refrigeration temperature.

Table 1. The experimental design.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage systems</td>
<td>3</td>
</tr>
<tr>
<td>Package types</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1 shows the experimental design.

2.2.2. Measurements

Temperature and relative humidity readings were recorded every hour at various locations in the storage systems. Temperature and relative humidity were recorded by using a HOBO Data Logger (Model HOBO U12 Temp/RH/Light-Range -20 to 70°C and 5 to 95% RH, USA). Okra samples were taken randomly from different systems every 3 days to determine the total weight losses.

Samples were taken every 3 days to determine the moisture loss. Okra samples were dried using drying oven at 105 °C until a constant weight was obtained. The moisture content was calculated as follows:

\[ MC = \frac{M_{\text{wet}} - M_{\text{dry}}}{M_{\text{wet}}} \times 100 \]

Where:
- MC is the moisture content (% wb)
- \( M_{\text{wet}} \) is the wet mass (kg)
- \( M_{\text{dry}} \) is the dry mass (kg)

Total contents of macro elements were evaluated after being digested according to Chapman and Partt (1961). Nitrogen was determined by Kjeldahl digestion apparatus (Bremmer and Mulvaney, 1982). Potassium, calcium and magnesium were determined by Photofatometer (Model Jenway PFP7 – Range 0 - 160 mmol L⁻¹, USA) and phosphorus (P) was determined colorimetrically.
following the Murphy and Riley (1962) method. Protein, fat, fibers and ash content were determined according to the method of AOAC (1990).

3. Results and Discussion

3.1. Storage conditions

Figures 1 and 2 show the average of temperature and relative humidity for the storage systems (cold, ventilated and traditional) under study. The average temperature ranged from 4.0 to 5.8, 30.0 to 33.2 and 18.4 to 34.8 °C for the cold storage, ventilated and traditional storage systems, respectively. It can be seen that the temperature in the traditional system fluctuated from 34 °C during the day time to less than 18 °C during the night time and relative humidity ranged from 26.1 to 99.8 %. The relative humidity values ranged from 25.3 to 61.1, 43.2 to 58.7 and 26.1 to 99.8 %, for the same previous order during the storage period.

![Figure 1: The average temperature for the storage systems.](image1)

![Figure 2: The average relative humidity for the storage systems.](image2)

3.2. Effect of storage conditions and packaging type on accumulated weight loss of okra pods.

Figures (3a, b and c) show the effect of different storage systems (cold, ventilated and traditional) and different packages (clothes, paper and plastic) on the accumulated weight loss of okra. The results indicated that the accumulated weight loss of okra pods increases with increasing storage period, where, it increased from 39.60 to 86.00, 10.67 to 58.17, 14.67 to 65.50 and 17.00 to 73.67 % for okra pods stored in without (control), clothes, paper and plastic packages, respectively under traditional storage system, when the storage period increased from 3 to 12 day, respectively. While, it increased from 37.41 to 84.37, 18.83 to 80.33, 13.33 to 63.17 and 22.83 to 83.17 % for okra pods stored in without (control), clothes, paper and plastic packages, respectively under ventilated storage system, when the storage period increased from 3 to 12 day, respectively. Also, it increased from 10.53 to 68.68, 2.93 to 33.03, 5.33 to 36.77 and 3.33 to 50.83 % for okra pods stored in without (control), clothes, paper and plastic packages, respectively under traditional storage system, when the storage period increased from 3 to 18 day,
respectively. Generally, the higher storage temperature, the higher vapor pressure deficit, the higher weight losses of fruits. These results were in agreement with those obtained by Khater and Bahnasawy (2016).

The results indicated that the highest value of accumulated weight loss in okra pods was 86.00% was found for without packages (control) under traditional storage system, while, the lowest value of accumulated weight loss in okra pods was 33.03% was found for clothes packages under cold storage system. These results were in agreement with those obtained by Khater and Bahnasawy (2018).

Regression analysis was carried out to find a relation between the accumulated weight loss and both storage systems and packages type. Equation (2) shows the most appropriate form for the relationship
between the accumulated weight loss and packages type at different storage systems. The constants of these equations and coefficient of determination are listed in Table (2).

\[
WL = a + bT
\]

Where:
- \(WL\) is the accumulated weight loss of okra \((\%}\)
- \(T\) is the storage period (day)

### Table 2. The constants \(a, b, c\) and coefficient of determination for accumulated weight loss at the different storage systems and the different packages type.

<table>
<thead>
<tr>
<th>Storage system</th>
<th>Packages Type</th>
<th>Constants</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>Control</td>
<td>9.18</td>
<td>6.81</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>0.99</td>
<td>4.92</td>
</tr>
<tr>
<td></td>
<td>Paper</td>
<td>1.19</td>
<td>5.27</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>0.67</td>
<td>6.09</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>11.28</td>
<td>7.06</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>3.03</td>
<td>7.06</td>
</tr>
<tr>
<td>Ventilated</td>
<td>Paper</td>
<td>-0.97</td>
<td>5.29</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>4.87</td>
<td>7.24</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>-0.75</td>
<td>4.82</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>-1.52</td>
<td>1.81</td>
</tr>
<tr>
<td>Cold</td>
<td>Paper</td>
<td>-0.50</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>-3.06</td>
<td>2.75</td>
</tr>
</tbody>
</table>

3.3. Effect of storage conditions and packaging type on moisture loss of okra pods.

Figures (4a, b and c) show the effect of different storage systems (cold, ventilated and traditional) and different packages (clothes, paper and plastic) on the moisture loss of okra. The results indicated that the moisture loss of okra pods decreases with increasing storage period, where, it decreased from 86.00 to 14.00, 58.17 to 16.17, 65.50 to 14.67 and 73.67 to 21.20 \(\%\) for okra pods stored in without (control), clothes, paper and plastic packages, respectively under traditional storage system, when the storage period increased from 3 to 12 day, respectively.

In the ventilated system, the moisture content decreased from 84.37 to 3.77, 80.33 to 10.50, 63.17 to 17.27 and 83.17 to 9.33 \(\%\) for okra pods stored in without (control), clothes, paper and plastic packages, respectively when the storage period increased from 3 to 12 day, respectively. Also, it decreased from 68.68 to 14.61, 33.03 to 5.97, 36.77 to 5.43 and 50.83 to 10.53 \(\%\) for okra pods stored in without (control), clothes, paper and plastic packages, respectively under traditional storage system, when the storage period increased from 3 to 18 day, respectively.

Concerning the effect of package type, under the cold storage system, the highest value of moisture loss (14.61 \%) was recorded by the okra pods stored for without packages (control) while the lowest value of moisture loss (5.43 \%) was recorded for the garlic stored in paper packages. At the ventilated storage system, the highest value of moisture loss (17.27 \%) was recorded for the garlic stored in paper packages while the lowest value of moisture loss (3.77 \%) was recorded by the okra pods stored for without packages (control). At the traditional storage system, the highest value of moisture loss (23.60 \%) was recorded for the garlic stored in paper packages while the lowest value of moisture loss (14.00 \%) was recorded by the okra pods stored for without packages (control).
Regression analysis was carried out to find a relation between the moisture loss and both storage systems and packages type. Equation (3) shows the most appropriate form for the relationship between the moisture loss and packages type at different storage systems. The constants of these equations and coefficient of determination are listed in Table (3).

\[ ML = a + bT \]

Where:
- \( ML \) is the accumulated weight loss of okra (%)
- \( a \) and \( b \) are constants

Figure (4): The effect of storage temperature and packages on the accumulated weight loss of green beans pods.

a: Traditional system  
b: Ventilated system  
c: Cold system
3.4. Effect of storage system and packaging type on the chemical composition of okra before and after storage

Table 5 shows the effect of storage system and package type on the chemical composition of garlic before and after storage. The results indicate that the ash was increased from 11.96 to 22.95, 11.96 to 20.66, 11.96 to 21.93 and 11.96 to 21.46 % for okra stored in without package (control) clothes, paper and plastic packages, respectively, at the end of period storage. While, it was increased from 11.96 to 21.77, 11.96 to 20.89, 11.96 to 20.13 and 11.96 to 21.76 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the cold storage system at the end of period storage.

Table 3. The constants a, b, c and coefficient of determination for moisture loss at the different storage systems and the different packages type.

<table>
<thead>
<tr>
<th>Storage system</th>
<th>Packages Type</th>
<th>a</th>
<th>b</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>Control</td>
<td>102.22</td>
<td>-7.64</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>73.86</td>
<td>-4.77</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Paper</td>
<td>79.12</td>
<td>-4.71</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>91.40</td>
<td>-5.89</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>105.97</td>
<td>-9.01</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>105.83</td>
<td>-8.28</td>
<td>0.96</td>
</tr>
<tr>
<td>Ventilated</td>
<td>Paper</td>
<td>79.45</td>
<td>-5.20</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>108.67</td>
<td>-8.68</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>77.37</td>
<td>-3.84</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>38.08</td>
<td>-1.49</td>
<td>0.99</td>
</tr>
<tr>
<td>Cold</td>
<td>Paper</td>
<td>40.77</td>
<td>-1.55</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>59.27</td>
<td>-2.27</td>
<td>0.97</td>
</tr>
</tbody>
</table>

The results also indicate that, the protein was increased from 6.67 to 13.05, 6.67 to 10.98, 6.67 to 12.17 and 6.67 to 11.33 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the traditional storage system at the end of period storage. In the ventilated storage, the protein was increased from 6.67 to 12.27, 6.67 to 10.82, 6.67 to 9.26 and 6.67 to 9.16 % for okra stored in without package (control) clothes, paper and plastic packages, respectively, at the end of period storage. While, it was increased from 6.67 to 11.01, 6.67 to 11.21, 6.67 to 9.26 and 6.67 to 10.47 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the cold storage system at the end of period storage.

The result revealed that the nitrogen (N) was increased from 1.27 to 2.49, 1.27 to 2.09, 1.27 to 2.32 and 1.27 to 2.19 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the traditional storage system at the end of period storage. In the ventilated storage, the nitrogen (N) was increased from 1.27 to 2.15, 1.27 to 2.06, 1.27 to 1.76 and 1.27 to 1.74 % for okra stored in without package (control) clothes, paper and plastic packages, respectively, at the end of period storage. While, it was increased from 1.27 to 2.09, 1.27 to 2.14.
1.27 to 1.76 and 1.27 to 1.99 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the cold storage system at the end of period storage.

The fiber was decreased from 18.78 to 13.11, 18.78 to 11.61, 18.78 to 12.54 and 18.78 to 12.30 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the traditional storage system at the end of period storage. In the ventilated storage, the fiber was decreased from 18.78 to 15.24, 18.78 to 14.18, 18.78 to 14.60 and 18.78 to 12.63 % for okra stored in without package (control) clothes, paper and plastic packages, respectively, at the end of period storage. While, it was decreased from 18.78 to 16.17, 18.78 to 15.19, 18.78 to 15.46 and 18.78 to 14.35 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the cold storage system at the end of period storage.

The fat was increased from 9.34 to 6.78, 9.34 to 5.17, 9.34 to 6.34 and 9.34 to 5.13 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the traditional storage system at the end of period storage. In the ventilated storage, the fat was increased from 9.34 to 6.39, 9.34 to 5.50, 9.34 to 5.50 and 9.34 to 6.05 % for okra stored in without package (control) clothes, paper and plastic packages, respectively, at the end of period storage. While, it was increased from 9.34 to 5.65, 9.34 to 5.02, 9.34 to 5.50 and 9.34 to 4.37 % for okra stored in without package (control) clothes, paper and plastic packages, respectively under the cold storage system at the end of period storage.

Conclusions

An experimental study was carried out successively to study the effect of storage system and package type on the quality of okra during storage. The obtained results can be summarized as follows:

- The highest value of accumulated weight loss (86.00%) was recorded by the okra pods stored without packages (control) for the okra stored in the traditional system, while the lowest value of accumulated weight loss (33.3 %) was recorded for the okra stored in clothes package for the cold systems.
- The highest value of moisture loss was recorded by the okra pods stored without packages, while the lowest value of moisture loss was recorded for the okra stored in without packages.
- The ash, protein, nitrogen and fat composition were increased with increasing storage period for different storge system and package types.
- The fiber composition was decreased with increasing storage period for different storge system and package types.

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