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# Effect of Neem leaf powder on Post harvest shelf life and quality of tomato fruits in storage

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## Abstract

Three varieties of tomato fruits (UTC, Shase and Hoozua) obtained from Wurukum market in Makurdi were treated with Neem leaf powder to extend their shelf life and maintain quality of tomato fruits during storage. Significant variations were observed among the varieties in relation to most of the parameters studied. Irrespective of treatment, weight loss, postharvest decay, marketability and firmness decreased with increase in storage duration. Temperature ranged from 28.43 – 31.89$^{0}$C. For weight evaluation, UTC ranged from 4.95 – 45.28, Shase ranged from 4.40 – 45.16 and Hoozua ranged from 4.62 – 59.48. Among the three varieties, UTC and Shase showed lower postharvest decay of 0.00 – 10.00 than Hoozua with postharvest decay of 1.00 – 10.00 and the lower postharvest decay was found in the treated fruits. Marketability ranged from 10.00 – 0.00 for all varieties and firmness ranged 4.00 – 2.00 for all varieties. Comparatively, all varieties treated with Neem leaf powder had same shelf life of ($22.0 \pm \mathbf{0.00}$) days, while control fruits of Hoozua variety produced the least shelf life of ($15.0 \pm \mathbf{0.00}$) days and UTC control fruits produced the highest with ($19.0 \pm \mathbf{0.00}$) days. Four fungi namely *Aspergillus niger*, *Fusarium oxysporum* and *Botryodiplodia theobromae* were isolated from the decaying tomato fruits. The findings therefore indicate that powder from the leaf of Neem plant can be used to extend the shelf life and quality of tomato fruits beyond their known natural limits.

***Keywords:*** Postharvest; Shelf Life; Quality; Neem; Tomato



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## 1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most important vegetable crops in the world. In Nigeria, about one million hectares of total land area is used for its cultivation and this crop makes up about 18% of the average daily consumption of vegetables in Nigerian homes (Babalola et al., 2010). Nigeria ranks second to Egypt in Africa and 13th globally in tomato production (Ebimieowei et al., 2013a).

Tomato is an important condiment in daily diets, consumed both fresh and in paste form and a very cheap source of vitamins A, C, E and minerals which protect the body against diseases. It contains lycopene, a flavonoid antioxidant together with carotenoids which protect the body cells and other structures in the human body (Ogo-Oluwa and Liamngee, 2016).

Tomato fruits are of a highly perishable nature, with a short shelf life of between 12 hours to 72 hours (Ejale and Abdullah, 2004). Due to the high perishable nature of the fruits, a lot of them rot before they get to the various areas of the country where they are not cultivated and where the demand is high (Irokanulo et al., 2015). This results in heavy quantitative and nutritional losses to farmers and consumers as well as the rural and urban dwellers far from areas of production who will have to pay more for few healthy fruits that gets to them (Ejale and Abdullah, 2004). Its preservation and storage is therefore important to the economy of individual homes, farmers and the country considering the vital role it plays in the health of people (Irokanulo et al., 2015).

People in developing countries often cannot afford the use of cold storage facilities for their preservation, which may be due to lack of capital or lack of technical knowledge by small scale growers and retailers in these areas as well as poor or inadequate power supply (Thirupathi et al., 2006). Another challenge is limited finances to invest in such storage facilities (Sood et al., 2011). Many synthetics, like Sodium hypochloride, Sodium metabisulphite, and Calcium chloride have also been used to preserve tomato fruits but consumers are becoming very concerned on the use of synthetics on horticultural crops like tomatoes. Little attempt has been made in the use of plants, which are multipurpose, cheap, easy to use and have found tremendous use in food and medicine to preserve the fruit.

This research was therefore conducted to investigate the effect of Neem leaf powder on postharvest shelf life and quality of tomato fruits as a means of extending its life span in storage.

## 2. Materials and methods

### 2.1. Collection of tomato samples

Tomato fruits used for this study were obtained from Wurukum market, Makurdi, Benue State. The varieties bought include Shase, Hoozua and UTC. The fruits were ripe, firm, smooth and free of any defects.

### 2.2. Collection of Neem (Azadirachta indica) Leaves

Fresh leaves of *Azadirachta indica* were obtained from the campus of the Benue State University Makurdi. The leaves were air-dried in a dust-free room for 10 days. The dried leaves were ground using pistil and mortar and sieved to get a fine powder. The powder was stored in well covered clean jars and kept away from direct light in a dust-proof locker.

## 2.3. Experiment 1

The first experiment was treatment and storage of tomato fruits using neem leaf powder. Ripe, firm, smooth and healthy tomato fruits of three varieties were selected and washed in clean water to remove dirt, rinsed again in water and kept to air-dry before treatment. The tomato fruits were coated (treated) with the powder of Neem leaf. The tomato fruits were then arranged in rubber crates and kept at room temperature. Three varieties of tomato fruits were used for each treatment, each replicated three times and arranged in complete randomized design with each plot containing thirty fruits. Untreated tomato fruits were used as control. Data Collected include:

i. *Postharvest decay percentage (PDP)*: Postharvest decay or rotting was determined by visual evaluation for symptoms of decay during the storage period. Samples having symptoms of decay were counted, recorded and expressed in percentage as shown below.

$$PDP = \frac{\text{Number of fruits Decaying}}{\text{Total number of fruits}} \times 100$$

ii. *Weight percentage (WLP)*: Tomato fruits were weighed at the beginning and during the storage interval using weighing balance. The difference between the initial and final weight of the fruits was considered as total weight loss during the storage interval and expressed as a percentage.

$$WLP = \frac{\text{Initial weight - final weight}}{\text{Initial weight}} \times 100$$

iii. *Shelf life*: Shelf lives of tomato fruits were evaluated by counting the number of days tomato fruits were still acceptable for marketing. It was decided based on appearance and spoilage of fruits.

iv. *Firmness*: Firmness of tomato fruits was determined by hand estimation using a numerical rating scale of 1-5. Where 1= Very poor, 2= poor, 3= acceptable, 4= Good, and 5= Excellent.

v. *Marketability*: Based on descriptive quality attributes such as level of visible lesion, shriveling, smoothness and shininess of fruit, percentage of marketable fruits during the experiment was calculated by the formula.

$$\text{Marketability of tomato fruit} = \frac{\text{number of marketable fruits}}{\text{Total number of fruits}} \times 100$$

vi. *Temperature*: Temperature of the storage room was measured during the storage period using thermometer.

### 2.4. Experiment 2

The second experiment was isolation of microorganisms associated with spoilage of tomato fruits.

#### *2.4.1. Media preparation*

The medium used for isolation of fungi was Potato Dextrose Agar (PDA) which was prepared according to the manufacturer's instruction.

#### *2.4.2. Isolation of fungi*

Small sizes were cut from tomato fruits infected with rot and surface sterilized by dipping in 1% sodium hypochlorite (NaOCl) solution for one minute. They were removed and rinsed in several changes of sterile distilled water then placed on sterile paper towels to dry. They were then placed on solidified Potato Dextrose Agar medium. Three replicates were made for each sample. The inoculated plates were incubated at ambient temperature and observations were made for microbial growth. After 5 - 7 days of growth, sub culturing was done to obtain pure cultures of the isolates as reported by Ogo-Oluwa and Liamngee (2016).

#### *2.4.3. Identification of fungi*

Identification was done microscopically and macroscopically. Colony characteristics such as appearance, change in medium colour and growth rate were observed. Shape of the conidia and conidiophores were taken note of. These features were matched with standards described by Barnett and Barry (1999) as reported by Ogo-Oluwa and Liamngee (2016).

#### *2.4.4. Pathogenicity test*

Mycelia plugs of the fungal isolates from 5 day old cultures were used to inoculate four tomato fruits per pathogen. On appearance of symptoms, the tissues at the margin of the healthy and diseased parts were excised, sterilized and placed onto Potato Dextrose Agar (PDA) and incubated at ambient temperature for 5–7 days. At the end of this period, morphological characteristics and growth patterns observed in each case were compared with the ones of the original isolates. Three tomato fruit each was used for each fungal isolate replicated four times and arranged in completely randomized design. Controls were tomato fruits inoculated with sterile PDA only as reported by Ogo-Oluwa and Liamngee (2016).

## 3. Data analysis

Data collected was analyzed using Analysis of Variance (ANOVA) and the Fishers Least Significant Difference (FLSD) was used to separate the means at 5% level of significance.

## 4. Results

### 4.1. Temperature (0C) evaluation during the storage duration

Temperature (˚C) evaluation of the storage room within the storage period showed that there was no significant difference (p > 0.05) in temperature between mornings and afternoons except on days eleven, fifteen, nineteen and twenty two. On day eleven, the temperature in the afternoon was higher (30.73±0.57) compared to the temperature in the morning (31.30±0.10). On day fifteen, the temperature in the afternoon was higher (31.89±0.01) compared to the temperature in the morning (30.50±0.10). On day nineteen, the temperature in the morning was higher (30.76±0.05) compared to the temperature in the afternoon (30.17±0.11). On day twenty two, the temperature in the afternoon was higher (28.63±0.05) compared with the temperature in the morning (28.43±0.05) as shown in table 1.

**Table 1.** Temperature (˚C) evaluation of the room within storage duration

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Morning** | 31.17± 0.11 | 31.17± 0.11 | 31.03± 0.15 | 31.27± 0.25 | 31.30± 0.10 | 31.70± 0.26 | 30.50± 0.10 | 28.53± 1.15 | 30.76± 0.05* | 28.43± 0.05 |
| **Afternoon** | 31.17± 0.11 | 31.87± 0.04 | 31.20± 0.17 | 31.33± 0.05 | 31.89± 0.01* | 31.53± 0.06 | 30.73± 0.57* | 29.33± 0.05 | 30.17± 0.11 | 28.63± 0.05* |
| **LSD(0.05)** | NS | NS | NS | NS | 0.44 | NS | 0.12 | NS | 0.09 | 0.15 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

### 4.2. Weight evaluation of tomato fruits during storage

There was significant difference (p<0.05) in weight loss with respect to UTC variety between treated and control fruits except on day nine. On day three, the control fruits showed higher weight loss (5.23±0.01) compared to treated fruits (4.95±0.13). On day five, the treated fruits showed the highest weight loss (9.75±1.17) compared to the control (7.44±0.01). On day seven, the treated fruits had the highest weight loss (17.0±3.42) compared to the controls (11.22±0.01). On day eleven, the control fruits had a higher weight loss (33.82±0.01) compared to the treated fruits (25.35±4.22). On day thirteen, control fruits showed higher weight loss (36.51±0.01) compared to the treated fruits (28.96±2.31). On day fifteen, control fruits showed higher weight loss (36.50±0.01) compared to the treated fruits (30.69±2.28). On day seventeen, the control fruits had a higher weight loss (39.10±0.01) compared to the treated fruits (32.58±2.22). On day nineteen, control fruits had a higher weight loss (42.04±0.01) compared to the treated fruits (36.35±1.54). On day twenty two, control fruits had a higher weight loss (45.28±0.02) compared to the treated fruits (39.21±0.51). The highest weight loss observed on UTC variety was observed at day22 (45.28±0.02) as shown in table 2a.

For Shase variety, no significant difference (p>0.05) in weight loss was observed between treated and control fruits within the storage duration. The highest weight loss was observed on day twenty two for both treated and control fruits expressed as (45.16±6.14) and (42.45±0.01) respectively as shown in table 2b. For Hoozua variety, no significant difference (p > 0.05) in weight loss was observed within all the days between treated and control tomato fruits except on day five. The highest weight loss was observed on day twenty two for both treated and control fruits expressed as (53.51±6.01) and (59.48±0.01) respectively as shown in table 2c.

**Table 2a.** Weight evaluation UTC variety of tomato fruit during storage

| | **Storage duration (DAYS)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **UTC** | 4.95±0.13 | 9.75±1.17* | 17.0±3.42* | 20.75±4.49 | 25.35±4.22 | 28.96±2.31 | 30.69±2.28 | 32.58±2.22 | 36.35±1.54 | 39.21±0.51 |
| **Control** | 5.23±0.01* | 7.44±0.01 | 11.22±0.01 | 27.36±0.01* | 33.82±0.01* | 36.51±0.01* | 36.50±0.01* | 39.10±0.01* | 42.04±0.01* | 45.28±0.02* |
| **LSD(0.05)** | 0.18 | 1.21 | 2.61 | NS | 1.42 | 5.23 | 3.71 | 3.42 | 2.68 | 4.04 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 2b.** Weight evaluation Shase variety of tomato fruit during storage

| | **Storage duration (DAYS)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Shase** | 4.42±0.27 | 8.81±1.99 | 11.84±1.46 | 17.96±3.29 | 21.86±5.57 | 27.29±5.75 | 31.68±7.82 | 36.10±9.33 | 41.31±5.86 | 45.16±6.14 |
| **Control** | 4.63±0.01 | 8.63±0.01 | 14.10±0.02 | 20.14±0.01 | 25.23±0.01 | 27.34±0.01 | 33.57±0.01 | 37.02±0.01 | 42.46±0.01 | 42.45±0.01 |
| | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*NS= No Significant difference where (p>0.05); Values are Mean ± SD (in 3 determinations)*

**Table 2c.** Weight evaluation of Hoozua variety of tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Hoozua** | 4.62 ±1.08 | 8.54±1.54 | 14.38±4.55 | 17.80±6.75 | 24.79±10.14 | 34.16±9.43 | 37.63±10.26 | 43.05±6.97 | 48.36±5.91 | 53.51±6.01 |
| **Control** | 5.54±0.01 | 11.30±0.17* | 14.15±0.01 | 18.90±0.02 | 21.89±0.01 | 32.87±0.11 | 44.51±0.01 | 49.19±0.01 | 55.27±0.01 | 59.48.0.01 |
| **LSD(0.05)** | NS | 1.34 | NS | NS | NS | NS | NS | NS | NS | NS |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

## 4.3. Postharvest decay of tomato fruits during storage

Postharvest decay of tomato fruits during storage showed that there was significant difference with respect to UTC variety between treated and control fruits except on day3, 5 and 7. On day 9, the highest post-harvest decay was observed on control fruits 5(50.0%) compared with the treated fruits 3(30.0%). On day 11, the highest post-harvest decay was observed on the control fruits 7(70.0%) compared with treated fruits 4(40.0%). On day13, the highest post-harvest decay was observed on the control fruits 8(80.0%) compared with the treated fruits 5(50.0%). On day15, the highest post-harvest decay was observed on the control fruits 9(90.0%) compared with the treated fruits 5(50.0%). On day 17, the highest post-harvest decay was observed on the control fruits 9(90.0%) compared with the treated fruits 6(60.0%). %). On day19, the highest post-harvest decay was observed on the treated fruits 6(60.0%) compared with the control fruits 10(100.0%). On day 22, the highest post-harvest decay was observed on the treated fruits 6(60.0%) compared with the control fruits with no post-harvest decay. The highest decay was recorded on day19 on the control fruits 10(100.0) while the least was recorded on the treated fruits on day 5 and 7 with decay of 2(20.0%) respectively. No fruit decay was observed on treated fruits on day3 and control fruits on day22 as shown in table 3a.

With respect to Shase variety, significant difference in post-harvest decay was observed within all the days between treated and control tomato fruits except on day 3, 5, 11, 13 and 15. On day 7, the highest postharvest decay was observed on the control fruits 5(50.0%) compared with the treated fruits 2(20.0%). On day 9, the highest post-harvest decay was observed on the control fruits 8(80.0%) compared with the treated fruits 3(30.0%). On day17, the highest post-harvest decay was observed on control fruits 10(100.0%) compared with the treated fruits 7(70.0%). On day19 and day 22, the highest post-harvest decay of 70(70.0%) was observed on the treated fruits while the control fruits showed no decay. No fruit decay was observed on treated fruits on day 3 and control fruits of day19 and day 22 as shown in table 3b.

The Hoozua variety showed significant difference ($p<0.05$) in postharvest decay on all the storage days between treated and control tomato fruits except on days 3 and 5. On day 7, highest post-harvest decay was observed on the control fruits 50 (50.0%) compared to the treated fruits 30 (30.0%). On day 9, highest post-harvest decay was observed on the control fruits 80(80.0%) compared with the treated fruits 40 (40.0%). On day 11, highest post-harvest decay was observed on the control fruits 90 (90.0%) compared with the treated fruits 60 (60.0%). On day15, highest post-harvest decay was observed on the control fruits 10 (100.0%) compared with the treated fruits 70(70.0%). On day17 and 19, highest postharvest decay of 70 (70.0%) was observed on the treated fruits while no post-harvest decay was observed on each of the control fruits. On day 22, the highest postharvest decay was observed on the treated fruits 80(80.0%) while no post-harvest decay was observed on the control fruits. The highest decay was recorded on day15 on the control fruits; 10(100.0) while the least was recorded on the treated fruits of day 3; 1(10.0%). No decay was observed on the control fruits of day17, 19 and 22 as shown in table 3c.

**Table 3a.** Postharvest decay of UTC variety tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **UTC** | - | 2(20.0) | 2(20.0) | 3(30.0) | 4(40.0) | 5(50.0) | 5(50.0) | 6(60.0) | 6(60.0) | 6(60.0)* |
| **Control** | 1(10.0) | 3(30.0) | 4(40.0) | 5(50.0)* | 7(70.0)* | 8(80.0)* | 9(90.0)* | 9(90.0)* | 10(100.0)* | - |
| **LSD(0.05)** | NS | NS | NS | 1.0 | 2.0 | 1.0 | 2.0 | 1.0 | 3.0 | 4.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 3b.** Postharvest decay of Shase variety tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Shase** | - | 2(20.0) | 2(20.0) | 3(30.0) | 6(60.0) | 5(50.0) | 6(60.0) | 7(70.0) | 7(70.0)* | 7(70.0)* |
| **Control** | 1(10.0) | 3(30.0) | 5(50.0)* | 8(80.0)* | 8(80.0) | 9(90.0) | 9(90.0) | 10(100.0)* | - | - |
| **LSD(0.05)** | NS | NS | 1.0 | 2.0 | NS | NS | NS | 2.0 | 4.0 | 2.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 3c.** Postharvest decay of Hoozua variety tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Hoozua** | 1(10.0) | 2(20.0) | 3(30.0) | 4(40.0) | 6(60.0) | 6(60.0) | 7(70..0) | 7(70.0)* | 7(70.0)* | 8(80.0)* |
| **Control** | 2(20.0) | 3(30.0) | 5(50.0)* | 8(80.0)* | 9(90.0)* | 9(90.0)* | 10(100.0)* | - | - | - |
| **LSD(0.05)** | NS | NS | 1.0 | 2.0 | 2.0 | 1.0 | 1.0 | 3.0 | 3.0 | 4.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

### 4.4. Marketability of tomato fruits during the storage duration

Marketability of tomato fruits within the storage duration revealed that the UTC variety showed significant difference ($p < 0.05$) between treated and control tomato fruits except on days 3, 5 and 7. On day 9, the highest marketability was observed on the treated fruits with 7 (70.0%) compared with the control fruits 5 (50.0%). On day11, the highest marketability was observed on the treated fruits with 6 (60.0%) compared with the control fruits 3 (30.0%). On day13, the highest marketability was observed on the treated fruits with 5(50.0%) compared with the control fruits 2 (20.0%). On day 15, the highest marketability was observed on the treated fruits 5 (50.0%) compared with the control fruits 1(10.0%). On day17, the highest marketability was observed on the treated fruits 4 (40.0%) compared with the control fruits 1(10.0%). On day 19 and 22, the highest marketability was observed on the treated fruits 4 (40.0%) respectively while no marketability was observed for the control fruits as shown in table 4a.

For the Shase variety, no significant difference ($p > 0.05$) in marketability between treated and control tomato fruits were observed within the storage duration except on days 9, 19 and 22. On day 9, the highest marketability of 7 (70.0%) as observed on the treated fruits compared to the control fruits 2 (20.0%). On day 17, 19 and 22 the highest marketability of 3 (30.0%) was observed on the treated fruits while no marketability was observed on each of the control fruits. The highest marketability of 9 (90.0%) was observed on day 3 for both treated and control fruits while the least; 1(10.0%) was observed on the control fruits for days 13 and 15. No marketability was observed for the control fruits on days17, 19 and 22 as shown in table 4b.

For the Hoozua variety, no significant difference ($p < 0.05$) in marketability was observed between treated and control tomato fruits except on days 9, 11, 13, 15 and 17. On day 9, the highest marketability of 6 (60.0%) was observed on the treated fruits compared to the control fruits; 2 (20.0%). On day11, the highest marketability of 4 (40.0%) was observed on the treated fruits compared with the control fruits 1(10.0%). Also on day 13, the highest marketability of 4 (40.0%) was observed on the treated fruits compared with the control fruits 1(10.0%). On day15 and 17, the highest marketability of 3 (30.0%) was observed on the treated fruits while no marketability was observed on each of the control fruits. The highest marketability of 9 (90.0%) for Hoozua variety was observed on the treated fruits on day 3 while the least of 1 (10.0%) was on control fruits on days 11 and 13 respectively as shown in table 4c.

**Table 4a.** Marketability of UTC variety of tomato within storage duration

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **UTC** | 10(100.0) | 8(80.0) | 8(80.0) | 7(70.0)* | 6(60.0)* | 5(50.0)* | 5(50.0)* | 4(40.0)* | 4(40.0)* | 4(40.0)* |
| **Control** | 9(90.0) | 7(70.0) | 6(60.0) | 5(50.0) | 3(30.0) | 2(20.0) | 1(10.0) | 1(10.0) | - | - |
| **LSD(0.05)** | NS | NS | NS | 1.0 | 2.0 | 1.0 | 3.0 | 2.0 | 3.0 | 3.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 4b.** Marketability of Shase variety of tomato within storage duration

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Shase** | 9(90.0) | 8(80.0) | 8(80.0) | 7(70.0) * | 5(50.0) | 5(50.0) | 4(40.0) | 3(30.0) * | 3(30.0) * | 3(30.0) * |
| **Control** | 9(90.0) | 7(70.0) | 5(50.0) | 2(20.0) | 2(20.0) | 1(10.0) | 1(10.0) | - | - | - |
| **LSD(0.05)** | NS | NS | NS | 4.0 | NS | NS | NS | 1.0 | 1.0 | 1.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 4c.** Marketability of Hoozua variety of tomato within storage duration

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Hoozua** | 9(90.0) | 8(80.0) | 7(70.0) | 6(60.0) * | 4(40.0) * | 4(40.0) * | 3(30.0) * | 3(30.0) * | 2(20.0) | 2(20.0) |
| **Control** | 8(80.0) | 7(70.0) | 5(50.0) | 2(20.0) | 1(10.0) | 1(10.0) | - | - | - | - |
| **LSD(0.05)** | NS | NS | NS | 2.0 | 2.0 | 2.0 | 1.0 | 1.0 | NS | NS |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

## 4.5. Firmness of tomato fruits during storage

For UTC variety, no significant difference ($p > 0.05$) in firmness between treated and control fruits were observed except on days19 and 22 in which significant scores ($p< 0.0$) were noted. On days19 and 22, the treated fruits had a score of 3(Acceptable) respectively while no firmness was recorded on each of the control fruits. The highest firmness recorded during storage period of UTC variety was 4 (Good) observed on the treated fruits of days 3, 5, 7 and the control fruits of day 3 as shown in table 5a. For Shase variety, no significant difference in firmness was observed between treated and control fruits at ($p > 0.05$). However, the highest firmness was observed on both treated and control fruits of day 3 with a rating of 4 (Good) respectively as shown in table 5b. For Hoozua variety, no significant difference ($p < 0.0$) in firmness of fruits was observed within the storage duration. However, the highest firmness was observed on the control fruits on days 3 and 5 with a firmness rating of 4 (Good) respectively as shown in table 5c.

**Table 5a.** Firmness of UTC variety of tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **UTC** | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3* | 3* |
| **Control** | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | - |
| **LSD(0.05)** | NS | NS | NS | NS | NS | NS | NS | NS | 2.0 | 2.0 |

**Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations) Key: 1=very poor, 2=poor, 3=acceptable, 4=good, 5=Excellent*

**Table 5b.** Firmness of Shase variety of tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Shase** | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| **Control** | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **LSD(0.05)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*NS= No Significant difference where (p>0.05); Values are Mean ± SD (in 3 determinations); Key: 1=very poor, 2=poor, 3=acceptable, 4=good, 5=Excellent*

**Table 5c.** Firmness of Hoozua variety of tomato fruit during storage

| | Storage duration (DAYS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **22** |
| **Hoozua** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Control** | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **LSD(0.05)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*NS= No Significant difference where (p>0.05); Values are Mean ± SD (in 3 determinations); Key: 1=very poor, 2=poor, 3=acceptable, 4=good, 5=Excellent*

## 4.6. Shelflife of tomato fruits during storage

For UTC variety, the treated fruits had a higher shelf life of (22.0±0.00) days compared with (19.0±0.00) days for control fruits as shown in table 6a. For Shase variety, the treated fruits had a higher shelf life of (22.0±0.00) days compared with (17.0±0.00) days for the control fruits as shown in table 6b. For the Hoozua variety, the treated fruits had a higher shelf life of (22.0±0.00) days compared with (15.0±0.00) days for control fruits. Comparatively, all varieties treated with the botanical, had same shelf life of (22.0±0.00) days. Control fruits of Hoozua variety produced the least shelf life of (15.0±0.00) days as shown in table 6c.

**Table 6a.** Shelf life of UTC variety of tomato during storage

| **Variety** | **Shelf life (Days)** |
|---|---|
| **UTC** | 22.0±0.00 |
| **Control** | 19.0±0.00 |
| **LSD(0.05)** | NS |

*NS= No Significant difference. Values are Mean ± SD (in 3 determinations).*

**Table 6b.** Shelf life of Shase variety of tomato during storage

| **Variety** | **Shelf life (Days)** |
|---|---|
| **Shase** | 22.0±0.00* |
| **Control** | 17.0±0.00 |
| **LSD(0.05)** | 3.45 |

*Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

**Table 6c.** Shelf life of Hoozua variety of tomato during storage

| Variety | Shelf life (Days) |
|---|---|
| **Hoozua** | 22.0±0.00* |
| **Control** | 15.0±0.00 |
| **LSD(0.05)** | 4.65 |

*Means in the same column tagged with asterisk are significantly higher at (p<0.05); NS= No Significant difference. Values are Mean ± SD (in 3 determinations)*

## 4.7. Fungi isolated from tomato samples in storage

A total of three fungi were isolated from the tomato samples. They are A*spergillus niger, Fusarium Oxysporum* and *Botryodiplodia theobromae*.

## 4.8. Characterization and identification of fungi isolated from tomato samples in storage.

### *4.8.1. Aspergillus niger*

Colony texture is velvety and fast growing and bears abundant erect conidia structures, typically deep brown to black in colour. Conidiophores are hyaline and faintly brown near the apex. Conidia are hyaline and globose.

### *4.8.2. Fusarium Oxysporum*

Colony has white aerial mycelia becoming tinged in purple and having a purple to pink reverse. Colony texture is floccose; conidiophores are short, slender, hyaline and septate with abundant microconidia. Conidia are produced singly and not in chains.

### *4.8.3. Botryodiplodia theobromae*

The colony has white aerial mycelia with a milky/creamy reverse. Conidiophore is septate. Pycnidium is oval, brownish with one septum in the middle.

# 5. Discussion

The ability of Neem leaf powder to decrease the decay level of tomatoes is an indication that Neem leaf powder can serve as a possible alternative in the prevention of tomato decay by pathogens. This observation is in agreement with the reports of Raheja and Thakore (2002) who reported that extract from medicinal plants like *Allum sativum* (cloves), *Azadirachta indica* (leaves), *Mentha arvensis* (leaves) and *Psoralea Corylifolia* were found most effective in preserving plant fruits from attack by pathogenic and environmental factors. The ability of Neem leaf powder to minimize the decay of tomato fruits in this study can be attributed to the fact that the Neem leaf powder suppressed the activity of certain fungi that cause spoilage of tomato fruits. This statement is in agreement with Singh et al. (1999) who conducted an experiment on the efficiency of crude plant extracts as an alternative to commercial fungicides in the preservation of plant products.

Shelf life of the various varieties of tomato fruits considered in this study was quite significant. Shase and Hoozua varieties treated with Neem leaf powder had a significant shelf life as compared to the control fruits. The UTC variety however was not significantly different in shelf life between treated and control fruits. This can be attributed to the fact that UTC has a naturally long shelf life which cannot be significantly affected by treatment with natural plant extracts. However, treating tomato fruits with Neem leaf powder significantly increased their shelf life as seen in the number of days it took for complete spoilage of the fruits to occur. The result in this study is similar to the findings of Ejale and Abdullah (2004), who reported that treating tomato fruits with Neem significantly increased their shelf life. Irokanulo et al. (2015) also noted that tomato fruits treated with the powders of *Moringa oleifera* plant parts had an extended storage life.

Tomato fruits treated with Neem leaf powder showed low post harvest decay. This was observed in the difference between the number of decayed fruits in both treated and control tomato fruits. Control fruits were completely rotten on day 19 of storage while the treated fruits still retained their colour and number. Among the varieties of tomato fruits used for this research, the UTC variety recorded the least decay percentage after the experimental period elapsed followed by Shase and Hoozua variety. This is an implication that UTC variety withstands environmental challenges better than the other varieties of tomato while the Hoozua variety has the least resistance to environmental and pathogenic attack. This was noticed in the number of days it took for the various varieties to experience significant decay in their post-harvest decay percentages. Temperature of the storage room changed between 28.53˚C – 31.89˚C during the experimental period. The high temperature in this study can be attributed to seasonality. Thompson (1994) and Kumar et al. (1999) showed that, loss of tomatoes stored at room temperature was significantly higher than low temperature stored tomatoes. Thus, a higher temperature leads to high respiratory rate of the fruits which in turn leads to high metabolic activity and subsequently an increase in weight loss during storage.

Firmness of the tomato fruits used in the study was also considered as a quality parameter to test the preservative ability of Neem leaf powder. This is due to the fact that most buyers of tomatoes tend to feel the tomato fruits before buying especially after colour observation. In terms of firmness, only UTC variety was significantly firm after the experimental period elapsed. The other varieties lost their firmness during storage. This decrease in firmness can be attributed to the higher rate of metabolic activities and activity of cell wall degrading enzymes that loosens the fruit skin which result in higher permeability of the cell for higher rate of moisture loss.

Weight loss of the tomato varieties progressively increased during 22 days of storage at ambient temperature. Weight loss in this study ranged from 4.42-59.48% during storage. Shase and Hoozua varieties exhibited the highest percentage loss of weight while the UTC had least weight loss at the end of the experimental period. There was progressive weight loss among UTC, Shase and Hoozua varieties in the course of this research. This is in agreement with Atta-Aly and Bretch (1995) whose statement revealed that there is significant weight loss as ripening progressed. Similar findings were also reported by Meseret et al. (2012), Tefera et al. (2007) and Hiru et al. (2008) that weight loss of fruits increased as storage period advanced. The variation in weight loss among the different varieties considered could be due to the variation in the pericarp thickness as thin pericarp leads to aggravating weight loss and rate of respiration among the varieties because higher rate of respiration is related to higher loss of stored food and dry matter of the fruits. Thick pericarp on the other hand, reduces weight loss as evident in the UTC variety thus reducing the degree of moisture loss and shriveling. Weight loss difference among tomato varieties in this study is also attributed to the genetic makeup of the various varieties of tomato fruits and rate of loss of water through transpiration.

The study showed that a number of fungi are associated with post-harvest rot of tomato fruits in storage. They include *Aspergillus niger, Fusarium species* and *Botryodiplodia theobromae*. They have been previously reported as pathogens of tomato fruits by Ogo-Oluwa and Liamngee (2016) who isolated and identified *Aspergillus niger* and *Fusarium* spp from decayed tomato fruits. Also, Ijato et al., (2011) isolated *Aspergillus* and *Fusarium spp* from rotten tomato fruits. Onuorah and Orji (2015) also reported that *Aspergillus niger* and *Fusarium spp* were isolated from rotten tomato fruits. Olaniran et al. (2014) also isolated *Aspergillus niger, Fusarium spp* and *Botryodiplodia theobromae* in orange fruits. These pathogens have been reportedly isolated from Sour-sop fruits and Orange fruits in Nigeria.

These results clearly demonstrate that these pathogens are omnipresent irrespective of geographical area and involved in tomato rot. Association of these fungi with different types of fruits indicates that these fungi are not host specialized. They may be found anywhere food is available. This agrees with the work of Liamngee et al. (2015) who isolated *Aspergillus niger* and *Botryodiplodia theobromae* from garri.

## 6. Conclusion

Results obtained from this study show that Neem leaf powder is able to extend the shelf life and quality of tomato fruits beyond their known natural limits. This has provided baseline information on the use of plant leaves in post-harvest preservation of fruits. However, this study did not address the in vitro and in vivo potential of the leaf extract to prevent disease development on the tomato fruits. Further research should be carried out to determine the phytochemicals present in the leaf powder which could serve as possible explanations for the effect of the powder on the tomato fruits.

## References

Atta-Aly, M. and Brecht, J. (1995), "Effects of Postharvest high temperature on tomato fruit ripening and quality", *Advances in Applied Science Research*, Vol. 2 No.4, pp. 217-220.

Babalola, D., Makinde, Y., Omonona, B. and Oyekanmi, M. (2010), "Determinants of postharvest losses in tomato production: a case study of Imeko-Afon local government area Ogun State", *Acta SATECH,* Vol. 3, pp. 14-18.

Barnett, H.L. and Barry, B. (1999), Illustarted genera of imperfect fungi, 4th ed. t. paul, Minn., APS press, pp. 23-24.

Ebimieowei, E., Nwauzoma, A. and Bawo, D. (2013a), “Postharvest Spoilage of Tomato (*Lycopersicon esculentum* Mill.) and Control Strategies in Nigeria”, *Journal of Biology, Agriculture and Healthcare*, Vol. 3 No. 10, pp. 51-52.

Ejale, A. and Abdullah, H. (2004), “Preservation of ripe tomato (*Lycopersicon esculentum* Mill) fruits with dried leaf powder of Neem (*Azadirachta indica* A. Juss)”, *Nigerian Journal of Applied Science,* Vol. 22, pp. 344-350.

Hiru, G., Seyoum, T. and Kebede, W. (2008), “The effect of cultivar, maturity stage and storage environment on quality of tomatoes”, *Ethiopian Journal of Food Engineering,* Vol. 87 No. 4, pp. 467- 468.

Ijato, J., Otoide, J., Ijadunola, J. and Aladejimokun, A. (2011), “Efficacy of antimicrobial effect of *Vernonia amygdalina* and *Tridax procumbens* in invitro control of tomato (*Lycopersicon esculentum*) post-harvest fruit rot”, *Report and Opinion*, Vol. 3 No. 1, pp. 120-123.

Irokanulo, E., Egbezien, I. and Owa, S. (2015), “Use of *Moringa oleifera* in the preservation of Fresh Tomatoes”, Journal *of Agriculture and Veterinary Science*, Vol. 8 No. 2, pp. 127-132.

Kumar, A., Ghuman, B. and Gupta, A. (1999), “Non-refrigerated storage of tomatoes: effect of HDPE film wrapping” *Journal of Food Science and technology*, Vol. 36, pp. 438-440.

Liamngee, K., Onah, D. and Zakki, H. (2015), “Evaluation of three plant extracts in the control of fungal pathogens isolated from Garri (fried mashed fermented cassava) in Makurdi, Nigeria”, *Archives of Applied Science Research*, Vol. 7 No. 9, pp. 6-12.

Meseret, D., Ali, M. and Kassahun, B. (2012), “Evaluation of Tomato (*Lycopersicon esculentum* Mill) Genotypes for fruit quality and shelf life”, *The African Journal of Plant Science and Biotechnology,* Vol. 3, pp. 50-56.

Ogo-Oluwa, A. and Liamngee, K. (2016), “Evaluation of bitter leaf (*Vernonia amygdalina*) extract in the inhibition of fungi causing post-harvest rot of tomato fruits in Makurdi, Benue State, Nigeria”, *Der Pharmacia Lettre*, Vol. 3 No.11, pp. 69-73.

Olaniran, O., Ojo, O. and Odelade, K. (2014), “Survey of the Post-Harvest Diseases and Aflatoxin Contamination of Marketed Orange Fruit (*Citrus* sp) in major Cities in Oyo State, Nigeria”, *Journal of Agriculture and Veterinary Science*, Vol. 7 No. 8, pp. 27-31.

Onuorah, S. and Orji, M. (2015), “Fungi Associated with the Spoilage of Post-Harvest Tomato Fruits Sold in Major Markets in Awka, Nigeria”, *Universal Journal of Microbiology Research,* Vol. 3 No. 2, pp. 11-12.

Raheja, S. and Thakore, B. (2002), “Effect of physical factor, plant extracts and bioagent on *Colletotrichum gloeosporioides* Penz, the causal organism of anthracnose of Yam”, *Journal of Mycology and Plant Pathology*, Vol. 32, pp. 293-294.

Singh, H., Korpraditskul, D. and Singh, P. (1999), “Evaluation of some plant extracts for control of Colletotrichum capsici the causal agent of *Chilli anthracnose”*, *Journal of Science and Food Agriculture*, Vol. 55, No. 5, pp. 1-2.

Sood, M., Kaul, R., Bhat, A, Singh, A. and Singh, J. (2011), “Effect of harvesting methods and postharvest treatments on quality of tomato”, *Journal of Food Science and Technology*, Vol. 12 No. 1, pp 58-62.

Tefera, A., Seyoum, T. and Woldetsadik, K. (2007), "Effect of disinfection, packaging and storage environment on the shelf life of mango", *Biosyst. Eng,* Vol. 96 No. 2, pp. 201-212.

Thirupathi, V., Sasikala, S. and John, K. (2006), "Preservation of fruits and vegetables by Wax coating", *Journal of Science and Food Agriculture*, Vol. 55 No. 3, pp. 1-10.

Thompson, J. (1994), "Ethylene control in storage facilities", *Perishables handling newsletter*, New York.