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Research Article


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# Effect of postharvest application of plant powders on physical quality and shelf life of okra during storage in Makurdi

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## ABSTRACT

The effect of postharvest application of plant leaf powders on the physical quality and shelf life of okra fruits during Storage in Makurdi was determined. Moringa and Neem leaf powders were used to coat the okra fruits, which were then kept at room temperature. The experiment was a 2 x 3 factorial combination of treatments, fitted in a completely randomized design, and replicated thrice. Data collected were subjected to Analysis of variance (ANOVA) using GENSTAT statistical package, and Fisher's Least Significant Difference (F-LSD) at a 5% level of probability to separate the means. Results revealed that plant leaf powders of *Azadirachta indica* (Neem) and *Moringa oleifera* have the ability to enhance the shelf life and maintain the physicochemical quality of okra fruits under storage. These powders also have the potential to be antifungal. Among the okra varieties studied, Clemson spineless gave better physical quality as compared to stubby okra thus the shelf life during storage. Treated okra shelf life extended to day 15 whereas the untreated fruits ranged from 1 - 7 days. These botanicals offer alternatives for maintaining crop management and postharvest physiology in addition to being safe for consumers, inexpensive, easy to create, and easy to apply formulations. It is therefore recommended the use of plant leaf powders particularly *M. oleifera* for the storage of okra fruits in Makurdi.

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## INTRODUCTION

Okra plant or lady's finger (*Abelmoschus esculentus* L. Moench) belongs to the genus Hibiscus, section Abelmoschus in the family Malvaceae (Singh *et al*., 2014). Its origin had been reported to be Ethiopia and was cultivated by the ancient Egyptians by the $12^{th}$ century B.C. Its cultivation spread throughout the Middle East and North Africa (Tindall, 1983; Lamont, 1999). It is one of the most commonly grown vegetable crops in the Tropics (Udoh *et al*., 2005) and the second most important vegetable in the West African market after tomatoes (Ubani & Okonkwo, 2011; Kelechi *et al*., 2013). Okra pods have the following nutrients per 100 g of edible portion: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fiber 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 g, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg (Owolarafe & Shotonde, 2004; Gopalan *et al*., 2007; Dilruba *et al*., 2009; Saifullah & Rabbani, 2009) which plays a vital role in the human diet (Kendall & Jenkins, 2004; Kahlon *et al*., 2007; Stylecraze, 2018). Nigeria is the largest producer in Africa and the second-largest producer of okra in the world, according to production (Factfish, 2016).

Due to its high respiration rate at warm temperatures, loss in quality and short shelf life are important issues when marketing fresh okra in Nigeria. Postharvest okra wastage has been reported to be around 38% (Farinde *et al*., 2006). Similarly, Fresh okra fruits have a short shelf life, only lasting 7 to 10 days even when stored at temperatures between $7^0$ and $10^0$C, according to Katende (2006). Fruit rot carried on by fungal plant disease causes significant postharvest losses of fruit. Inhibiting the growth of fungi is therefore crucial for postharvest fruit, but synthetic fungicide use has recently raised consumer concerns, and its use is becoming more limited due to their carcinogenic effects, residual toxicity issues, environmental pollution, the occurrence of microbial resistance, and high inputs cost (Diánez *et al*., 2002; Marín *et al*., 2003; Rial-Otero *et al*., 2005). One of the alternate techniques is the use of plant extracts or powders with fungicidal and insecticidal characteristics. The use of this powder/extracts acts as a semi-permeable barrier to control the diffusion of oxygen and carbon dioxide into and out of the fruit, slowing metabolism and avoiding water loss thus controlling fruit rot and extending shelf life (Alleyne & Hagenmaier, 2000).

## RELATED WORKS

Plants include a variety of phytochemical compounds, including vitamins, terpenoids, phenolics, lignins, stilbenes, tannins, flavonoids, quinones, coumarins, alkaloids, amines, betalains, and other metabolites that are rich sources of free radical scavengers (Cai *et al*., 2003; Gracelin *et al*., 2012). Additionally, these chemicals have antioxidant properties and anti-inflammatory, anti-atherosclerotic, anti-tumor, anti-mutagenic, anti-carcinogenic, antibacterial, and antiviral properties (Sala *et al*., 2002; Gracelin *et al*., 2012). Moreover, consuming natural antioxidants has been linked to lower chances of diabetes, cancer, cardiovascular disease, and other age-related disorders (Ashokkumar *et al*., 2008). Therefore, the study objective was to look at the phytochemical analysis of certain plant powders, as well as their post-harvest application on physical parameters and shelf life of okra during storage.

According to reports, plant extracts and their analogs are significant sources of agricultural biopesticides (Taiga & Friday, 2009). Ijalo *et al.* (2010) claimed that leaves, spices, herbs, and other plant materials have antifungal action. A thin coating of plant leaf/flower extract/powder is coated around each fruit, acting as a semi-permeable barrier to control the diffusion of oxygen and carbon dioxide into and out of the fruit, slowing down metabolism and avoiding water loss (Alleyne & Hagenmaier, 2000; Malik *et al*., 2015).

In their study on the postharvest application of aqueous extracts of neem, chinaberry, and marigold on physical parameters and shelf-life of guava, Malik *et al.* (2015) found that neem application resulted in the least amount of guava spoilage when compared to other extracts. Additionally, the fruit's color and flavor were acceptable for up to 16 days of storage, as opposed to just the first 8 days of storage in the control group. According to Irokanulo *et al.* (2015), plant powders made from stem and leaf bark preserved tomatoes more effectively (p 0.05) than seed powder. Therefore, the results show that powder made from *Moringa oleifera*'s leaf and stem bark was said to have antibacterial qualities and can be utilized as a preservative to lengthen the shelf life of fresh tomatoes. Similar to this, Kator *et al.* (2019) demonstrated that tomato fruits treated with aqueous extracts of moringa showed noticeably lower postharvest decay compared to the control, and they came to the conclusion that aqueous extracts of moringa leaves have antifungal potential and can extend the shelf life and preserve the quality of tomato fruits during storage. In Tesfay *et al.* (2017) research on avocado, carboxymethylcellulose (CMC), which contains moringa leaf and seed extract, suppresses or delays postharvest diseases and improves avocado's shelf life when stored. On the effectiveness of *Moringa oleifera* leaf powder against the *Callosobruchus maculatus* (F.) cowpea beetle in storage. Dimetry and El-Behery (2018), reported that the application of moringa leaf powder greatly increased *C. maculatus* mortality, and they draw the conclusion that, under the right storage circumstances, moringa powder might be utilized to successfully manage cowpea beetles. More so, on the shelf-life and quality of okra, Moses and Blessing (2020), showed that while preserving the physicochemical properties of the okra fruits during storage, plant leaf powders of Neem and Moringa can extend the shelf life of okra by up to 15 days.

## MATERIALS AND METHODS

The experiment was conducted in the Benue State University's biological laboratory in Makurdi. Okra fruits were carefully hand-picked at the breaker stage from commercial farms in Makurdi. The fruits were chosen for their similar sizes, maturity level, and lack of obvious signs of disease or abnormalities. Fresh leaves of *Azadirachta indica* (Neem) and *Moringa oleifera* (Drumstick tree) were gathered from various areas within Makurdi city. Each plant's leaves were meticulously prewashed in the lab for one to two minutes using a mild stream of tap water to eliminate any surface debris. After that, the leaves were washed for 30 seconds in sterile, distilled water that contained 1 percent sodium hypochlorite. After that, the leaves were taken out and cleaned three times in sterile distilled water. Before being ground into a powder form with a mortar and pestle and then a blender, the plant leaves were cleansed and let to air dry for 7 days. Each plant's powders were maintained in their own lockers, which were kept free of dust, and in clean, well-covered jars. To remove dirt, the two varieties of firm, smooth, and healthy okra fruits were rinsed in clean water and let to air dry prior to treatment. The okra fruits were coated or treated by dipping them in the powders of each plant species. The fruits were taken out, put in plastic crates with wooden racks, and stored at room temperature. The experiment was 2 x 3 factorial combinations of treatments laid in a completely randomized design (CRD) and replicated thrice. The two okra types were Clemson spineless and Stubby, and the fruits were treated with powders made from the leaves of Moringa and Neem while a control group received no treatment with either Neem or Moringa. There were 6 different treatment combinations for each type. There were 18 treatment combinations in each replication.

The phytochemical analysis was carried out qualitatively and quantitatively using different standard methods in order to identify the secondary metabolites present in the sample such as tannins, phenols, saponins, alkaloids, flavonoids, terpenoids, steroids and glycosides. During the storage period, physical measurements of the okra fruit's weight (g), firmness (measured with a penetrometer), pH, and shelf life were made. GENSTAT statistical software was used to analyze the data using Analysis of Variance (ANOVA), and the Fisher's least significant difference was employed to separate the means at the 5% level of significance.

## RESULTS AND DISCUSSION

Table 1 shows the phytochemical properties of Moringa leaf powder and Neem leaf powder. The phytochemical screening showed that both Moringa leaf and Neem leaf powder were made up of tannins, phenolics, flavonoids, glycosides, and terpenoids. Only the Moringa leaf powder had alkaloids, and only the Neem leaf had steroids and saponin. This study confirms what other studies have found: that Moringa and Neem plant leaf powders have antifungal properties (Imaran *et al.*, 2010; Irokanulo *et al.*, 2015; Kator *et al.*, 2018). Plant powders or extracts also have antibacterial, antimicrobial, and antifungal properties, which could make fruits last longer and keep their physicochemical quality while they are being stored (Irokanulo *et al.*, 2015; Kator *et al.*, 2018). Malik *et al.* (2016) also said that plant leaf powders have fungicidal and insecticidal properties and are an important source of agrochemicals used to control diseases and insect pests that happen after harvest.

The weight loss of okra fruits during storage was significantly affected by variety and plant leaf powders ($P \leq 0.05$) (Table 2). However, the interaction effect of variety and plant leaf powders (Figures 1 & 2) on okra fruit weight loss during storage did not differ significantly ($P \geq 0.05$). Similarly, the effect of variety on okra fruit weight decrease was not significant (P0.05) on days 3, 6, and 12. When variety was considered, Stubby okra lost more fruit weight than Clemson spineless on all days of storage, and the difference was statistically significant at 12 and 15 days of storage. Despite the fact that there was no significant difference on days 3, 6, and 9, Stubby okra lost more weight (Table 2). In terms of plant leaf powders, untreated (control) okra fruits lost the most weight during storage, while Moringa fruits lost the least weight over the course of the days studied. Okra fruits lost the least weight after moringa treatment, regardless of variety, and the weight loss decreased progressively over the storage days (Table 2). In general, the weight loss of okra fruits decreased with storage time, decreasing from 77.32 g to 10.80 g (Figures 1 & 2). Over the storage period, both treated and untreated okra fruits lost weight. Nonetheless, Moringa-treated okra had the lowest weight loss, followed by Neem-treated samples. The fact that the control samples had the greatest weight loss implied that the leaf powders were effective in minimising weight loss, which improved shelf life. The hygroscopic properties of plant leaf powders are the foundation for these beneficial effects because they enable the construction of a barrier to water diffusion between the fruit and the environment, preventing external transference. This supports the findings of Zekrehiwot *et al.* (2017) and Kator *et al.* (2018) that a moringa, neem, and bitter leaf covering was effective in preventing weight loss and lowering the respiration rate of tomatoes during postharvest storage. Weight loss differences between varieties could be attributed to differences in the genetic makeup of the okra varieties and the rate of water loss through transpiration. Thus, the use of plant powder coatings can increase the shelf life of fresh-cut products by creating a semi-permeable barrier to gases and water vapour and thus lowering respiration and water loss.

Plant leaf powders and variety had a significant effect on okra firmness at days 3, 6, 9, and 12 during storage ($P<0.05$), but not at day 15. However, variety and plant leaf powders did not affect okra fruit firmness on any storage day ($P>0.05$). Table 3 shows that Clemson spineless okra had the highest firmness

**Table 1: Phytochemical Screening of Moringa and Neem Leaf powder**

| Parameters | Moringa leaf powder | Neem leaf powder |
|---|---|---|
| Alkaloid | + | - |
| Flavonoid | + | + |
| Saponins | - | + |
| Tannin | + | + |
| Glycoside | + | + |
| Terpenoids | + | + |
| Steroids | - | + |
| Phenol | + | + |

Key: + Present, - Absent

**Table 2: Effect of Plant Leaf Powders and Variety on Okra Fruit Weight Loss During Storage in Makurdi**

| Variety | Weight Loss (g) | | | | |
|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 (Days) |
| Clemson spineless | 71.75 | 59.08 | 42.11 | 23.72 | 12.41 |
| Stubby okra | 73.12 | 59.78 | 43.44 | 25.71 | 13.69 |
| F-LSD ($P \leq 0.05$) | NS | NS | NS | 1.73 | 1.00 |
| F.Pr | 0.543 | 0.297 | 0.174 | 0.031 | 0.022 |
| Leaf Powders | | | | | |
| *Moringa* | 66.79 | 54.26 | 39.71 | 22.59 | 11.84 |
| Neem | 74.06 | 59.49 | 42.39 | 24.58 | 13.15 |
| Control | 76.51 | 64.55 | 46.22 | 26.98 | 14.12 |
| F-LSD ($P \leq 0.05$) | 3.82 | 3.42 | 2.63 | 2.12 | 1.22 |
| F.Pr | 0.003 | 0.002 | 0.004 | 0.009 | 0.012 |

F-LSD – Fisher's Least Significant Difference at 5% level of Probability; NS – Not Significant; F.Pr – is the probability value corresponding to a variance ratio

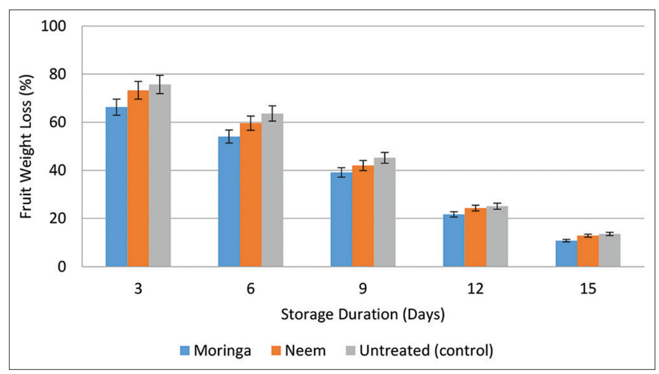


**Figure 1:** Effect of Clemson spineless x Powder Applications on Okra Fruit Weight Loss during storage

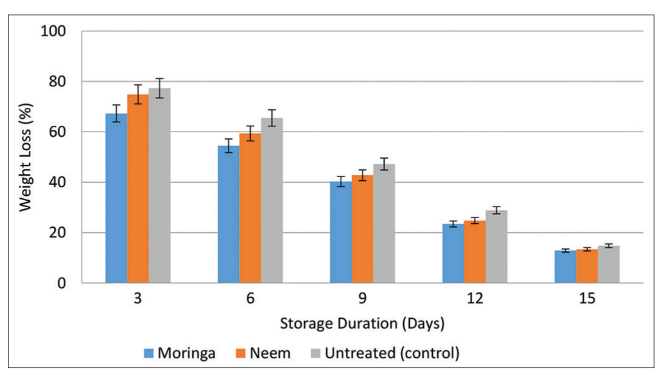


**Figure 2:** Effect of Stubby Okra and Powder Applications on Okra Fruit Weight Loss during storage

Table 3: Effect of Variety and Plant Leaf Extracts on the Firmness of Okra Fruit during storage in Makurdi

| Variety | Firmness (N/cm) | | | | |
|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 (DAYS) |
| Clemson spineless | 2.07 | 1.53 | 0.83 | 0.42 | 0.02 |
| Stubby okra | 1.82 | 1.28 | 0.55 | 0.28 | 0.00 |
| F-LSD (P≤0.05) | 0.01 | 0.15 | 0.10 | 0.09 | NS |
| F.Pr | <0.001 | 0.009 | <0.001 | 0.015 | 0.363 |
| Leaf Powders | | | | | |
| *Moringa* | 2.10 | 1.53 | 0.85 | 0.50 | 0.03 |
| Neem | 1.90 | 1.33 | 0.63 | 0.28 | 0.00 |
| Control | 1.83 | 1.38 | 0.60 | 0.28 | 0.00 |
| F-LSD (P≤0.05) | 0.07 | NS | 0.13 | 0.12 | NS |
| F.Pr | <0.001 | 0.092 | 0.007 | 0.006 | 0.431 |

F-LSD – Fisher's Least Significant Difference at 5% level of Probability, NS – Not Significant

Table 4: Effect of Varieties and Plant Leaf Powder on Okra Fruit pH During Storage in Makurdi

| Variety | pH | | | | |
|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 (DAYS) |
| Clemson spineless | 6.52 | 6.44 | 6.37 | 6.27 | 6.16 |
| Stubby okra | 6.61 | 6.50 | 6.42 | 6.29 | 6.18 |
| F-LSD (P≤0.05) | 0.01 | 0.01 | 0.02 | 0.02 | NS |
| F.Pr | <0.001 | <0.001 | <0.001 | 0.024 | 0.084 |
| Leaf Powders | | | | | |
| *Moringa* | 6.59 | 6.50 | 6.42 | 6.31 | 6.24 |
| Neem | 6.57 | 6.47 | 6.40 | 6.29 | 6.15 |
| Control | 6.54 | 6.44 | 6.36 | 6.25 | 6.11 |
| F-LSD (P≤0.05) | 0.02 | 0.01 | 0.02 | 0.02 | 0.03 |
| F.Pr | <0.001 | <0.001 | 0.003 | 0.003 | <0.001 |

F-LSD – Fisher's Least Significant Difference at 5% level of Probability; NS – Not Significant

during storage for 3, 6, 9, and 12 days, whereas Stubby had the lowest. By day 15, Clemson spineless okra was firmer than Stubby, but not significantly. On days 3, 9, and 12, Moringa produced the highest firmness value, followed by Neem, while the untreated (control) okra fruit during storage had the lowest firmness. However, moringa-treated fruits exhibited higher okra firmness scores on days 6 and 15, although not significantly (Table 3).

When plant leaf powders were examined, Moringa extract had the highest hardness value across all assessment days, but there was no statistically significant difference during storage. Untreated (control) powder had the lowest firmness value across all kinds. Storage reduces okra firmness from 3.50 to 0.00 (Figures 3 & 4). Moringa-treated okra was firmer than Neem and untreated (control). The high calcium concentration of leaf powders may boost okra fruit firmness. Since calcium plays a very essential function in cell wall formation, it contributes to fruit tissue firmness (Valero *et al*., 2003; Mishra *et al*., 2013), prevents physiological problems, reduces respiration, maintains firmness, and slows ripening (Picchioni *et al*., 1995), lengthening fruit shelf life. Thanaa *et al.* (2017) found that foliar Moringa leaf aqueous extract boosted plum firmness. Tefera *et al.* (2007), Hiru *et al.* (2008), Meseret *et al.* (2012) and Kator *et al.* (2018) also found that fruit hardness diminishes with storage time.

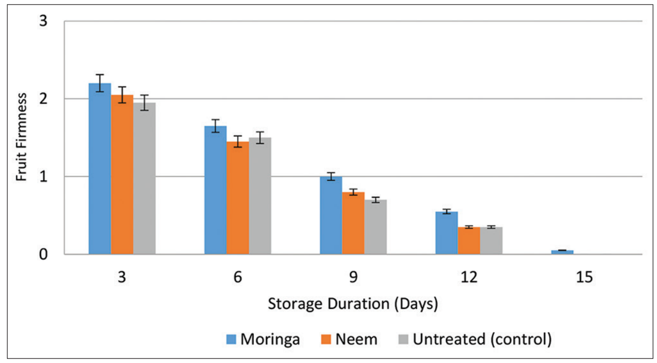


**Figure 3:** Interaction of Clemson spineless x Powder Applications on Firmness of okra fruits during storage

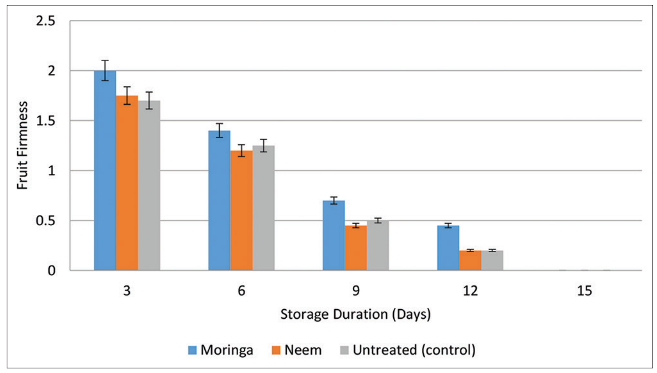


**Figure 4:** Interaction of Stubby Okra x Powder Applications on Firmness of okra fruits during storage

Plant leaf powders affected okra fruit pH on days 3, 6, 9, and 12, but not on day 15. On days 3, 6, 9, 12, and 15, the variety-plant leaf powder interaction on okra fruit pH was not statistically significant (P>0.05). Stubby okra had a higher pH than Clemson spineless throughout storage, according to Table 4. From 3 to 15, okra pH dropped. Okra fruits treated with Moringa had the highest pH value (6.59) on day 3, followed by Neem, while untreated (control) fruits had the lowest pH (6.11) on day 15. Figures 5 and 6 show that the interactions were similar on all days. On days 3–15, Moringa-treated okra fruits had the greatest pH value, however, the change was only noticeable compared to Neem and the control (Figures 5 & 6). As storage time increased, fruit pH values fell. Okra acidity gives it flavour. Stubby okra has a higher pH than Clemson spineless. Moringa and neem treatments increased the pH of okra fruits during storage. Storage dropped pH from 6.63 to 6.11. This study confirms the reports of Babarinde and Fabunmi (2009) found a pH drop from 6.7 to 6 in okra fruits preserved in LDPE films for 9 days. Also, okra coated with nanoparticles and chitosan had a pH reduction of 1.02 % by the twelfth week, according to Laila *et al.* (2018). Athmaselvi *et al.* (2013) also found that tomato fruits treated with aloe vera retained pH better than untreated ones.

Okra's shelf life was not affected by variety or plant powders on days 3, 6, 9, 12, and 15 (P>0.05). Table 5, Figures 7 and 8, show that treated okra fruits had a shelf life of 15 days, while untreated (control) fruits had a shelf life of 7. The moringa

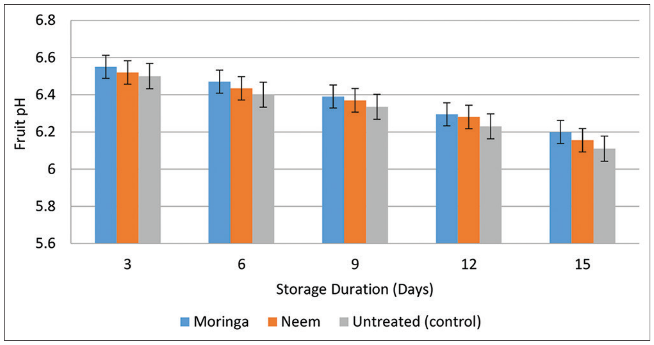


**Figure 5:** Interaction of Clemson spineless x Powder Applications on pH of okra fruits during storage

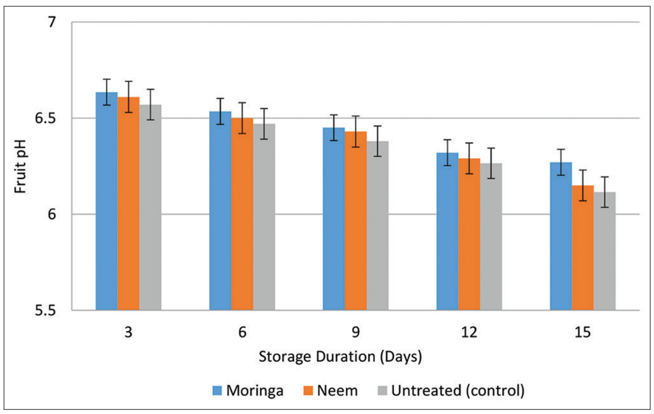


**Figure 6:** Interaction of Stubby Okra x Powder Applications on pH of okra fruits during storage

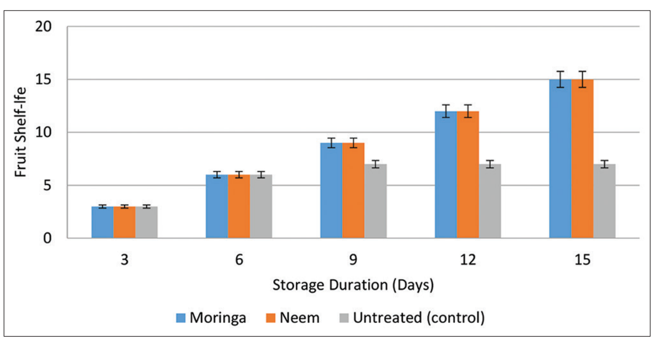


**Figure 7:** Interaction of Clemson spineless x Powder Applications on Shelf-life of okra fruits during storage

and neem leaf powder treatments and controls did not differ statistically (Figures 7 & 8). Plant leaf powders preserved okra fruit. Okra fruit freshness depended on the plant powder coating/film. Okra preserved with plant leaf powder had the longest shelf life (15 days), while untreated fruits had the shortest (7 days). They may reduce postharvest degradation (Badawy & Rabea, 2009). Mandal *et al.* (2018) found that tomato fruits covered with wax had the longest shelf life (26.33 days), followed by those coated with 2% chitosan (22.00 days). According to Kator *et al.* (2018) tomatoes covered with plant leaf powders had the longest shelf life (25 days) and untreated fruits the shortest (21 days) as this also confirms with the present study.

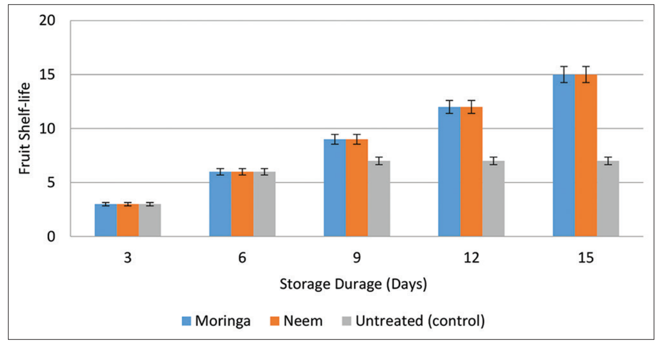


**Figure 8:** Interaction of Stubby Okra x Powder Applications on the Okra fruit Shelf-life during storage

Table 5: Effect of Variety and Plant Leaf Powders on the Shelf-Life of Okra Fruit Stored in Makurdi

| Variety | Shelf Life (Days) | | | | |
|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 (DAYS) |
| Clemson spineless | 3.00 | 6.00 | 9.00 | 12.00 | 15.00 |
| Stubby Okra | 3.00 | 6.00 | 9.00 | 12.00 | 15.00 |
| F-LSD ($P \leq 0.05$) | NS | NS | NS | NS | NS |
| F.Pr | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Leaf Powders | | | | | |
| *Moringa* | 3.00 | 6.00 | 9.00 | 12.00 | 15.00 |
| Neem | 3.00 | 6.00 | 9.00 | 12.00 | 15.00 |
| Control | 3.00 | 6.00 | 7.00 | 7.00 | 7.00 |
| F-LSD ($P \leq 0.05$) | NS | NS | NS | NS | NS |
| F.Pr | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

F-LSD – Fisher's Least Significant Difference at 5% level of Probability, NS – Not Significant; F.Pr – is the probability value corresponding to a variance ratio

## CONCLUSION

According to the study's findings, plant leaf powders of *Azadirachta indica* (Neem) and *Moringa oleifera* have the capacity to fight off fungus, extend the shelf life of okra fruits, and preserve their physical quality. Clemson spineless okra outperformed stubby okra in terms of physical quality and, thus, shelf life when stored. These botanicals offer alternatives for preserving postharvest physiology and crop management while also being safe for consumers, inexpensive, simple to create, and easy to apply formulations. This research, therefore, recommends the use of plant leaf powders particularly *M. oleifera* for the storage of okra fruits in Makurdi.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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