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EFFECT OF WOOD ASH, SAWDUST, AND MORINGA LEAF POWDER ON THE SHELF LIFE, AND SENSORY ATTRIBUTES OF TOMATO VARIETIES IN NIGERIA

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ABSTRACT

Reducing post-harvest losses is a critical challenge for food security in developing countries, particularly in communities where small-scale rural farmers lack access to advanced storage and preservation facilities. This study investigated the use of locally sourced wood ash, sawdust, and moringa leaf powder as plant-based preservatives to enhance the post-harvest shelf-life and sensory attributes of tomato varieties in Enugu, Nigeria. The tomato fruits treated with these plant-based preservatives demonstrated a significantly longer shelf life than the untreated control fruits. The efficacy of the preservatives varied: moringa leaf powder showed the highest effect (26 days) on the shelf life of the tomatoes before 100% decay, sawdust (21 days) and wood ash (20 days). Among the tomato varieties used in the study, Roma VF exhibited the longest shelf life at the end of the 28-day treatments with the plant-based preservatives. The tomatoes preserved in sawdust maintained better appearance, aroma, texture, and general acceptability, followed by those stored in moringa leaf powder, while those preserved in wood ash were rated the lowest across all sensory attributes. The preservation time was also influenced by the tomato variety, suggesting that farmers should consider the variability in spoilage between tomato varieties when using plant-based preservatives to extend tomato shelf life. Our findings highlight the potential of locally sourced wood ash, sawdust, and moringa leaf powder as alternative preservatives to mitigate post-harvest losses due to perishability, particularly when advanced storage facilities are inaccessible or unaffordable.

Keywords: preservation, tomato, shelf life, postharvest physiology, sensory attributes
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INTRODUCTION

Tomato cultivation has significantly improved the livelihoods of rural and semi-urban farmers in Nigeria (Adenuga *et al*., 2013). With approximately 541,800 hectares of land dedicated to its cultivation and an annual production of about 1.8 million metric tons, Nigeria contributes 10.8% to tomato production in Africa (Sahel, 2017). Despite the substantial production, Nigeria struggles to meet its domestic demand for tomatoes due to seasonal cultivation patterns (Adenuga *et al*.,

2013; Irokanulo *et al*., 2015) and challenges associated with post-harvest storage and preservation (Kitinoja & Gorny, 1999; Ugonna *et al*., 2015; Bakpa *et al*., 2018). In Nigeria, the tomato production value chain suffers from post-harvest losses of around 50% during peak production, leading to subsequent scarcity and resulting in low returns on investment for small-scale farmers (Ogundele, 2022; Affognon *et al*., 2015). Typically, small-scale rural farmers do not have access to good storage and preservation facilities in developing countries like Nigeria (Bakpa *et al*. 2018). Hence, perishable crops like tomatoes with short post-harvest shelf-life (Irokanulo, 2015) present economic challenges for small-scale rural farmers, especially under unfavourable market conditions.

Post-harvest preservation of tomatoes usually involves refrigeration, application of chemicals, and technologically complex modified atmosphere packaging to extend their shelf-life and maintain their physical appeal, texture, taste, and nutritional contents (Ochida *et al*., 2018). However, these methods are expensive for small-scale rural farmers and could be environmentally harmful (Ochida *et al*., 2018; Omojasola *et al*., 2022). Alternative approaches, such as the use of locally sourced extracts from Neem and Jatropha plants, moringa (*Moringa oleifera)* leaf powder and wood ash, which are cheap and less toxic to humans, have been reported to effectively extend the post-harvest shelf-life of tomatoes (Nwufo *et al*., 2014; Irokanulo, 2015; Asogwa *et al*., 2017; Bakpa *et al*., 2018; Garuba *et al*., 2018; Omojasola *et al*., 2022). Thus, to improve tomato preservation beyond its natural shelf life and reduce economic losses, it is important that small-scale rural farmers, who are the primary cultivators of commercially sold tomatoes in Nigeria, leverage indigenous plant-based resources.

Most studies on tomato preservation have focused on evaluating the effects of one or two plant extracts or agricultural by-products on a tomato variety. However, to leverage indigenous plant-based resources that are affordable, accessible, and less toxic for tomato preservation, it is essential to expand the scope and evaluate a variety of plant materials on different tomato varieties. Thus, in the present study, we assessed the use of locally accessible and affordable wood ash, sawdust, and moringa leaf powder as preservatives for improving the shelf life and sensory attributes of three commonly cultivated tomato varieties (Ogbomosho local, Ibadan local, and Roma VF) in Enugu State, Nigeria. We asked the following research questions: (1) what are the effects of locally sourced plant-based preservatives on the shelf life of the three tomato varieties? (2) do the locally sourced preservatives; wood ash, sawdust, and moringa leaf powder affect the sensory attributes (appearance, aroma, texture, and colour) of commonly cultivated tomato varieties in Enugu State, Nigeria?

MATERIALS AND METHODS

Tomato varieties, treatment materials, and study site

Locally sourced wood ash, sawdust, and moringa leaf powder were used as plant-based preservatives to improve the shelf life of the tomato varieties (Figure 1). Five kilograms of wood

ash obtained from burnt dried palm trunks at the Faculty of Agriculture Palm Plantation, University of Nigeria, Nsukka, was collected and sieved with 150mm mesh size to remove stones and wood remains. Fresh Moringa leaves were obtained from Ukehe in the Igbo-Etiti local government area of Enugu state and air-dried for nine days at room temperature. The dried leaves were blended into a powdery form, and five kilograms of Moringa leaf powder were collected. Five kilograms of sawdust was obtained from a carpentry workshop at the Nsukka timber market.

We used three widely cultivated and consumed tomato varieties: Ogbomosho local, Ibadan local, and Roma VF, derived from hybrid and heirloom varieties of tomatoes (Masley, 2017) in Enugu state, Nigeria. The hybrid variety used was the Roma VF, identified with the features of bright red, oval-shaped, thick skin, and fleshy tomato fruit (Known as tomato Jos in Nigeria). The Heirloom varieties are the Ogbomosho local and Ibadan local. Ogbomosho local was identified with its features of bright red, oval-shaped, thin skin, and medium-sized tomato fruit, while the Ibadan local was identified with the features of bright red, round-shaped, thin skin, and small-sized tomato fruit. The tomatoes were identified based on Olaniyi *et al*., (2010). The tomatoes were obtained from sellers at the Ikpa market in Nsukka, Enugu State, Nigeria.

This study was conducted at the Laboratory of Agricultural Education, University of Nigeria Nsukka, Enugu State, Nigeria, in February 2020.

Preservation treatment and evaluation of sensory attributes

One hundred and twenty healthy tomato berries of each tomato variety (Roma VF, Ibadan local, and Ogbomosho local) were selected based on uniformity in size, colouration, and absence of physical defects. Hence, a total of 360 tomato berries were used. Ten randomly selected tomato fruits for each of the 120 fruits per variety were then assigned into 12 groups. The 12 groups for the treatment combinations comprised three preservation materials (wood ash, sawdust, and moringa leaf powder) and a control group for each of the tomato varieties. The treatment combinations were replicated into three to give the study a total of 36 combinations (treatment and control). Wood ash, sawdust, and moringa leaf powder were applied separately as preservatives to each of the treatment groups arranged in brown carton boxes and kept at room temperature on a lab table. Four hundred grams of each preservative were used for treatment in each paper box. No treatments were applied to the separate control group for the three tomato varieties. This gave rise to 36 paper boxes under observation for 28 days.

To assess tomato spoilage and preservative rate, the control and treatment groups were visually inspected for changes in the colour and smoothness of the tomatoes. The number of rotten fruits and preserved fruits from each group was recorded.

To evaluate the sensory attributes of the local tomato varieties, 15 sensory evaluation panelists utilized a 5-point hedonic scale to assess the tomatoes' colour, texture, aroma, and general acceptability. Between the tomato sample evaluations, the panelists rinsed their hands with clean water at room temperature.

Data Analysis

The experiment was set up in a completely randomized design with three replicates. The collected data was subjected to a two-way analysis of variance (ANOVA) and was assessed for significant differences among treatments. The significant means were compared using the least significant difference (LSD $\leq$ 0.05). Statistical analyses were performed using the SPSS software version 21.0 (IBM Statistics).

RESULTS AND DISCUSSIONS

Effect of plant-based preservatives on the shelf life of tomato varieties

The shelf life of ripped tomatoes ranges from 2 to 7 days when stored at a room temperature of 25 to 28 ^{o}C (Irokanulo *et al*., 2015) but can be extended by good storage practices (Ochida *et al*. 2018). In the present study, tomato fruits treated with wood ash, sawdust, and moringa leaf powder had longer shelf life than the untreated control (Figure 2, Table 1).The efficacy of preservation also varied as the moringa leaf powder had the highest preservative effect (26 days) on the shelf life of the tomatoes before 100% decay, compared to sawdust (21 days), and wood ash (20 days) (Figure 2, Table 1).The result is in agreement with previous findings that showed the efficacy of plant extracts in limiting spoilage of freshly harvested tomatoes, albeit in only one or two varieties (Omojasola *et al*. 2022; Liamngee *et al*. 2019; Irokanulo *et al*., 2015; Fashanu *et al*., 2019; Ahmad *et al*., 2020; Bakpa *et al*., 2018; Tunwari *et al*., 2019). The use of plant-based preservatives is effective in extending the shelf life of fruits while inhibiting the growth of pathogens and increasing the physical quality of fruits (Garuba *et al*., 2018). Thus, rural farmers in Nigeria can locally source wood ash, moringa leaf powder, and sawdust as an alternative preservation approach to reduce post-harvest losses that result from perishability, particularly when technologically advanced storage is unavailable or expensive (Ochida *et al*., 2018). Contrastingly, Onwumere *et al*. (2022) showed that wood ash had a higher preservative effect than moringa leaf powder, albeit with the beefsteak tomato variety. This implies that while the plant-based preservatives influence the shelf life of tomatoes, the extent of preservation time is also affected by the tomato variety. Therefore, farmers need to consider this variability when utilizing plant-based preservatives to extend tomato shelf life.

As the experiment progressed, we also observed differences in spoilage among the tomato varieties despite storage in similar environmental conditions and treatment with the same plant-based preservatives. The Roma VF had the highest significant shelf life (25 days) before all the fruits were rotten, followed by Ogbomosho local (19 days) and Ibadan local (16 days) (Figure 3, Table 1). Variations in spoilage time between the tomato varieties may also be attributed to the genetic makeup of the individual varieties (Bakpa *et al*., 2019).

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Effect of plant-based preservative on the sensory attributes of tomato varieties

Sensory attributes, such as appearance, aroma, and texture, detectable by human senses, are often used to evaluate food quality (Chumngoen & Tan, 2015). Here, the tomato varieties differed in sensory evaluation values as the overall sensory acceptability of the tomatoes was rated highest in Ibadan Local and Ogbomoso Local varieties and lowest in Roma VF for all plant-based preservatives. Sensory attributes of tomatoes provide an estimate of their shelf life, as characteristics detectable by the senses tend to degrade before microbial spoilage becomes evident (Sharif *et al*., 2017). The more appealing a tomato is to the senses, the higher its consumption and usage (Bijina *et al*., 2011; Mubarak *et al*., 2018).

Additionally, our results showed that the plant-based preservatives effectively maintained the texture, colour, aroma, and overall acceptability of the Ibadan Local, Ogbomoso Local, and Roma VF varieties (Table 2). The tomatoes preserved in sawdust maintained better appearance, aroma, texture, and general acceptability, followed by those stored in moringa leaf powder, while those preserved in wood ash were rated the lowest across all sensory attributes (Table 2). These findings align with Onwumere *et al*. (2022), who reported that tomatoes treated with moringa leaf powder had a fresher appearance than those treated with wood ash. Omojosola *et al*. (2022) also observed that while wood ash extended the shelf life of tomatoes, it caused them to shrink. Additionally, Liamngee *et al*. (2019) showed that tomatoes treated with moringa leaf extract had high marketability value. The acceptability rating (Table 2) of tomatoes treated with sawdust after 28 days demonstrates that sawdust retains the quality of tomatoes better than other plant materials. However, the use of sawdust for preserving tomatoes is still under-utilized compared to other plant materials (Garuba *et al*. 2018). Here, saw-dust was effective for improving tomato shelf life and sensory attributes for all three tomato varieties studied and does not leave dirt stains on the tomatoes when used as preservatives. Additionally, it is easier to source than moringa leaf powder and wood ash, and it is usually found as waste in timber shops and, therefore, can be obtained by the farmers to reduce post-harvest losses at little to no cost.

CONCLUSION

This study highlights the efficacy of locally sourced plant-based preservatives in extending the shelf life and sensory attributes of tomato varieties in Nigeria. Moringa leaf powder proved to be the most effective in post-harvest preservation of tomatoes during a 28-day period, while sawdust also demonstrated a notable preservative effect comparable to wood ash. Among the tomato varieties studied, Roma VF showed the longest shelf life before 100% spoilage under all treatments, suggesting that hybrid tomato varieties may have more extended shelf life with these preservation methods. The sensory evaluation indicated that tomatoes preserved in sawdust had generally more acceptable texture, colour, aroma, and overall acceptability, followed by those preserved in moringa leaf powder and wood ash. However, some shrinkage and reduced firmness were observed, especially in tomatoes preserved with wood ash. Overall, our results indicate that small-scale rural farmers in Nigeria should consider using moringa leaf powder and sawdust as

cost-effective and accessible methods for preserving tomatoes. These plant-based materials not only extend the shelf life of the fruits but also maintain acceptable sensory qualities. Farmers should prioritize hybrid tomato varieties like Roma VF for long-term storage, as these have shown better preservation results than heirloom varieties. Finally, to maintain the quality and firmness of the tomatoes, it is advisable to limit the storage period to less than 28 days, especially when using wood ash, to prevent shrinkage and loss of texture. Farmers can reduce post-harvest losses by leveraging the indigenous preservative capacity of indigenous plants and plant-based by-products, thus improving food security.

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APPENDICES

Figure 1: The plant-based preservatives (Wood ash, Moringa leaf powder and Sawdust), locally sourced from Enugu State, Nigeria.

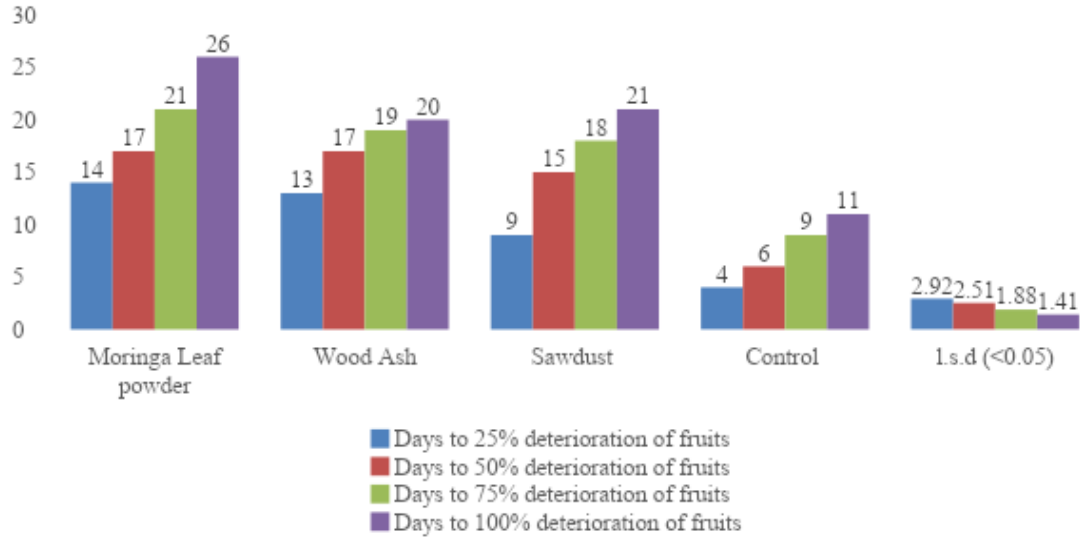

Figure 2: Effect of the plant-based preservatives on the shelf life of the tomatoes. Moringa leaf powder had the most pronounced effect, significantly extending the shelf life of the tomatoes compared to sawdust and wood ash.

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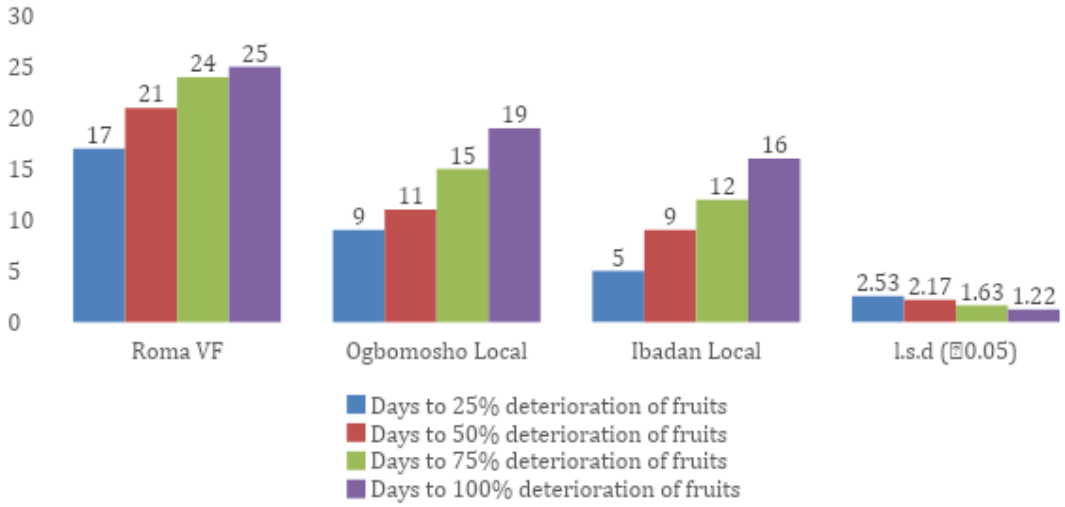

Figure 3: Variation in post-harvest shelf-life of the tomato varieties. Roma VF tomato variety exhibited the longest shelf life during post-harvest storage with plant-based preservatives, indicating its superior storage stability compared to Ogbomosho local and Ibadan local varieties.

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Table 1: The interaction effect of plant-based preservatives and tomato varieties

Variability (in days to percentage (%) rate of fruit deterioration) of locally sourced plant-based preservation media (moringa leaf powder, wood ash, and sawdust) on the shelf life of Roma VF, Ogbomosho local, Ibadan local tomato varieties after 28 days of storage. The tomato varieties differed ($p < 0.05$) in days due to the deterioration of the tomato fruits during storage. The mean values with the same superscript alphabet are statistically similar.

Tomato variety	Preservative	Days to 25% spoilage	Days to 50% spoilage	Days to 75% spoilage	Days to 100% spoilage
Roma VF	Moringa	25^{a}	27^{a}	28^{a}	28^{a}
Roma VF	Wood Ash	19^{b}	26^{a}	28^{a}	28^{a}
Roma VF	Sawdust	15^{bc}	20^{b}	26^{a}	28^{a}
Roma VF	Control	8^{c}	10^{c}	13^{c}	14^{b}
Ogbomosho Local	Moringa	10^{cb}	13^{c}	21^{b}	28^{a}
Ogbomosho Local	Wood Ash	13^{cb}	14^{c}	16^{c}	17^{cf}
Ogbomosho Local	Sawdust	7^{dc}	14^{c}	15^{c}	19^{c}
Ogbomosho local	Control	3^{d}	4^{d}	9^{d}	11^{d}
Ibadan Local	Moringa	7^{dc}	12^{c}	15^{c}	22^{e}
Ibadan Local	Wood Ash	7^{dc}	10^{c}	14^{c}	16^{f}
Ibadan Local	Sawdust	3^{d}	10^{c}	14^{c}	16^{f}
Ibadan Local	Control	2^{d}	4^{d}	6^{d}	9^{d}
	L.S.D (0.05)	5.05 (0.05)	4.34 (0.04)	3.25 (0.01)	2.44 (0.001)

Table 2: The effect of plant materials on the sensory attributes of tomato varieties

Effect of locally sourced plant-based preservatives (moringa leaf powder, wood ash and sawdust) on the sensory attributes of Roma VF, Ogbomosho local, and Ibadan local tomato varieties after 28 days of storage. The difference is significant at $p < 0.05$. NS= non-significant.

Tomato Varieties	Preservative	Texture (softness)	Colour (appearance)	Aroma (smell)	Overall acceptability
Roma VF	Moringa	7.53	7.00	7.00	7.07
Roma VF	Wood ash	5.47	6.07	6.73	5.73
Roma VF	Sawdust	7.47	6.67	7.43	7.40
Ogbomosho local	Moringa	7.00	6.80	6.40	6.93
Ogbomosho local	Wood ash	6.73	6.80	6.93	6.40
Ogbomosho local	Sawdust	7.80	7.73	7.67	6.71
Ibadan local	Moringa	7.60	7.53	7.47	7.45
Ibadan local	Wood ash	6.13	6.40	6.33	6.30
Ibadan local	Sawdust	7.87	7.67	7.60	7.67
	L.S.D (0.05)	NS (1.52)	NS (1.40)	NS (1.3)	NS (0.52)