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RESEARCH ARTICLE

Effect of *Moringa oleifera* leaf extract on the postharvest quality of tomato fruits during storage

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ABSTRACT

The effect of *Moringa oleifera* leaf extract on the shelf life and postharvest condition of tomato fruits during storage was evaluated. Two varieties of tomato fruits: RioGrande and Roma were collected from different markets in Makurdi metropolis, washed and treated with aqueous extracts of *Moringa* leaves at different concentrations of 0%w/v, 20%w/v and 100%w/v. The tomato fruits were left in storage for a period of 11 days during which different quality parameters associated with tomato fruits were observed and recorded. These included: decay, marketability, weight and shelf life. The fruits treated with 0%w/v *Moringa* leaf extract concentration (control fruits) produced the highest decay values while fruits treated with 100%w/v concentration produced the lowest decay values on days 5, 7, 9 and 11. Also, the Rio Grande variety had a higher decay value than the Roma variety on days 7 and 9 but the difference between them was not significant. The marketability of the tomato fruits treated with 100%w/v concentration was higher than those treated with 0%w/v concentration. The Roma variety produced higher marketability values than the Rio Grande variety except on day 5. The Roma variety treated with 100%w/v concentration produced the highest fruit weight on days 5, 7, 9 and 11. Comparatively, all the fruits treated with *Moringa* extracts had a higher shelf life (11 days) than the untreated fruits (control fruits) (7 days). Four fungi namely: *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus* and *Penicillium griseofulvum* were isolated from decaying tomato fruits. Pathogenicity test revealed that *Aspergillus niger* caused the highest rot and decay in the Rio Grande variety while *Aspergillus flavus* caused the highest decay in the Roma variety. The results of this research carried out shows that *Moringa oleifera* extract can be used to extend the shelf life and preserve the quality of tomato fruits in storage.

Keywords: Shelf life, tomato, moringa leaf extract, postharvest, quality

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is a member of the family Solanaceae. Botanically, this fruit is known as a berry (Salunkhe et al., 2005). It is one of the most important vegetables grown for edible fruit consumption in virtually every home in Nigeria. (Akintoye, 2002). In Nigeria, tomato accounts for about 18% of daily consumption of vegetables. It is used for a variety of dishes and is also processed into various products such as tomato juice, puree, cocktail, paste, ketchup, sauce, jelly, soups, and tomato chutneys. Tomato fruits are rich sources of vitamins, calcium, iron, phosphorus, magnesium, potassium and zinc (Ahmad and Singh, 2005). Wener (2008) opined that tomato rich in carotenoids that have attracted interest because

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of their role in preventing cancer. Tomatoes are highly perishable with a short shelf life and high susceptibility to fungal infections so it is usually consumed immediately after harvest. In the event that consumption does not take place after harvest, there is a need to preserve so that spoilage does not occur. Although synthetic antimicrobial and antioxidant agents are approved in many countries, their usage has created environmental and health concerns, which draws the public attention to application of safe natural preservatives. For this reason, the present investigation was undertaken to study the effect of *Moringa* leaf extracts on shelf life of extension of tomato.

MATERIALS AND METHODS

Sample Collection

Collection of tomato fruits

Firm, ripe and healthy tomato fruits of two varieties namely Rio Grande and Roma variety were collected from various markets in Makurdi metropolis and taken to the laboratory for further studies.

Collection of *Moringa oleifera* leaves

Fresh leaves of *Moringa oleifera* were obtained from the campus of Benue State University, Makurdi. They were packed in clean polythene bags and taken to the laboratory.

Preparation of crude extracts

Moringa oleifera leaves were weighed and the leaves were washed and rinsed with distilled water. The leaves were then crushed using a clean mortar and pestle. The macerates were then transferred to beakers each containing 100ml of sterile distilled water. The set up was left to stand for three hours, after which sieving was done using a muslin cloth (Liamngee et al., 2015).

Extract concentrations

Concentrations of the plant leaf extract were prepared to give 20%w/v and 100%w/v respectively. Extract concentration of 20%w/v was obtained by dissolving 20g of the macerated plant leaves in 100mls of sterile distilled water in a beaker. Extract concentration of 100%w/v was obtained by dissolving 100g of the macerated plant leaves in 100mls of sterile distilled water in a beaker (Kator et al., 2019).

Treatment of tomato fruits with Moringa leaf extracts

Firm and healthy tomato fruits of the two varieties were selected and washed in clean water to remove dirt, rinsed again in water and kept to air dry before treatment (Liamngee et al., 2017). The tomato fruits were treated by dipping them in the *Moringa* leaf extract at different concentrations of 20%w/v and 100%w/v respectively. Control fruits were dipped in sterile distilled water only. The tomato fruits were then arranged in plastic crates and kept at room temperature.

Experimental design

Factors in the experiment were;

i. Three extract concentrations
ii. Two tomato varieties

3 x 2 Factorial in Complete Randomized Design

Treatment combinations = 3 x 2 = 6 treatments.

Replications = 3

Total Units= 6 x 3 = 18

Each plot contained 10 fruits = 10 x 18 = 180 fruits

Analytical methods

Weight

A weighing balance was used to measure the weight of tomato during the storage period.

Shelf life

Shelf life of tomato fruits was determined by counting the number of days the fruits were still acceptable for marketing and consumption. It was decided based on appearance and spoilage of fruits (Liamngee et al., 2017).

Marketability (%)

Based on descriptive qualities such as smoothness, shriveling, shininess of fruits, colour and absence of mould growth, the marketability (%) of fruits during the storage period was calculated using the formula as reported by Liamngee et al. (2017).

Marketability of tomato fruits= number of marketable fruits/total number of fruits x 100

Postharvest decay (%)

The numbers of decaying fruits were counted on each day of storage and calculated using the formula:

$$\text{Decay} = \frac{\text{Number of fruits decaying}}{\text{Total number of fruits}} \times 100 \qquad \text{(Liamngee et al., 2017)}$$

Preparation of media

The medium used for the isolation of fungal microorganisms was Potato Dextrose Agar (PDA). PDA was prepared by dissolving 39 grams of media into 1000ml of distilled water. The solution was heated on a heating mantle to dissolve the medium completely. The medium was then sterilized by autoclaving at 121ºC for 15 minutes at 15 psi (Pounds Per square Inch), after which it was removed and allowed to cool before pouring into sterile petri dishes (Liamngee et al., 2013).

Isolation of fungi from decaying tomato fruits during storage

Decaying tomato fruits were washed with clean water and small sizes of 0.1to 0.5cm were cut from the rotted parts and surface sterilized by dipping in 1% Sodium hypochloride (NaOCl) solution for one minute (Liamngee et al., 2017). They were

removed and rinsed in three changes of sterile distilled water and placed on solidified potato dextrose agar (PDA) medium. The inoculated plates were incubated at ambient temperature and observations were made for microbial growth. After 5-7 days, sub-culturing was done to obtain pure culture of the isolates (Kator et al., 2019).

Identification of fungi

Identification was done microscopically and macroscopically. For macroscopic identification, colony characteristics such as appearance, change in medium colour and growth rate were observed on the petri dishes. For microscopic identification, a drop of lactophenol in cotton blue dye was placed on a clean glass slide and a thin smear of fungi isolates from 5 - 7 days old cultures was made aseptically in the dye and the mixture was covered with a cover slip and viewed under 40x objective of the light microscope. Shapes of the conidia and conidiophores were critically examined (Kator et al., 2019).

Pathogenicity Test

Fresh, ripe tomato fruits were washed with distilled water and thereafter sterilized in 1% sodium hypochloride solution for one minute (Liamngee et al., 2017). Mycelia discs of fungal isolates from five day old cultures were used to inoculate the tomato fruits. The cylindrical plugs were used to plug holes created in the tomato fruits by the cork borer. The discs of the tomato fruits in the cork borer were replaced and sealed with sterile PDA (Liamngee et al., 2019). After 5 - 6 days of post inoculation, hand feel and visual examination were used to ascertain the symptoms of fruit rots (Liamngee et al., 2018). Decay severity was calculated using the formula given below:

$$\textbf{Area of rot} = \Pi d1$$

Where Π = 22/7; d = diameter and 1 = depth (Ezeibekwe and Ibe, 2010).

Data analysis

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

RESULTS

Main and interaction effects of variety and Moringa leaf extract concentration on the weight of tomato fruits in storage.

The main effect of variety and Moringa concentration as well as the interaction effect of variety and Moringa concentration on the weight of tomato fruits during storage was not significant ($p \geq 0.05$) on days 1, 3, 5, 7 and 9 as shown in Tables 1 and 2. The main effect of concentration on weight of tomato fruits was significant ($p \leq 0.05$) on day 11 but the main effect of variety as well as the interaction effect of variety and concentration was not significant. Generally, Roma variety gave higher fruit weight than Rio Grande variety on all the days evaluated but the difference between them was not significant as shown in Table 1. Among all the concentrations evaluated, 100%w/v Moringa extract concentration gave higher fruit weight than all the other concentrations on day 11. The control groups (with 0%w/v Moringa concentration) gave the lowest fruit weights on days 1, 3, 5, 7, 9 and 11 as shown in Table 1.

Table 1: Main Effect of Moringa Leaf Extract Concentration and Tomato Variety on the Weight of Tomato Fruits.

Concentration	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11
0	44.03	43.53	40.48	37.40	36.66	33.70
20	49.37	48.89	45.66	43.16	42.42	40.50
100	46.32	45.79	44.40	42.72	42.06	40.80
LSD (0.05)	NS	NS	NS	NS	NS	5.74
Variety						
RioGrande	45.66	45.23	42.84	40.71	39.77	37.40
Roma	47.49	46.91	44.19	41.48	40.99	39.30
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2: Interaction Effect of Concentration and Variety on the Weights of the Tomato Fruits.

Variety	Concentration	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11
RioGrande	0	43.93	43.40	40.15	37.18	36.28	33.20
	20	51.00	50.59	47.73	45.70	44.75	41.80
	100	42.05	41.70	40.66	39.24	38.28	37.20
Roma	0	44.14	43.66	40.83	37.61	37.03	34.20
	20	47.74	47.20	43.59	40.62	40.10	39.20
	100	50.59	49.88	48.14	46.20	45.85	44.50
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Main and interaction effects of concentration and variety on the decay of tomato fruits in storage

The main effect of variety as well as the interaction effects of variety and Moringa extract concentration on the decay of tomato fruits was not significant ($p \geq 0.05$) on days 1 and 3 as shown in Tables 3 and 4. The main effect of Moringa extract concentration on decay of tomato fruits was significant ($p \leq 0.05$) on days 5,7,9 and 11 but the main effect of variety as well as the interaction effect of variety and concentration on the decay of tomato fruits was found non-significant. On days 1and 3, decay showed no significant difference. However, the control group for the Rio Grande variety produced the highest decay on day 11 and this was higher than that produced by all the other treatments as shown in Table 4. Generally, RioGrande variety gave higher decay than Roma variety on days 7 and 9 but the difference between them was not significant as shown in table 3. On a general note, 0%w/v Moringa concentration (control group) and 100%w/v Moringa concentration produced the highest and lowest decay respectively and the difference was significant as shown in Table 3.

Table 3: Main Effect of Moringa Leaf Extract Concentration and Tomato Variety on the Decay of Tomato Fruits

Concentration	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11
0	0.00	0.00	15.00	30.00	35.00	41.70
20	0.00	0.00	10.00	23.30	25.00	35.00
100	0.00	0.00	3.30	6.70	10.00	20.00
LSD (0.05)	**NS**	**NS**	**7.26**	**11.48**	**12.92**	**15.97**
Variety						
Rio	0.00	0.00	7.80	21.10	24.40	32.20
Roma	0.00	0.00	11.10	18.90	22.20	32.20
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4: Interaction Effect of Variety and Concentration on Decay of Tomato Fruits

Variety	Concentration	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11
Rio	0	0.00	0.00	16.70	33.30	36.70	43.30
	20	0.00	0.00	3.30	23.30	26.70	36.70
	100	0.00	0.00	3.30	6.70	10.00	16.70
Roma	0	0.00	0.00	13.30	26.70	33.30	40.00
	20	0.00	0.00	16.70	23.30	23.30	33.30
	100	0.00	0.00	3.30	6.70	10.00	23.30
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Main and interaction effects of concentration and variety on the marketability of tomato fruits.

Figure 1 shows a general decrease in the marketability of tomato fruits during the storage period. The main effect of variety and Moringa extract concentration as well as the interaction effects of variety and concentration was not significant ($p \geq 0.05$) on the marketability of tomato fruits on days 1 and 3. The main effect of Moringa extract concentration was significant ($p \leq 0.05$) on the marketability of tomato fruits on days 5, 7, 9 and 11 but the main effect of variety as well as the interaction effects of variety and concentration was not. 100%w/v showed significantly higher marketability on days 7, 9 and 11 compared to 20%w/v and 0%w/v respectively as shown in Figure 1.

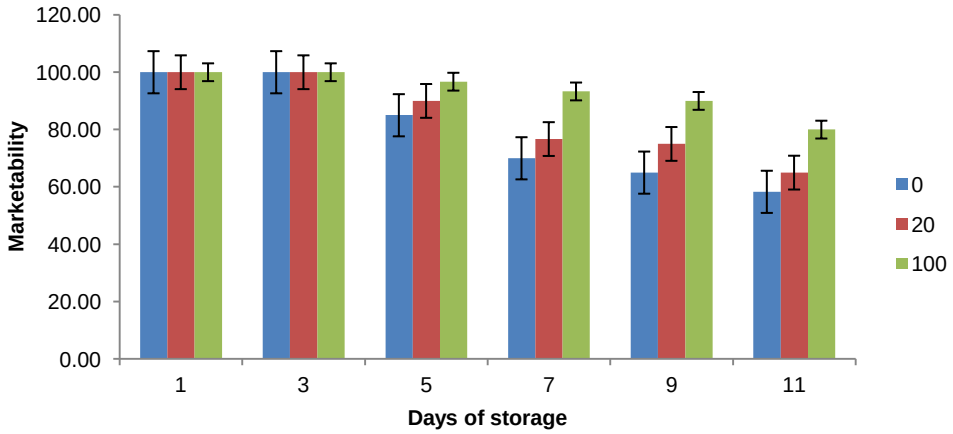


Figure 1: Effect of *Moringa* extract concentration on the marketability of tomato fruits during storage

Main and interaction effects of variety and moringa concentration on the shelf life of tomato fruits in storage.

The main effect of variety and Moringa extract concentration as well as the interaction effect of variety and concentration on the shelf life of tomato fruits was not significant on days 1, 3, 5 and 7. The main effect of variety as well as the interaction effect of variety and concentration on the shelf life of tomato fruits was not significant on days 9 and 11 but the main effect of concentration was significant as shown in Figure 2. Fruits treated with 0%w/v had the lowest shelf life of 7 days while those treated with 20%w/v and 100%w/v had a shelf life of 11 days.

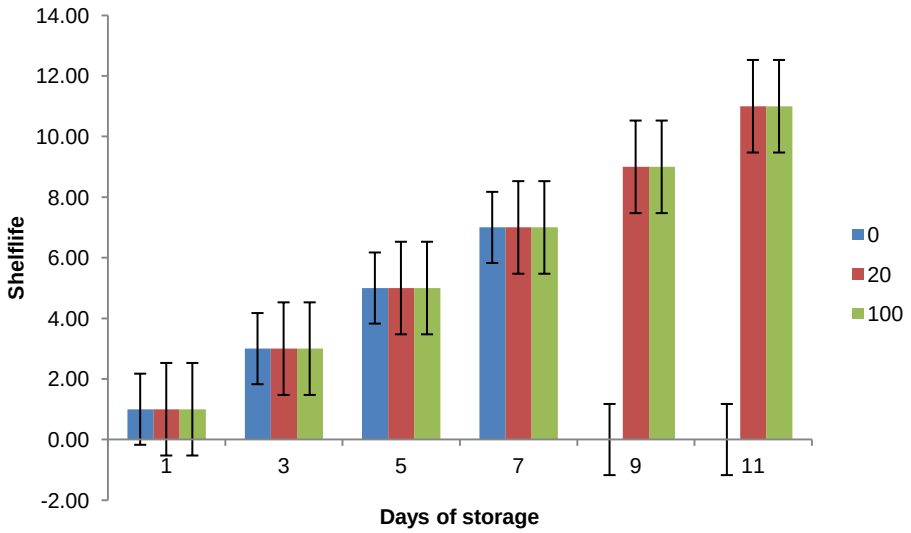


Figure 2: Effect of *Moringa* extract concentration on the shelf life of tomato fruits during storage

From table 5 above, it can be seen that all the three species of fungi inoculated in the tomato fruits had the ability to cause rots in the fruits. *Aspergillus niger* caused the highest rot in the Rio Grande variety followed by *Aspergillus flavus* and *Penicillium griseofulvum* caused the least rot. In the Roma variety, *Aspergillus flavus* caused the highest rot followed by *Penicillium griseofulvum* and *Aspergillus niger* caused the least rot.

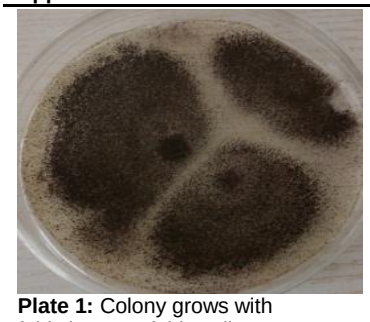
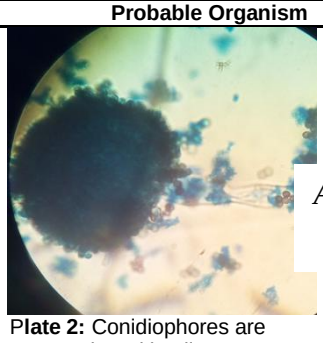
Table 5: Pathogenicity of fungal organisms on healthy tomato fruits

	Aspergillus niger	***Penicillium griseofulvum***	***Aspergillus flavus***
Control	0.00	0.00	0.00
Rio Grande	4.61	3.84	4.01
Roma	3.71	4.27	4.38
LSD	**0.62**	**0.24**	**0.35**

Fungal organisms isolated from rotting tomato fruits

A total of four fungi were isolated from the tomato fruits in storage. They are *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus* and *Penicillium griseofulvum* as shown in Table 6.

Table 6: Characterization of Fungal Isolates from decaying tomato fruits during storage

Appearance on PDA	Microphotographs	Probable Organism
 **Plate 1:** Colony grows with fairly loose to fairly yellow basal mycelium.are spherical Conidia heads are black.	 **Plate 2:** Conidiophores are smooth and hyaline.	*Aspergillus niger*

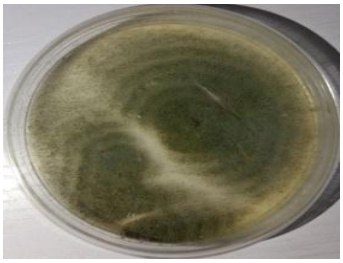


Plate 3: Colony is spreading and light green in colour.

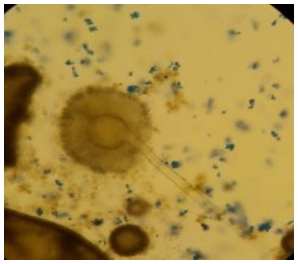


Plate 4: Conidiophore is heavy walled and hyaline conidia in long chains.

Aspergillus flavus.

Plate 5: Colony is grey with greenish overtones and moderate growth rate

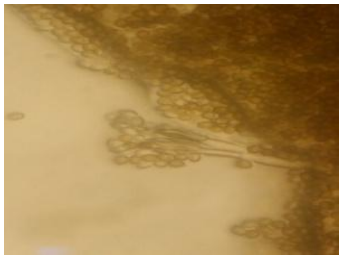


Plate 6: Conidia is smooth-walled, borne in closely-.packed and disordered chains

Penicillium griseofulvum

Plate 7: The colony is dark to greyish green in colour and the margins are entire.

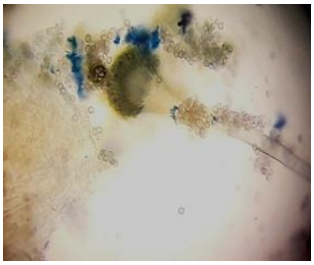


Plate 8: The conidiophore is hyaline and the vesicle is dome-shaped. The conidia is blue green in colour with uniseriate phialides covering only the upper portion of the vesicle.

Aspergillus fumigatus

DISCUSSION

Tomato fruits treated with *Moringa* extracts produced lower decay values than the untreated fruits. Among the varieties considered, Rio Grande variety recorded higher decay percentages than the Roma variety even though the difference between them was not significant. This might be as a result of the fact that Roma variety has higher resistance to environmental and pathogenic attacks than the Rio Grande variety. The ability of *Moringa oleifera* leaves extracts to decrease the decay level on tomato fruits is an indication that *Moringa oleifera* can serve as a potential alternative in the prevention of tomato decay by pathogens. This is in agreement with the results of Raheja and Thakore (2002) who reported that extracts from medicinal plants like *Alium sativum* (cloves), *Azadirachta indica* (leaves) and *Mentha arvensis* (leaves) were found most effective in preserving plant fruits from attack by pathogenic and environmental factors. The ability of *Moringa* leaf extracts to minimize the decay on tomato fruits can be attributed to the fact that the extract suppressed the activity of certain fungi that cause spoilage of tomato fruits in storage. This 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 lives of the two varieties of tomato fruits considered in this study were quite significant. Tomato fruits dipped in aqueous extracts of *Moringa* leaves had higher shelf life when compared to that of the untreated (control) fruits. This is in agreement with the findings of Liamngee et al. (2019), who reported that tomato fruits treated with aqueous extracts of *Moringa oleifera* had shelf life of about 25 days while the untreated (control) fruits had a shelf life of about 21 days.

Also, the marketability of the tomato fruits dipped in the aqueous extract of *Moringa oleifera* was higher than that of the control group. On days 1 and 3 of the storage duration, there was no significant difference between the marketability of the treated fruits and the untreated but at the end of the storage period, the marketability of the untreated fruits had reduced greatly but the treated fruits still retained their quality. This result agrees with the findings of Liamngee et al. (2019) who reported that there were no significant differences between the treated and the control for marketability on days 1, 5 and 9 of the storage duration while on days 13 to 25, the treated reflected significantly higher marketability compared to the control. The ability of the Moringa leaf extract to maintain marketability of the fruits might be due to its ability to form a protective layer around the fruit thereby preventing oxygen and moisture loss and inhibiting the action of microorganisms.

During this study, the weight of the tomato fruits treated with the Moringa leaf extracts as well as the untreated fruits decreased during the storage period. Lower weight loss was observed in the tomato fruits dipped in the plant leaf extracts than the untreated fruits. This is also in agreement with the findings of Liamngee et al. (2019) who observed that Moringa leaf extract was able to form a coating on the tomato fruit which reduced the rate of respiration in the fruit and therefore lowered the weight loss because an increase in respiration results in an increase in metabolic rate and higher weight loss due to the expiration of moisture from the fruit. Similar results were reported by Rameshwar (2007) who observed that a combination of Neem leaf extract at 20% plus UV radiation exposure for 10minutes plus rice starch 6% proved to be the most appropriate treatment in minimizing the reduction of juice contents and fruit rotting.

This study also showed that a number of fungi are associated with decay of tomato fruits in storage. They include *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus* and *Penicillium griseofulvum.* They have been previously reported as pathogens of tomato fruits by Onuorah and Orji (2015) who isolated *Aspergillus niger* and *Fusarium spp* from rotten tomato fruits. Wogu and Ofuase (2014) isolated *Aspegillius spp*, *Penicillum spp*, *Fusarium spp* and *Saccharomyces spp* from spoilt tomato fruits. Mbajiuka and Enya (2014) also isolated *Aspergillius spp, Penicillum spp* and *Saccharomyces cerevisiae* from spoilt tomatoes while Fatih et al. (2005) reported the presence of *Alternaria alternata* and *Fusarium oxysporum* in the spoilt tomato fruits they studied. From the pathogenicity test results, *Aspergillus niger* caused the highest rot in the Rio Grande variety while *Aspergillus flavus* caused the highest rot in the Roma variety. This result agrees with the findings of Onuorah and Orji (2015) who reported that *Aspergillus spp* caused the highest rot in the tomato fruits sampled in Awka, Nigeria.

Fungal spoilage of tomatoes is attributable to the high water content, environmental conditions, state of handling, state of storage facilities, the fungal load of the handlers and the quality of the tomatoes. These fungi isolated in this study are sources of potent mycotoxins which are detrimental to health. *Aspergillus flavus* in particular has been associated with the production of aflatoxins while *Aspergillus nige r*and *Aspergillus flavus* have both been indicted with the production of carcinogens (Barkai-Golan, 2008).

CONCLUSION

The result of this study has established that the aqueous extract of *Moringa oleifera* leaves have the ability to increase the shelf life and maintain the quality of tomato fruits during storage. The preservation and storage of tomatoes using extracts from the leaves of *Moringa oleifera*, which does not require any form of refrigeration or additional application of chemicals makes its

use for tomato preservation very convenient for low income earners and rural dwellers, either for market or for consumption.

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