RESEARCH ARTICLE

Antifungal effect of extracts of plant leaves on postharvest decay and quality of tomato fruits during storage

ABSTRACT

Keywords: Antifungal, postharvest decay, quality, tomato, storage, leaf extracts.

INTRODUCTION

Tomato (*Solanum Lycopersicum* L.) which belongs to the family Solanaceae is one of the most widely cultivated and extensively consumed horticultural crop in the world [1]. It is rich in vitamins, minerals and lycopene, an excellent antioxidant,

sodium, iron, phosphorus, beta- carotene, potassium and magnesium [2]. In the Nigerian Savanna, fresh tomato is the most valuable vegetable crop [3]. It accounts for about 18% of the average daily consumption of vegetables in Nigeria [4].

Over the last century, the growth in fresh fruit consumption, particularly whole tomato fruits have led to improvements in preservation treatments to control post-harvest disease proliferation and maintain fruit quality and consequently to extend its shelf-life [5].

Preservation and storage of tomato fruits is important to the economy of individual homes and farmers considering the vital role tomato play in the health of people and food security. Keeping in view the above facts, the study was conducted to evaluate the antifungal potential of some botanicals, which are multi-purpose plants that are easily grown locally and have been found to be of tremendous use in food and medicine, on postharvest decay and quality of tomato fruits during storage. This will provide flexibility to farmers and traders on when and where to market the commodity to obtain maximum net return and to provide consumers with the best quality tomato fruits for consumption. For researchers in agriculture, it will provide baseline information for further research in postharvest preservation. For policy makers in agriculture, it will provide the necessary foundation for planning and budgeting for tomato fruit preservation, thereby reducing capital expenditure on tomato importation. For students in agriculture, it will provide literature for studies in preservation and storage, and for extension workers; it will increase their performance credibility in design and implementation of storage programmers. Furthermore, corporate good will between farmer and extension worker will be enhanced.

MATERIALS AND METHODS

Experimental location

The experiment was carried out in the botany laboratory of the Benue State University, Makurdi from 2017 to 2018. Makurdi is located in North central Nigeria along the Benue River, between latitude 07° 44′ 28″ N and longitude 08° 32′ 44″ E. It is situated within the Benue trough, at the lower Benue valley and found in the guinea savanna region.

Collection of tomato fruits

Healthy tomato fruits of the Roma variety were carefully harvested at breaker stage by hand picking from the experimental farm. Fruits were selected on the basis of similar sizes and maturity level with absence of visual symptoms of disease and defects. The fruits were carefully placed in plastic crates and taken to the laboratory for further studies.

Collection and disinfection of plant leaves

Fresh leaves of *Moringa oleifera* (Drumstick tree), *Vernonia amygdalina* (Bitter leaf) and

Azadirachta indica (Neem) were collected from different locations in Makurdi metropolis.

A cutlass was used to cut branches while the leaves were harvested by handpicking. The leaves were put in clean polythene bags and taken to the laboratory. The leaves of each plant were first prewashed carefully under a gentle stream of tap water for one to two minutes to remove surface dirt. This was followed by washing for thirty seconds in sterile distilled water containing 1% sodium hypochloride. The leaves were then removed and rinsed in three successions of sterile distilled water.

Preparation of plant extracts and extracts concentrations

Plant leaves were weighed using a weighing balance for water extractions to give 80% w/v and 100% w/v respectively. The weighed leaves of each plant species were ground into fine paste first, with mortar and pestle and then with a blender and soaked in 100 ml of sterile distilled water for 1 hour after which

sieving was done using a muslin cloth into separate beakers for each plant species and for each concentration.

Antifungal effect of plant leaf extracts on postharvest decay of tomato fruits during storage

Semi ripe, firm and healthy tomato fruits (Roma variety) were surfaced sterilized by dipping them in 1% sodium hypochloride solution for thirty seconds and rinsed in three changes of sterile distilled water. The fruits were then inoculated by dipping them in spore suspensions of each pathogenic fungus for 1 - 2 minutes and incubated for 24 hours at room temperature. After incubation, the fruits were dipped into the aqueous extracts of the plant leaves at different concentrations of 80%w/v and 100%w/v of each plant species. Control fruits were dipped in sterile distilled water only. Fruit quality parameters such as marketability, weight, post harvest decay and shelf life were evaluated.

Experimental Design

3 × 5 × 3 factorial in

completely randomised

design Treatment

combinations = 45
Replications = 3

Total plots; 3 × 45 = 135

Each plot contained 30 fruits; 30 × 135 = 4050 fruits

Phytochemical screening of the botanicals

Botanicals were tested for the presence of active compounds such as steroids, glycosides, saponins, alkaloids, carbohydrates, flavonoids, cardiac glycosides, tannins and anthraquinones.

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Two to three drops of alpha naphthalene solution were added to

2 ml of each plant leaf extract in a test tube after which alcohol was added and shaken for two minutes. One milliliter of concentrated sulphuric acid was thereafter added slowly from the sides of the test tubes. A deep violet colour at the junction of two layers indicated the presence of carbohydrates [6].

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Three milliliters of 5% w/v ferric chloride solution were added respectively to three millilitres of each plant leaf extract in a test tube. A blue – black colour indicated the presence of tannins and phenols [6].

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Two milliliters each of sodium chloride (18% w/v) were placed in six test tubes respectively. To three of the test tubes, 2 ml of chloroform, ethanol and water (8:2) were added sequentially and to the other three, 2 ml of the aqueous extracts of the leaves of each plant species were added respectively after which few drops of blood were added to all the test tubes and shaken vigorously and thereafter observed for hemolysis under the microscope [7].

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Dragendroff's test

One milliliter of Dragendroff's reagent (Potassium bismuth iodide) was added respectively to 3 ml of each aqueous leaf extract of the different plant species in a test tube. The appearance of a brick red precipitate indicated the presence of alkaloids [8].

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Five milliliters of ethanol (95% v/v) were added to two grams each of the plant leaf powders of each plant species in a beaker after which five drops of hydrochloric acid and 0.5g of magnesium turnings were added sequentially. Appearance of a pink colour indicated the presence of flavonoids [8].

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Ten drops of acetic anhydride were added to 2 ml of each of the aqueous leaf extract of each plant species and shaken vigorously. To this mixture, 5 ml of concentrated sulphuric acid were added from the sides of the test tubes. Appearance of greenish blue colour indicated the presence of triterpenoids and steroids [7].

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One milliliter of glacial acetic acid was added respectively to two milliliters of each aqueous plant leaf extract in a test tube. Thereafter, three drops of 5% w/v of ferric chloride and concentrated sulphuric acid were added sequentially. Disappearance of a reddish-brown colour at the junction of two layers and the presence of a bluish green colour in the upper layer indicated the presence of cardiac glycosides [7].

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Two milliliters of dilute sulphuric acid were added respectively to each of 2 ml of aqueous leaf extracts of each plant species in a test tube. The mixture was thereafter boiled and filtered. To the filtrates, equal volumes of chloroform were added, and the mixture was agitated. Organic layers were separated, and ammonia was added. A pinkish red colour of the ammonia layer indicated the presence of anthraquinones [9].

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To about 0.5 g of each plant leaf powder, 5 ml each of concentrated. H_2SO_4 were added and boiled for 15 minutes. This was then cooled and neutralized with 20% KOH. The solution was divided into two portions. Three drops of ferric chloride solution were added to one of the

portions respectively, and a green to black precipitate indicated phenolic aglycone as a result of hydrolysis of glycoside [6].

RESULTS

The main effect of leaf extract and concentration on quality parameters of tomato fruits previously dipped in conidia suspensions of organism 1 (*Aspergillus flavus*) revealed that fruits dipped in bitter leaf extract (BLE) showed significantly higher marketability (4.47) followed by Neem leaf extract (NLE) (4.39) and *Moringa* leaf extract (MLE) (4.17) while fruits dipped in BLE showed the highest postharvest decay (PD) (1.10) followed by NLE (1.05) and MLE (0.86) respectively. Weight of BLE treated fruits were significantly higher (33.27) followed by NLE (28.18) and MLE (27.97). At concentration of 100%w/v, marketability was significantly higher (4.98) followed by 80% w/v (4.80) and control treatment (3.24). At control , postharvest decay showed significantly highest value (2.30) followed by 100%w/v (0.37) and 80%w/v (0.34). Weight showed significantly highest value at 80%w/v (32.18) followed by 100%w/v (30.04) and 0%w/v (27.20) respectively as shown in Table 1.

Table 1: Main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 1 (*Aspergillus flavus*).

Leaf Extract	Marketability	Postharvest decay	Weight
MLE	4.17	0.86	27.97
NLE	4.39	1.05	28.18
BLE	4.47	1.10	33.27
F-LSD (0.05)	**0.20**	**NS**	**3.12**
Concentration			
0	3.24	2.30	27.20
80	4.80	0.34	32.18
100	4.98	0.37	30.04
F-LSD (0.05)	**0.20**	**0.24**	**3.12**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference

The interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 1 (*Aspergillus flavus*) was significant on marketability and PD but not significant on weight as shown in Table 2. BLE at 100%w/v, produced the highest marketability (5.15) followed by NLE at

100%w/v (5.13) and BLE at 80%w/v (4.96). 0%w/v produced the lowest

marketability (3.12) and (3.30)and this was significantly lower across the interaction. 0%w/v produced the highest PD (2.62) and this was significantly higher across the leaf extract concentration. The lowest PD (0.29) was produced by MLE and BLE at 80 and 100%w/v respectively.

Table 2: Interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 1 (*Aspergillus flavus*).

Leaf extract	Concentration	Marketability	Post harvest decay	Weight
MLE	0	3.12	2.00	27.09
	80	4.70	0.29	29.16
	100	4.67	0.29	27.66
NLE	0	3.30	2.29	24.92
	80	4.73	0.43	28.78
	100	5.13	0.43	30.85
BLE	0	3.30	2.62	29.60
	80	4.96	0.29	38.60
	100	5.15	0.38	31.60
F-LSD (0.05)		**0.93**	**1.21**	**NS**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference

The main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 2 (*PenicilIium waksmanii*) revealed that tomato fruits treated with BLE showed the highest marketability (4.43) followed by NLE (4.42) and MLE (4.21) respectively which was not significant across the extracts. BLE treated fruits showed significantly higher PD (1.16) followed MLE (0.96) and NLE (0.92). Weight of *Moringa* treated fruits were significantly higher (35.56) followed by NLE (28.88) and bitter leaf (27.54). Concentration of 80%w/v and 100%w/v produced significantly higher marketability (4.83) respectively while the least was at 0%w/v (3.41). 0%w/v showed the highest PD (2.23) and this was significantly higher than that

produced by 80%w/v (0.40) and 100%w/v (0.39) respectively. The highest weight was observed at a concentration of 100% w/v (35.07) and this was significantly higher than that produced by 80%w/v (30.86) and 0%w/v (26.06) as shown in Table 3.

Table 3: Main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 2 (*Penicillium waksmanii*).

Leaf Extract	Marketability	Post harvest Decay	Weight
MLE	4.21	0.96	35.56
NLE	4.42	0.92	28.88
BLE	4.43	1.16	27.54
F-LSD (0.05)	**NS**	**0.17**	**4.03**
Concentration			
0	3.41	2.23	26.06
80	4.83	0.40	30.86
100	4.83	0.39	35.07
F-LSD (0.05)	**0.20**	**0.17**	**4.03**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The interaction effect of leaf extract and concentration on quality parameters of tomato fruits was significant on marketability, PD and weight as shown in Table 4. BLE and NLE at 100%w/v gave the highest marketability (5.00) respectively which was significantly higher to that produced by MLE at 80% w/v (4.74) and 100%w/v (4.51) and to all the other interactions. The lowest marketability was produced by BLE at 0%w/v (3.37) followed by MLE at 0%w/v (3.38) and NLE at 0%w/v (3.50) which was significantly lower to all other extract interactions. BLE at 0%w/v gave the highest PD (2.67) followed by MLE at 0%w/v (2.14) and NLE at 0%w/v (1.90) and these were significantly higher than all other extract concentrations. MLE at 100%w/v produced the lowest PD (0.34) followed by NLE at 80%w/v (0.38) and BLE at 100%w/v (0.38) which were significantly lower than all the other extract interactions. MLE at 100%/v gave significantly higher weight (55.10) followed by BLE

at 80%w/v (38.90) and NLE at 80%w/v (29.07). BLE at 100%w/v produced the lowest weight (21.46) and this was not significantly different from that produced by BLE at 0%w/v (22.27) and MLE at 80%w/v (24.60).

Table 4: Interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 2 (*Penicillium waksmanii*)

Leaf extract	Concentration	Marketability	Postharvest Decay	Weight
	0	3.38	2.14	26.98
MLE	80	4.74	0.39	24.60
	100	4.51	0.34	55.10
	0	3.50	1.90	28.92
NLE	80	4.81	0.38	29.07
	100	5.00	0.48	28.66
	0	3.37	2.67	22.27
BLE	80	4.92	0.43	38.90
	100	5.00	0.38	21.46
LSD (0.05)		**1.02**	**0.30**	**6.99**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 3 (*Botryodiplodia theobromae*) was not significant on marketability. BLE gave the highest marketability (4.42) followed by MLE (4.34) and NLE (4.32) respectively. Tomato fruits treated with BLE showed the highest postharvest decay (1.27) and this was significantly higher than that produced by NLE (0.97) and MLE (0.87) respectively. Weight was significantly higher in *Moringa* treated fruits (31.84) followed by BLE (30.43) and NLE (27.72) respectively. At concentration of 80%w/v, marketability was highest (4.92) followed by 100%w/v (4.83) and 0%w/v (3.33) respectively. PD had significantly higher value at 0%w/v (2.38) followed by 80%w/v (0.37) and 100%w/v (0.37) respectively. At 100%w/v, weight was significantly higher (32.16) followed by 80%w/v (30.64) and 0%w/v (27.19) respectively as shown in Table 5.

Table 5: Main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 3(*Botryodiplodia theobromae*).

Leaf Extract	Marketability	Postharvest Decay	Weight
MLE	4.34	0.87	31.84
NLE	4.32	0.97	27.72
BLE	4.42	1.27	30.43
LSD (0.05)	**NS**	**0.18**	**2.71**
Concentration			
0	3.33	2.38	27.19
80	4.92	0.37	30.64
100	4.83	0.37	32.16
LSD (0.05)	**NS**	**0.18**	**2.71**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The interaction effect of leaf extract and concentration on quality parameters of tomato fruits was significant on marketability, PD and weight as shown in Table 6. BLE at 80% w/v gave the highest marketability (5.10) which was significantly higher than that produced by MLE at 100%w/v (4.89) and NLE at 80%w/v (4.80). MLE at 0%w/v produced the lowest marketability (3.30) followed by BLE at 0%w/v (3.32) and NLE at 0%w/v (3.36) respectively which were significantly lower than all other extract concentrations. BLE at 0%w/v gave significantly higher PD (3.05) followed by MLE and NLE at 0% w/v (2.05) respectively. The lowest PD was given by MLE at 80% wlv (0.28). NLE at 100%w/v produced significantly higher weight (35.92) followed by BLE at 80%w/v (34.18) and MLE at 80%w/v (33.05). NLE at 0%w/v gave the lowest weight (22.53) followed by NLE at 80%w/v (24.74) and BLE at 0%w/v (28.26).

Table 6: Interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 3 (*Botryodiplodia theobromae*)

Leaf extract	Concentration	Marketability	Postharvest decay	Weight
	0	3.30	2.05	30.77

MLE	80	4.84	0.28	33.05
	100	4.89	0.29	31.70
	0	3.36	2.05	22.53
NLE	80	4.80	0.43	24.74
	100	4.79	0.43	35.92
	0	3.32	3.05	28.26
BLE	80	5.10	0.38	34.18
	100	4.83	0.38	28.55
LSD (0.05)		**0.19**	**0.32**	**4.69**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 4 (*Fusarium oxysporum*) was not significant on marketability and weight. Tomato fruits treated with BLE gave the highest marketability (4.41) followed by MLE (4.39) and NLE (4.32) respectively. Tomato fruits treated with BLE showed significantly higher PD (1.38) followed by NLE (0.95) and MLE (0.86) respectively. Weight was highest in tomato fruits treated with MLE (31.34) and this was significantly higher than that of BLE (26.47) and NLE (26.36) respectively. At concentration of 80%w/v, marketability of tomato fruits was significantly higher (4.92) followed by 100%w/v (4.88) and 0%w/v (3.31) respectively while PD was significantly higher at 0%w/v (2.45) followed by 80%w/v (0.41) and 100%w/v (0.33) respectively. Weight was highest at 100%w/v (29.18) followed by 0%w/v (27.54) and 80% w/v (27.44) respectively as shown in Table 7.

Table 7: Main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 4 (*Fusarium oxysporum*).

Leaf extract	Marketability	Postharvest Decay	Weight
MLE	4.39	0.86	31.34
NLE	4.32	0.95	26.36
BLE	4.41	1.38	26.47
F-LSD (0.05)	**NS**	**0.13**	**3.07**
Concentration			
0	3.31	2.45	27.54
80	4.92	0.41	27.44

100	4.88	0.33	29.18
F-LSD (0.05)	**0.15**	**0.13**	**NS**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The interaction effect of leaf extract and concentration on quality parameters of tomato fruits was significant on marketability, PD and weight as shown in Table 8. BLE at 80% w/v produced significantly higher marketability (5.02) followed by MLE at 100%w/v (4.99) and BLE at 100%w/v (4.91). MLE at 0%w/v gave significantly lower marketability (3.27) followed by BLE at 0%w/v (3.30) and NLE at 0g/ml (3.37). BLE at 0%w/v produced significantly higher PD (3.24) followed by NLE at 0% w/v (2.09) and MLE at 0%w/v (2.00). The lowest PD was produced by MLE at 100g/ml (0.19). MLE at 100%w/v produced significantly higher weight (36.87) followed by NLE at 80%w/v (34.18) and NLE at 100%w/v (29.52). The lowest weight was produced by BLE at 100%w/v (21.16) followed by NLE at 0%w/v (25.37) and MLE at 0%w/v (28.09).

Table 8: Interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 4 (*Fusarium oxysporum*).

Leaf extract	Concentration	Marketability	Postharvest Decay	Weight
MLE	0	3.27	2.00	28.09
	80	4.89	0.38	29.05
	100	4.99	0.19	36.87
NLE	0	3.37	2.09	25.37
	80	4.85	0.38	34.18
	100	4.73	0.38	29.52
BLE	0	3.30	3.24	29.15
	80	5.02	0.47	29.09
	100	4.91	0.43	21.16
F-LSD (0.05)		**1.33**	**0.22**	**5.31**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract.

The main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 5

(*Colletotrichum asianum*) revealed that tomato fruits dipped in MLE showed the highest marketability (4.48) followed by BLE (4.36) and NLE (4.30) respectively. PD was highest in tomato fruits treated with BLE (1.55) and this was significantly higher than that produced by MLE (1.07) and NLE (1.00) respectively. Weight of the bitter leaf treated fruits were significantly higher (30.00) than MLE (27.53) and NLE (25.72). At concentration of 100%w/v, marketability was significantly higher (4.97) than 80%w/v (4.94) and 0%w/v (3.24) respectively. 0%w/v showed the highest PD (2.81) which was significantly higher than 80% w/v (0.43) and 100%w/v (0.37) respectively. Concentration of 80%w/v showed the highest weight (30.18) which was significantly higher than 0%w/v (26.98) and 100%w/v (25.72) respectively as shown in

Table 9.

Table 9: Main effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 5 (*Colletotrichum asianum*).

Leaf Extract	Marketability	Postharvest Decay	Weight
MLE	4.48	1.07	30.00
NLE	4.30	1.00	27.53
BLE	4.36	1.55	25.72
LSD (0.05)	**NS**	**0.16**	**2.84**
Concentration			
0	3.24	2.81	26.98
80	4.94	0.43	30.18
100	4.97	0.37	25.72
LSD (0.05)	**0.16**	**0.16**	**2.84**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

The interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 5 (*Colletotrichum asianum*) was significant on marketability, PD and weight as shown in Table 10. MLE at 80%w/v produced significantly higher marketability (5.17) followed by MLE at

100%w/v (5.09) and BLE at 100%w/v (5.02). NLE produced highest marketability of 4.81 at 100%w/v and lowest marketability at 0%w/v (3.40). The lowest marketability was produced by BLE at 0%w/v (3.14) followed by MLE at 0%w/v (3.20) and NLE at 0%w/v (3.40) respectively which were significantly lower across all extract concentrations. BLE at 0% w/v produced significantly higher PD compared to MLE at 0% w/v (2.33) and NLE at 0%w/v (2.24). The lowest PD was produced by NLE at 100%w/v (0.33) followed by BLE at 80%w/v (0.38) and MLE at 100%w/v (0.43), NLE at 80%w/v (0.43) and BLE at 100%w/v (0.43) which were significantly lower across all extract concentrations. BLE at 80%w/v produced significantly higher weight (38.17) followed by BLE at 0%w/v (29.96) and MLE at 80%w/v (28.55). MLE produced the highest weight at 80%w/v (28.55) and lowest weight at 0%w/v (25.62). NLE gave highest weight at 100%w/v (26.87) and lowest weight at 80% w/v (23.81) while BLE at 80%w/v produced the highest weight of (38.17) and lowest at 100%w/v (21.89).

Table 10: Interaction effect of leaf extract and concentration on quality parameters of tomato fruits inoculated with organism 5 (*Colletotrichum asianum*)

Leaf extract	Concentration	Marketability	Postharvest Decay	Weight
	0	3.20	2.33	25.62
MLE	80	5.17	0.46	28.55
	100	5.09	0.43	28.41
	0	3.40	2.24	25.37
NLE	80	4.73	0.43	23.81
	100	4.81	0.33	26.87
	0	3.14	3.86	29.96
BLE	80	4.91	0.38	38.17
	100	5.02	0.43	21.89
F-LSD (0.05)		**0.27**	**0.29**	**4.92**

Key: **MLE** – *Moringa* Leaf Extract, **NLE** – Neem Leaf Extract, **BLE** – Bitter Leaf Extract, **NS** – No Significant difference.

Phytochemical screening of plant leaf extracts

Phytochemical screening of aqueous leaf extracts The extracts are

shown in Table 11.

Table 11: Phytochemical screening of plant leaf extracts

S/N	Constituents	Tests	*Moringa*	Neem	Bitter leaf
1.	Carbohydrates	Molisch'stest	+	+	+
2.	Anthraquinones	Bontrager's test	-	-	-
3.	Glycosides	Ferric chloride test	+	+	+
4.	Cardiac Glycosides	Kelle Killiani test	+	+	+
5.	Saponins	Hemolysis	+	+	+
6.	Steroids and Triterpene	Liebermann Burchard test	+	+	+
7.	Tannins	Ferric chloride test	+	+	+
8.	Flavonoids	Shinoda test	+	+	+
9.	Alkaloids	Dragendroff's test	-	+	+

Key:+ = Present,

- = Absent

The leaf extracts of each plant species were applied at different concentrations on the tomato fruits after they were inoculated with conidia suspensions of the fungal isolates. There was significant reduction of disease development/ postharvest decay due to the dipping of the fruits in aqueous extracts. Similar findings were reported by [10] who stated that chitosan could effectively inhibit postharvest disease of fruits by direct inhibition of spores' germination, germ tube elongation and mycelia growth of phytopathogens as well indirect inducement of defense- related enzymes. The result of this study also revealed that extracts of the different plant species varied in their antifungal potentials *in vivo*. These differences are to be expected because plants vary in their chemical constituents, habitats and age at which they are collected. The antifungal activity exhibited by these plant parts might be attributed to the presence of secondary metabolites. These compounds spread into the bacteria membrane, damage it and cause the death of the cell [11].This agrees with the report that many plant products contain fungitoxic constituents that have the potential to control plant diseases and prevent postharvest decay [12].

Dessication and decay are the two major causes of the termination of commercial / marketable life span of fruits, which can be the result of various postharvest diseases and other physiological disorders. Dipping tomato fruits in aqueous extracts of the selected plant species showed a significant difference in their potential to maintain fruit marketability. Untreated fruits (control) were unmarketable while the highest marketable fruits were obtained from fruits treated with aqueous plant leaf extracts of the plant species. This might be because the plant leaf extracts checked the growth of microbes that were responsible for rotting and reduced metabolic rate of the fruits, which caused loss of weight through respiration. It was also reported that various plant extracts act as anti – senescent and arrest the metabolic breakdown and deterioration caused by various biochemical activities in fruits [13].

The treatment of tomato fruits with aqueous leaf extracts of plant species was observed to be effective in extending their shelf life during storage compared to the untreated (control). This might be because of the antimicrobial components (alkaloids, tannins, and saponins) reported to be present in the plant tissues (roots, leaf, stem and bark) [14]. Also,[15] reported on the preservative effect of aqueous suspension of *P. Biglobosa*pods and leaves of *Guera senegalensis* on tomato fruits and oranges in storage.

During the study, the weight of the tomato fruits treated with the plant leaf extracts as well as the untreated fruits (control) decreased during the storage period. However, significantly lower weight loss was observed in the tomato fruits dipped in the extract of the plant species than the untreated (control) fruits. Moisture losses from fruits are usually controlled by the epidermal layers provided with guard cells and stomata. The film formed on the surface of the fruit act as a physical barrier

to reduce moisture migration from the fruits thereby limiting weight loss [16].

Then present study revealed the presence of phytochemicals such as alkaloids, flavonoids, carbohydrates, glycosides, saponins, tannins and terpenoids in the aqueous leaf extracts of *Moringa,* Neem and bitter leaf. Phytochemicals are non – nutritive plant chemicals which occur naturally in plants that have protective or disease preventive properties. The Phytochemical constituents observed in the leaf extract in this study have been the documented to be the major bioactive plant ingredients as well as exhibiting physiological activity. This finding agrees with[17] who reported that leaves of *Moringa oleifera*have also been known to contain several phytochemicals such as flavonoids, saponins, tannins, alkaloids, glycosides that exhibit antimicrobial activities.

The author in [18] also reported the presence of alkaloids, flavonoids, glycosides, saponins, tannins, phenol, steroids and cyanogenic glycosides in the aqueous leaf extracts of *V. amygdalina and A. indica* respectively. Azadirachtin compound from Neem plant has been found to have anti-viral, anti-bacterial and anti-fungal properties [19]. The mechanisms of these compounds have been proven to be through cell membranes perturbations. This alongside with the action of β-lactams in the transpeptidation of the cell wall could lead to an enhanced antimicrobial effect of the combinations [20].

CONCLUSION

The results of the study have established that plant extracts possess antifungal potential and could maintain the physiological quality of tomato fruits during storage. These botanicals are not only environmentally friendly, cost effective, easy to produce and easy to apply formulations, they are also safe for consumers and they provide a simple method by which deterioration of the produce can be restricted as much as

possible at ambient temperatures between harvest and end use. This is an important step in developing plant based biopesticides as ideal treatments for future plant disease management programmers.

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