RESEARCH ARTICLE

Antifungal effect of extracts of plant leaves onpostharvestdecayandqualityoftomato fruits during storage

Comment [W1]: Antifungal effect of plant leaf extracts on postharvest decay and shelf life of tomato fruits in storage

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ABSTRACT

Antifungal effect of plant leaf extracts on quality(shelf life) and postharvest decay of tomato fruitsduring storage in Makurdi was determined. Tomato fruits of the Roma variety were dippedin conidia suspensions of the test fungi after which they were dipped in the aqueousextracts of each plant species(extract) and stored at room temperature. The results revealed anincrease in marketability, postharvest decay in fruits respectively from 1.00 to 8.40, 0.00 to 5.67 whileweightdecreasedfrom 44.3 to20.27 across alltreatments. Treatedtomatofruitsshowed significantly lower postharvest decay (0.00 – 1.02) compared to the control. Inanother set of experiments (Phytochemical analysis of) leaf extracts of *Moringa*, Neem and bitter leaf screened for thepresence of carbohydrates, glycosides and cardiac glycosides, saponins, steroids,triterpenes, tannins and flavonoids indicated present (+) respectively for each plant leafextract while alkaloids indicated present (+) for bitter leaf extract and anthraquinones wereabsent(-)ineachextract.Plantpowdersandtheirextracts possessantifungalpotential andcan increase the shelf life and maintain the physicochemical quality of tomato fruits duringstorage.This is an important step in developing plant based

Keywords: Antifungal,postharvestdecay,quality,tomato,storage,leafextracts.

Comment [W2]: Shelf life

INTRODUCTION

Tomato (*Solanumlycopersicum*L.) which belongs to the family Solanaceae is one of the mostwidely cultivated and extensively consumed horticultural crop in the world [1]. It is rich invitamins, minerals and lycopene, an excellent antioxidant, sodium, iron, phosphorus, beta-carotene, potassium and magnesium [2]. In the Nigerian Savanna, fresh tomato is the mostvaluable vegetable crop [3]. It accounts for about 18% of the average daily consumption

Comment [W3]: *Solanum lycopersicum* L.

ofvegetables in Nigeria [4].

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Comment [W4]: Why this space?

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Over the last century, the growth in fresh fruit consumption, particularly whole tomato fruitshave led to improvements in preservation treatments to control post-harvest diseaseproliferation 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 andfarmers consideringthevital roletomatoplay in thehealth ofpeopleandfoodsecurity. Keepingin view the above facts, the study was conducted to evaluate the antifungal potential of somebotanicals, which are multi-purpose plants that are easily grown locally and have been found tobe of tremendous use in food and medicine, on postharvest decay and quality of tomato fruitsduring storage. This will provide flexibility to farmers and traders on when and where to marketthe commodity to obtain maximum net return and to provide consumers with the best qualitytomatofruitsforconsumption.Forresearchersinagriculture,itwillprovidebaselineinformation for further research in postharvest preservation. For policy makers in agriculture, it will providethe necessary foundation for planning and budgeting for tomato fruit preservation, therebyreducing capital expenditure on tomato importation. For students in agriculture, it will provideliterature for studies in preservation andstorage, andfor extension workers; it will increase theirperformance credibility in design and implementation of storage programmes. Furthermore,corporate good will between farmer and extension worker will be enhanced.

Comment [W5]: Shelf life

Comment [W6]: in

Comment [W7]: are you sure is baseline information? Just leave it as to provide information

Comment [W8]: too much recommendations, I expect you to talk about the use of plant extracts in postharvest decay control and improvement of shelf life of fruits. Please find such information and add to your introduction.

MATERIALSANDMETHODS

Experimentallocation

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 Benuetrough, at the lower Benue valley and found in the guinea savanna region.

Comment [W9]: at

Collectionoftomatofruits

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

Comment [W10]: whose experimental farm please? Did the researcher plant the tomato himself or the school's experimental farm?

Collectionanddisinfectionofplantleaves

Freshleaves of *Moringaoleifera* (Drumsticktree),*Vernoniaamygdalina* (Bitter leaf)and *Azadirachtaindica*(Neem)werecollectedfromdifferentlocationsinMakurdimetropolis.

Comment [W11]: Scientific names when first mention, the authority that name the plant should be cited e.g. *Azadirachta indica* L.

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

Preparationofplantextractsandextractsconcentrations

Plant leaves were weighed using a weighing balance for water extractions to give 80%w/v and100%w/v respectively. Extract concentrations of 80%w/v and 100%w/v were obtained byobtaining 80g and 100g of the plant leaf of each plant species after weighing. The weighedleaves of each plant species were ground into fine paste first, with mortar and pestle and thenwith a blender and soaked in 100mls of sterile distilled water for 1 hour after which sieving wasdone using a muslin cloth into separate beakers for each plant species and for eachconcentration.

Antifungaleffectofplantleafextractsonpostharvestdecayoftomatofruitsduringstorage

Semi ripe, firm and healthy tomato fruits (Roma variety) were surfaced sterilized by dippingthem in 1% sodium hypochloride solution for thirty seconds and rinsed in three changes ofsterile distilled water. The fruits were then inoculated by dipping them in spore suspensions ofeachpathogenic fungus for1 - 2minutes andincubated for 24 hours at room temperature. Afterincubation, the fruits were dipped into the aqueous extracts of the plant leaves at differentconcentrations of 80%w/v and 100%w/v of each plant species. Control fruits were dipped insterile distilled water only.Fruit quality parameters such as marketability, weight, post harvestdecay and shelf life were evaluated.

Comment [W12]: Where did you get the fungi? What bases did you used to know that they are pathogenic to tomato?

Comment [W13]: This are the most important parameters of this research, please you should state clearly the procedure used to determine this under data collection.

ExperimentalDesign

3×5×3factorialincompletelyrandomiseddesignTreatment

combinations = 45

Replications=3

Totalplots;3×45=135

Eachplotcontained30fruits;30×135=4050fruits

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Phytochemicalscreeningofthebotanicals

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

Testforcarbohydrates

Molisch'stest

Twotothreedrops ofalpha naphthalenesolutionwereaddedtotwomillilitres ofeachplant leafextractinatesttubeafterwhichalcoholwasaddedandshakenfortwominutes.Onemillilitreofconcentratedsulphuricacidwasthereafteraddedslowlyfromthesidesofthetesttubes.A deepviolet colour at the junction of two layers indicated the presence of carbohydrates [6].

Testfortanninsandphenols

Ferric chloride test

Three millilitres of 5% w/v ferric chloride solutionwere added respectively to three millilitresofeach plant leaf extractin a test tube. A blue – black colour indicated the presence of tanninsand phenols [6].

Testforsaponins

Haemolysistest

Two millilitres each of sodium chloride (18% w/v) were placed in six test tubes respectively. Tothree of the test tubes, two millilitres of chloroform, ethanol and water (8:2) wereaddedsequentially and to the other three, two millilitres of the aqueous extracts of the leaves ofeach plant species were addedrespectively after which few drops of blood were added to all thetest tubesand shaken vigorously and thereafter observed for haemolysis under the microscope[7].

Test for alkaloids

Dragendroff'stest

One millilitre of Dragendroff's reagent (Potassium bismuth iodide) was added respectively tothree millilitres of each aqueous leaf extract of the different plant species in a test tube. Theappearance of a brick red precipitate indicated the presence of alkaloids [8].

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Testforflavonoids

Shinoda test

Five millilitres of ethanol (95% v/v) were added to two grams each of the plant leaf powders ofeachplant species in a beaker after whichfivedrops ofhydrochloricacidand0.5g ofmagnesiumturnings were added sequentially. Appearance of a pink colour indicated the presence offlavonoids [8].

Testfortriterpenoidsandsteroids

Liebermann Burchard test

Tendropsofaceticanhydride wereaddedtotwomillilitres ofeach oftheaqueousleafextractofeach plant species and shaken vigorously. To this mixture, five millilitres of concentratedsulphuric acid were added from the sides of the test tubes. Appearance of greenish blue colourindicated the presence of triterpenoids and steroids [7].

Testforcardiacglycosides

Keller – Killiani test

One millilitre of glacial acetic acid was added respectively to two millilitres of each aqueousplant leaf extract in a test tube. Thereafter, three drops of 5% w/v of ferric chloride andconcentrated sulphuric acid were added sequentially. Disappearance of a reddish-brown colourat the junction of two layers and the presence of a bluish green colour in the upper layerindicated the presence of cardiac glycosides [7].

Testforanthraquinones

Bontrager's test

Two millilitres of dilute sulphuricacidwere added respectively to each of two millilitres ofaqueous leaf extracts of each plant species in a test tube. The mixture was thereafter boiled andfiltered.To the filtrates, equal volumes of chloroform wereadded, and the mixture was agitated.Organic layers were separated,and ammonia was added. A pinkish red colour of the ammonialayer indicated the presence of anthraquinones [9].

Testforglycosides

Ferricchloridetest

To about 0.5 g of each plant leaf powder, 5 mls each of concentrated. H_2SO_4were added andboiled for 15 minutes. This was then cooled and neutralized with 20% KOH. The solution wasdividedintotwoportions.Threedropsofferricchloridesolutionwereaddedtooneofthe

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

RESULTS

The main effect of leaf extract and concentration on quality parameters of tomato fruitspreviously dipped in conidia suspensions of organism 1 (*Aspergillusflavus*) revealed that fruitsdipped in bitter leaf extract (BLE) showed significantly higher marketability (4.47) followed byNeem leaf extract (NLE) (4.39) and *Moringa* leaf extract (MLE) (4.17) while fruits dipped in BLEshowed the highest postharvest decay (PD) (1.10) followed by NLE (1.05) and MLE (0.86)respectively. Weightofbitter leaftreatedfruitsweresignificantlyhigher(33.27)followedbyNLE(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 0%w/v (3.24). At concentration of 0%w/v, postharvestdecay 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) and0%w/v (27.20) respectively as shown in Table 1.

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

LeafExtract	Marketability	Postharvestdecay	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 Significantdifference

The interaction effect of leaf extract and concentration on quality parameters of tomato fruitsinoculated with organism 1 (*Aspergillusflavus*) was significant on marketability and PD but notsignificant on weight as shown in Table 2. BLE at 100%w/v, produced the highest

Comment [W14]: Shelf life

Comment [W15]: SI unit?

Comment [W16]: SI unit?

Comment [W17]: SI unit?

Comment [W18]: How did you measure these parameters please?

Comment [W19]: Mean effect of leaf extracts and concentrations on shelf life of tomato fruits inoculated with *A. flavus*

Comment [W20]: LSD value please

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marketability(5.15)followedby
NLEat100%w/v(5.13)andBLEat80%w/v(4.96).0%w/vproducedthelowest

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

Table2: Interactioneffectof leafextractandconcentrationonqualityparametersof tomato fruits inoculated with organism 1 (*Aspergillus flavus*).

Leafextract	Concentration	Marketability	Postharvestdecay	Weight
	0	3.12	2.00	27.09
MLE	80	4.70	0.29	29.16
	100	4.67	0.29	27.66
	0	3.30	2.29	24.92
NLE	80	4.73	0.43	28.78
	100	5.13	0.43	30.85
	0	3.30	2.62	29.60
BLE	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*LeafExtract,**NLE**–NeemLeafExtract,**BLE**–BitterLeafExtract,**NS**–NoSignificantdifference

The main effect of leaf extract and concentration on quality parameters of tomato fruitsinoculated with organism 2 (*Penicilliumwaksmanii*) revealed that tomato fruits treated with BLEshowed the highest marketability (4.43) followed by NLE (4.42) and MLE (4.21) respectivelywhich 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 significantlyhigher (35.56) followed by NLE (28.88) and bitter leaf (27.54). Concentration of 80%w/v and100%w/v produced significantly higher marketability (4.83) respectively while the least was at0%w/v (3.41). 0%w/v showed the highest PD (2.23) and this was significantly higher than thatproduced by 80%w/v (0.40) and 100%w/v (0.39) respectively. The highest weight was observedat a concentration of 100%w/v (35.07) and this was significantly higher than that produced by80%w/v (30.86) and 0%w/v (26.06) as shown in Table 3.

Comment [W21]: Do same as table 1 please

Comment [W22]: SI unit for measurement

Comment [W23]: The LSD value should here please and for you to just say not significant. When you compare NLE (0%) with BLE (80%), you have a difference of 13.68 which I believe there should be a significant difference

Comment [W24]: Just state that there is no significant difference in marketability, no need of good further to explain again

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Table3:Maineffect ofleafextract andconcentrationon qualityparametersof tomatofruitsinoculated with organism 2 (*Penicillium waksmanii*).

LeafExtract	Marketability	PostharvestDecay	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*LeafExtract,**NLE**–NeemLeafExtract,**BLE**–BitterLeafExtract,**NS**–NoSignificantdifference.

Comment [W25]: Refer to table 1 and effect corrections accordly

The interaction effect of leaf extract and concentration on quality parameters of tomato fruitswas significant on marketability, PD and weight as shown in Table 4. BLE and NLE at 100%w/vgave the highest marketability (5.00) respectively which was significantly higher to thatproduced by MLE at 80%w/v (4.74) and 100%w/v (4.51) and to all the other interactions. Thelowest marketability was produced by BLE at 0%w/v (3.37) followed by MLE at 0%w/v (3.38) andNLEat0%w/v (3.50)whichwassignificantlylowerto allother extractinteractions.BLE at0%w/vgave the highest PD (2.67) followed by MLE at 0%w/v (2.14) and NLE at 0%w/v (1.90) and thesewere significantly higher than all other extract concentrations. MLE at 100%w/v produced thelowest PD (0.34) followed by NLE at 80%w/v (0.38) and BLE at 100%w/v (0.38) which weresignificantly lower than all the other extract interactions. MLE at 100%/v gave significantlyhigher weight (55.10) followed by BLE at 80%w/v (38.90) and NLE at 80%w/v (29.07). BLE at100%w/v produced the lowest weight (21.46) and this was not significantly different from thatproduced by BLE at 0%w/v (22.27) and MLE at 80%w/v (24.60).

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Table4: 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.

Comment [W26]: Refer to table 1

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Table5:Maineffect ofleafextract andconcentrationon quality parametersof tomatofruitsinoculatedwith organism3(*Botryodiplodiatheobromae*).

LeafExtract	Marketability	PostharvestDecay	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*LeafExtract, **NLE**– NeemLeafExtract, **BLE**– BitterLeafExtract, **NS**– NoSignificantdifference.

Comment [W27]: Refer to table 1

The interaction effect of leaf extract and concentration on quality parameters of tomato fruitswas significant on marketability, PD and weight as shown in Table 6. BLE at 80%w/v gave thehighest marketability (5.10) which was significantly higher than that produced by MLE at100%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 weresignificantly lower than all other extract concentrations. BLE at 0%w/v gave significantly higherPD (3.05) followed by MLE and NLE at 0%w/v (2.05) respectively. The lowest PD was given byMLEat 80%wlv(0.28). NLE at 100%w/v producedsignificantly higher weight(35.92) followedbyBLEat80%w/v (34.18)andMLEat80%w/v(33.05).NLEat 0%w/v gavethelowest weight(22.53)followed by NLE at 80%w/v (24.74) and BLE at 0%w/v (28.26).

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Table6:Interactioneffectof leafextractandconcentrationonqualityparametersof tomato fruits inoculated with organism 3 (*Botryodiplodiatheobromae*)

Leafextract	Concentration	Marketability	Postharvestdecay	Weight
MLE	0	3.30	2.05	30.77
	80	4.84	0.28	33.05
	100	4.89	0.29	31.70
NLE	0	3.36	2.05	22.53
	80	4.80	0.43	24.74
	100	4.79	0.43	35.92
BLE	0	3.32	3.05	28.26
	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*LeafExtract,**NLE**–NeemLeafExtract,**BLE**–BitterLeafExtract,**NS**–NoSignificantdifference.

Comment [W28]: Refer to table 1

The main effect of leaf extract and concentration on quality parameters of tomato fruitsinoculated with organism 4 (*Fusariumoxysporum*) was not significant on marketability andweight. 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 higherPD (1.38) followed by NLE (0.95) and MLE (0.86) respectively. Weight was highest in tomatofruitstreatedwith MLE (31.34)andthiswassignificantlyhigherthanthatof BLE(26.47) andNLE(26.36) respectively. At concentration of 80%w/v, marketability of tomato fruits wassignificantly higher (4.92) followed by 100%w/v (4.88) and 0%w/v (3.31) respectively while PDwas 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.

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

Leafextract	Marketability	PostharvestDecay	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*LeafExtract,**NLE**–NeemLeafExtract,**BLE**–BitterLeafExtract,**NS**–NoSignificantdifference.

Comment [W29]: Refer to table 1

The interaction effect of leaf extract and concentration on quality parameters of tomato fruitswas significant on marketability, PD and weight as shown in Table 8. BLE at 80%w/v producedsignificantly higher marketability (5.02) followed by MLE at 100%w/v(4.99) and BLEat 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 byNLE 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)andNLE at100%w/v (29.52).Thelowestweightwasproducedby BLEat 100%w/v (21.16)followed by NLE at 0%w/v (25.37) and MLE at 0%w/v (28.09).

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Table8:Interactioneffect of leafextractandconcentrationonqualityparametersof tomato fruits inoculated with organism 4 (*Fusarium oxysporum*).

Leafextract	Concentration	Marketability	PostharvestDecay	Weight
	0	3.27	2.00	28.09
MLE	80	4.89	0.38	29.05
	100	4.99	0.19	36.87
	0	3.37	2.09	25.37
NLE	80	4.85	0.38	34.18
	100	4.73	0.38	29.52
	0	3.30	3.24	29.15
BLE	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*LeafExtract,**NLE**–Neem LeafExtract,**BLE**–Bitter Leaf Extract.

Comment [W30]: Refer to table 1

The main effect of leaf extract and concentration on quality parameters of tomato fruitsinoculated with organism 5 (*Colletotrichumasianum*) revealed that tomato fruits dipped in MLEshowed the highest marketability (4.48) followed by BLE (4.36) and NLE (4.30) respectively. PDwas highest in tomato fruits treated with BLE (1.55) and this was significantly higher than thatproduced by MLE (1.07) and NLE (1.00) respectively. Weightofthe bitter leaftreated fruits weresignificantly 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) and100%w/v (0.37) respectively. Concentration of 80%w/v showed the highest weight (30.18) whichwas significantly higher than 0%w/v (26.98) and 100%w/v (25.72) respectively as shown in

Table9.

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

LeafExtract	Marketability	PostharvestDecay	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 Significantdifference.

Comment [W31]: Refer to table 1

The interaction effect of leaf extract and concentration on quality parameters of tomato fruitsinoculated with organism 5 (*Colletotrichumasianum*) was significant on marketability, PD andweight 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 highestmarketability of 4.81 at 100%w/v and lowest marketability at 0%w/v (3.40). The lowestmarketabilitywas producedbyBLEat0%w/v (3.14)followedbyMLEat0%w/v(3.20)andNLEat0%w/v (3.40) respectively which were significantly lower across all extract concentrations. BLEat 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 BLEat 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 weresignificantly lower across all extract concentrations. BLE at 80%w/v produced significantlyhigher weight (38.17) followed by BLE at 0%w/v (29.96) and MLE at 80%w/v (28.55). MLEproduced the highest weight at 80%w/v (28.55) and lowest weight at 0%w/v (25.62). NLE gavehighest weight at 100%w/v (26.87) and lowest weight at 80%w/v (23.81) while BLE at 80%w/vproduced the highest weight of (38.17) and lowest at 100%w/v (21.89).

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Table10:Interactioneffectofleafextractandconcentrationonqualityparametersoftomatofruitsinoculated with organism 5 (*Colletotrichum asianum*)

Leafextract	Concentration	Marketability	PostharvestDecay	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*LeafExtract,**NLE**–NeemLeafExtract,**BLE**–BitterLeafExtract,**NS**–NoSignificantdifference.

Comment [W32]: Refer to table 1

Phytochemicalscreeningofplantleafextracts

AqueousleafextractsofMoringa,Neemandbitterleafscreenedforthepresenceofconstituentssuchasascarbohydrates using the Molisch's test indicated present (+) respectively for all the plantleaf extracts while Bontrager's test for anthraquinones showed absent (-) respectively for eachextract. Ferric chloride and KelleKilliani tests for glycosides and cardiac glycosides respectivelyindicated present (+) for all the extracts. Haemolysis, Liebermann Burchard and ferric chloridetests for saponins, steroids and triterpenes and tannins respectively showed present (+) for allthe plant extracts. Shinoda test for flavonoids indicated present (+) for each plant extractscreened in this study while the Dragendroff's test for alkaloids indicated present (+) for bitterleaf and Neem leaf extracts and absent (-) for *Moringa* leaf extract as shown in Table 11.

Comment [W33]: All this explanations are not needed please, just state that aqueous leaf extracts of the botanicals were screened for presences of phytochemical constituents (mention them) according to the standard laboratory procedure and is presented in table 11

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Table11:Phytochemicalscreeningofplantleafextracts

S/N	Constituents	Tests	*Moringa*	Neem	Bitter leaf
1.	Carbohydrates	Molisch'stest	+	+	+
2.	Anthraquinones	Bontrager'stest	-	-	-
3.	Glycosides	Ferricchloridetest	+	+	+
4.	Cardiac Glycosides	KelleKillianitest	+	+	+
5.	Saponins	Haemolysis	+	+	+
6.	Steroidsand Triterpene	LiebermannBurchardtest	+	+	+
7.	Tannins	Ferricchloridetest	+	+	+
8.	Flavonoids	Shinoda test	+	+	+
9.	Alkaloids	Dragendroff'stest	-	+	+

Key:
+=Present,
-=Absent

The leaf extracts of each plant species were applied at different concentrations on the tomatofruits after they were inoculated with conidia suspensions of the fungal isolates. There wassignificant reduction of disease development/ postharvest decay due to the dipping of the fruitsin aqueous extracts. Similar findings were reported by [10] who stated that chitosan couldeffectively inhibit postharvest disease of fruits by direct inhibition of spores' germination, germtube elongation and mycelia growth ofphytopathogens as well indirect inducement of defense-related enzymes. The result of this study also revealed that extracts of the different plantspeciesvariedintheirantifungalpotentials *invivo*.Thesedifferencesaretobeexpectedbecauseplants vary in their chemical constituents, habitats and age at which they are collected. Theantifungal activity exhibited by these plant parts might be attributed to the presence ofsecondary metabolites. These compounds spread into the bacteria membrane, damage it andcause the death of the cell [11].This agrees with the report that many plant products containfungitoxicconstituentsthathavethepotentialtocontrolplantdiseasesandpreventpostharvestdecay [12].

Comment [W34]: Qualitative phytochemical

Comment [W35]: How? Did you use chitosan?

Comment [W36]: Bacteria???

Comment [W37]: No heading? But I believe it should be discussion

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Desiccations and decay are the two major causes of the termination of commercial / marketablelifespanoffruits,whichcanbetheresultofvariouspostharvestdiseasesandother physiologicaldisorders. Dipping tomato fruits in aqueous extracts of the selected plant species showed asignificant difference in their potential to maintain fruit marketability. Untreated fruits (control)were unmarketable while the highest marketable fruits were obtained from fruits treated withaqueous plant leaf extracts of the plant species. This might be because the plant leaf extractscheckedthegrowth ofmicrobes that were responsiblefor rottingandreduced metabolicrateofthe fruits, which caused loss of weight through respiration. It was also reported that variousplant extracts act as anti – senescent and arrest the metabolic breakdown and deteriorationcaused by various biochemical activities in fruits [13].

Comment [W38]: I still have a problem with the methodology you used in measuring this parameter and it is vital for this research

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

During the study, the weight of the tomato fruits treated with the plant leaf extracts as well asthe untreated fruits (control) decreased during the storage period. However, significantly lowerweight loss was observed in the tomato fruits dipped in the extract of the plant species than theuntreated (control) fruits. Moisture losses from fruits are usually controlled by the epidermallayers provided with guard cells andstomata. The film formed on the surface ofthefruit act as aphysical 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 occurnaturallyinplantsthathaveprotectiveordisease preventiveproperties.Theyarenon–essentialnutrients, meaning they are not required by the human body for sustaining life. ThePhytochemicalconstituents observedintheleafextract inthisstudy havebeen thedocumentedto be the major bioactive plant ingredients as well as exhibiting physiological activity. Thisfinding agrees with[17] who reported that leaves of *Moringaoleifera*have also been known tocontain several phytochemicals such as flavonoids, saponins, tannins, alkaloids, glycosides thatexhibit antimicrobial activities.

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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 foundto have anti-viral, anti-bacterial and anti-fungal properties [19]. The mechanisms of thesecompounds have been proven to be through cell membranes perturbations. This alongside withthe action of β-lactams in the transpeptidation of the cell wall could lead to an enhancedantimicrobial effect of the combinations[20].

CONCLUSION

The results of the study have established that plant extracts possess antifungal potential andcould maintain the physiological quality of tomato fruits during storage. These botanicals arenot only environmentally friendly, cost effective, easy to produce and easy to applyformulations, they are also safe for consumers and they provide a simple method by whichdeterioration of the produce can be restricted as much as possible at ambient temperaturesbetween harvest and end use. This is an important step in developing plant based biopesticidesas ideal treatments for future plant disease management programmes.

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