Academic City University College – Accra Ghana
Society for Multidisciplinary & Advanced Research Techniques (SMART) Africa
Tony Blair Institute for Global Change
FAIR Forward – Artificial Intelligence for All - Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Accra Bespoke Multidisciplinary Innovations Conference (ABMIC)

& The Africa AI Stakeholders' Summit 14th December, 2021

Mycotoxic potentials of *Azadirachta indica Adr. Juss.* and Aloe vera (L.) N. Burman extracts against Fungi associated with Rotting *Capsicum annuum L.* (Chilli Pepper)

Sobowale, A. A* & Adeyanju, M.I.
Department of Botany
Faculty of Science
University of Ibadan
Ibadan, Nigeria
E-mail: delesobowale@yahoo.com*
Phone: +2348037265148

Proceedings Citation Format

Sobowale, A. A* & Adeyanju, M.I. (2021): Mycotoxic potentials of *Azadirachta indica Adr. Juss.* and Aloe vera (L.) N. Burman extracts against Fungi associated with Rotting *Capsicum annuum L.* (Chilli Pepper). Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference. University of Ghana/Academic City University College, Accra, Ghana. December 2021. Pp 45-74. www.isteams.net/ghanabespoke2021.
DOI https://doi.org/ 10.22624/AIMS/ABMIC2021-V2-P5

Mycotoxic potentials of *Azadirachta indica Adr. Juss.* and Aloe vera (L.) N. Burman extracts against Fungi associated with Rotting *Capsicum annuum L.* (Chilli Pepper)

Sobowale, A. A* & Adeyanju, M.I.

ABSTRACT

The mycotoxic potentials of *Azadirachta indica* Adr. Juss. and *Aloe vera* (L.) N. Burman extracts was tested against rot of *Capsicum annuum* L. (Chilli pepper). The fungi were isolated from rotting pepper fruits by placing them aseptically on acidified potato dextrose agar. Pure cultures were obtained by sub culturing onto fresh acidified PDA and later stored at room temperature. Aqueous and methanol extracts of *Azadirachta indica* and *Aloe. vera* were obtained using standard measures. The isolated fungi were identified and cultured on acidified potato dextrose agar impregnated aqueous and methanol extracts and the combination of *Azadirachta indica* and *Aloe vera* extracts. All plates were incubated at room temperature for 7 days. The plates were observed daily for fungal growth with the measurement of each fungus taken using a meter rule. All experiments were done in duplicates. The data obtained was subjected to analysis using SAS version 9.2. Four fungal pathogens were isolated and these were *Aspergillus tamarii*, *Aspergillus flavus*, *Penicillium digitatum* and *Botrytis cinerea*. Days, Organisms and Concentrations levels recorded highly significant ($p<0.0001$) effects with respect to inhibition by all extracts. Highly significant ($p<0.0001$) interactions were obtained for Days and Organisms, Days and Concentrations and interactions among Days, Organisms and Concentrations. The synergistic effects (aqueous and methanol) of Neem leaf and Aloe leaf inhibited *A. tamarii*, *A. flavus* and *P. digitatum* at combinations of 75% Aloe (A) with 50% Neem (N) (A75+N50). *B. cinerea* was inhibited by the combination (aqueous) of 25% Aloe and 25% Neem (A25+N25) and the combination (methanol) of 75% Aloe with 75% Neem (A75+N75). This confirm the inhibitory potentials of interaction between the two botanicals. Phytochemical components present in the combinations need to be determined to understand how they interact with the inhibition of these organisms.

Keywords: Neem, Aloe, synergistic effect, botanicals, fungi

1. INTRODUCTION

Pepper is known to originate from South and Central America where it is still under cultivation and are considered the first spice to have been used by human beings (Pickersgill, 1997, FAO, 2009, Wada *et al*., 2015). It is the most used food all over the world and also the most widely grown spice crop. It is among the world's most important vegetable including tomato and onion (Dias *et al.,* 2013)

It is one of the most important spices used in making most Nigerian food. Most peppers grown belongs to *Capsicum annum* but the small, pungent peppers belongs to *Capsicum frutescens*. Production in tropical Africa was estimated at 1 million t, with Nigeria (725,000 t from 90,000 ha) and Ghana (270,000 t from 75,000 ha) as the largest producers. Most statistics for Africa does not include home farms and garden production (FAO, 2009).

Pepper production in Nigeria has served as a good source of income to local farmers. It also serves as raw materials for our industries, for example, in food production and cosmetic industry. It has improved the standard of living thereby creating employment opportunities to citizens. Pepper production has also contributed to the national income through exports.

Pepper has been used medically for the treatment of different ailments including fevers, colds, indigestion, constipation and pain killing (Dagnoko *et al.,* 2013). It is also used by the security agencies in the preparation of tear gas. The common varieties grown in Nigeria includes Bell peppers, bird peppers, habanero peppers, Cayenne peppers and Nsukka yellow peppers (which are yellow habanero peppers).

However, the plant is known to suffer from biotic and abiotic stresses that in turn leads to the development of different diseases. It is also known to be infected by different pathogens at different stages of its growth, most of which are of fungal origin (Howard *et al.,* 1994; Black *et al.,* 1991; Katoch and Kapoor, 2014; Ademoh *et al.,* 2018).

The need to introduce safe and ecofriendly control measures for plant diseases, has led researchers turning their attention to the use of different biological control measures including botanicals. Generally, Neem and *Aloe vera* have been severally reported to be a rich source of antimicrobial properties and they are known to produce active secondary metabolites. The numerous beneficial potentials of Neem and A*loe vera* has been severally documented (Hegger, 1996; Daodu, 2000; Olusegun, 2000; Pandey *et al.,* 2016).

The efficacy of different concentrations of Neem leaf on different fungal pathogens has also been documented *(*Simhadri *et al.,* 2017). The mycotoxic properties of *Aloe vera* has as well been documented (Muthomi *et al.,* 2017). However, there is little knowledge on the synergistic effects of extracts of both plants on fungal pathogens. The aim of this study therefore was to examine the synergistic effects of Neem leaf and *Aloe vera* leaf extracts on the fungi isolated from rotting pepper fruits.

The objectives of this experiment are:

a) To isolate and identify the fungi associated with postharvest rotting pepper fruits.
b) To examine the effects of crude extracts of *Azadirachta indica* and *Aloe vera* on the isolated fungi *in vitro*
c) To examine the interactive effects of aqueous and methanol extracts of *Azadirachta indica* and *Aloe vera* on the isolated fungi.
d) To examine the effect of concentration on fungal growth inhibition potential of the plant extracts.

2. MATERIALS AND METHODS

Collection of pepper fruits, Neem and *Aloe vera* leaves

Rotting fruits of pepper were collected from two selected markets within Ibadan metropolis. Fresh Neem (*Azadirzchta indica*) and *Aloe vera* leaves were collected from the University of Ibadan campus, packed in sterile polythene bags and brought to Plant Pathology laboratory, Department of Botany, University of Ibadan. The leaves were prepared for extraction following standard procedures.

Extraction of the botanicals and preparation of the extract concentrations

Aqueous and methano extraction was carried out in the Department of Botany and the Department of Pharmaceutical Chemistry, University of Ibadan following standard procedures. The stock solution was prepared by dissolving 3 gram of the resulting extract in 10ml of distilled water, for both aqueous and methanol extracts. 25%, 50% and 75% of each extract of both botanicals was then obtained from the stock solution.

Inoculation of rotting pepper fruits

Rotting sections of *Capsicum annuum* were sterilized in 1% solution of sodium hypochlorite for 30 seconds and then rinsed in five changes of sterile distilled water. They were cultured on acidified potato dextrose agar (APDA) Petri plates before incubating at 28 ± 2°C for 7 days and were examined daily. The experiment was done in triplicates. All pure cultures after sub culturing were identified and kept on slants.

Pathogenicity test and Bioassay of aqueous and methanol extracts of the plants

Pathogenicity test was carried out following the methods of Lin *et al*. (2002) and Than *et al*. (2008). Agar plate diffusion method was employed in the antifungal assay of the extracts following the method of Dutta, (2001). Concentrations of the extracts used were 25%, 50% and 75%.

Interactive bioassay and Data analysis

The interactive effects of different concentrations (25%, 50% and 75%.) of aqueous and methanol extracts of *Azadirachta indica* (N) and *Aloe vera* (A) were evaluated on each isolated fungus. The data obtained were subjected to ANOVA using Generalized Linear Model of Statistical Analysis Software (SAS).

3. RESULTS

The isolated fungi include *Penicillium digitatum, Aspergillus tamarii*, *Aspergillus flavus*, and *Botrytis cinerea*.

Table 1 shows the ANOVA Table for the effects of all extracts on growth of the isolated fungi. The F values (P>0.0001) for day, organism and concentration were highly significant. The F values for interaction between day and concentration, organism and concentration as well as day and organism were all highly significant.

Table 1: ANOVA table of the effects of all extracts on growth of the fungi isolated

Source	Df	SS	MS	F value	P > F
C	17	435.74	25.63	138.43	0.0001**
D	6	2104.25	350.71	1894.12	0.0001**
S	1	4850.44	4850.44	26196.4	0.0001**
O	3	1626.95	542.32	2928.96	0.0001**
D*C	102	142.09	1.39	7.52	0.0001**
C*S	17	398.46	23.44	126.59	0.0001**
O*C	51	332.54	6.52	35.22	0.0001**
D*S	6	899.61	149.93	809.77	0.0001**
D*O	18	382.80	21.27	114.86	0.0001**
O*S	3	1984.04	661.35	3571.82	0.0001**
D*C*S	102	147.15	1.44	7.79	0.0001**
D*O*C	306	208.04	0.68	3.67	0.0001**
O*C*S	51	285.18	5.59	30.20	0.0001**
D*O*S	18	463.88	25.77	139.18	0.0001**

C = Concentration
D = Days
S = Solvents
O = Organisms
**= Highly significant

Table 2 shows the growth inhibition (cm) of *Penicillium digitatum* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation. Compared to the control, 75% of *Azadirachta indica* extracts had more effect on inhibiting the growth of the fungus after 7 days, while all concentrations of *Aloe vera* had no effect. However, 25% of *Aloe vera* extracts had effect on the first day when compared to the control.

Table 2: Growth inhibition (cm) of *Penicillium digitatum* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation

	Treatment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.33^{b}	1.98^{d}	2.55^{e}	2.53^{efgh}	2.83^{efg}	3.08^{fgh}	3.45^{fgh}
	50%	1.30^{b}	2.10^{cd}	2.88^{d}	3.60^{c}	4.25^{c}	4.83^{c}	5.13^{c}
	75%	1.28^{bc}	1.55^{f}	1.60^{i}	1.63^{jk}	1.65^{klm}	1.63^{klmn}	1.58^{nop}
Aloe vera	25%	1.15^{de}	2.60^{b}	2.85^{d}	2.83^{def}	2.88^{ef}	2.90^{gh}	4.30^{de}
	50%	1.20^{cd}	2.28^{c}	2.45^{ef}	3.23^{cd}	3.75^{cd}	3.85^{de}	3.93^{efg}
	75%	1.33^{b}	2.00^{d}	2.20^{fg}	2.65^{efg}	3.33^{de}	3.85^{de}	4.13^{ef}
	Control	1.20^{cd}	1.45^{f}	1.65^{i}	2.20^{ghi}	2.30^{fghij}	2.45^{hij}	2.60^{jkl}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 3 shows the growth inhibition (cm) of *Penicillium digitatum* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation. Both *Aloe vera* (50%) and *Azadirachta indica* (75%) extracts showed high effects on the growth of the fungus when compared to the control while 25% of both extracts showed little effect after 7 days. However, 25% *Azadirachta indica* inhibited up to day 5 while 25% *Aloe vera* had effect up to day 3.

Table 3: Growth inhibition (cm) of *Penicillium digitatum* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.00^{g}	1.00^{j}	0.98^{k}	1.03^{lm}	1.03^{n}	1.15^{mn}	1.47^{nop}
	50%	1.03^{g}	1.00^{j}	1.00^{k}	1.00^{m}	1.00^{n}	1.00^{n}	1.00^{p}
	75%	1.00^{g}	1.00^{j}	0.98^{k}	1.00^{m}	1.00^{n}	1.00^{n}	1.00^{p}
Aloe vera	25%	1.00^{g}	1.00^{j}	1.13^{k}	1.25^{klm}	1.35^{lmn}	1.43^{lmn}	1.58^{nop}
	50%	1.03^{g}	1.00^{j}	1.00^{k}	1.00^{m}	1.00^{n}	1.00^{n}	1.00^{p}
	75%	1.00^{g}	1.00^{j}	1.00^{k}	1.00^{m}	1.03^{n}	1.00^{n}	1.00^{p}
	Control	1.00^{g}	0.98^{j}	0.98^{k}	1.00^{m}	1.03^{n}	1.00^{n}	1.08^{p}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 4 shows the synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Penicillium digitatum*. When comparing all levels of interaction, it showed that the combinations of 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) had the most effect after 7 days, followed by 75% *Aloe vera* with 75% *Azadirachta indica* (A75+N75) and 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50). The combination of 50% *Aloe vera* with 75% *Azadirachta indica* (A50+N75) almost had no effect in inhibiting the fungus after the first 2 days.

The synergy of methanol extracts of *Azadirachta indica* and *Aloe vera* on growth of *P. digitatum* revealed all levels of interaction showed inhibition up till the 3rd day of incubation. However, the best inhibition of the fungus after 7 days was shown in 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) combination.

Table 4: Synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Penicillium digitatum*

Solvent	Level of interaction	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	A25+N25	1.13^{def}	1.25^{ghi}	2.55^{e}	2.55^{efgh}	2.78^{efgh}	2.83^{ghi}	3.38^{ghi}
	A25+N50	1.08^{efg}	2.23^{c}	2.43^{ef}	2.38^{fgh}	2.43^{fghi}	2.50^{hij}	2.88^{hij}
	A25+N75	1.10^{efg}	1.53^{f}	2.48^{ef}	1.83^{ij}	2.23^{hijk}	3.43^{efg}	4.10^{ef}
	A50+N25	1.33^{b}	2.90^{a}	3.30^{c}	3.50^{c}	3.83^{cd}	4.25^{d}	4.93^{cd}
	A50+N50	1.15^{de}	2.50^{b}	2.90^{d}	2.98^{de}	3.08^{e}	3.58^{ef}	3.93^{efg}
	A50+N75	1.75^{a}	2.95^{a}	4.15^{a}	6.05^{a}	6.10^{a}	7.25^{a}	7.53^{a}
	A75+N25	1.05^{fg}	2.58^{b}	3.70^{b}	4.90^{b}	5.30^{b}	5.75^{b}	5.90^{b}
	A75+N50	1.13^{def}	1.78^{e}	2.05^{gh}	2.10^{hi}	2.20^{hijk}	2.15^{jk}	2.20^{j-n}
	A75+N75	1.10^{efg}	1.98^{d}	2.13^{g}	2.30^{gh}	2.28^{ghij}	2.25^{ijk}	2.35^{jklm}
Methanol	A25+N25	1.13^{def}	1.13^{hij}	1.25^{jk}	1.50^{jkl}	1.88^{ijkl}	2.18^{jk}	2.48^{jklm}
	A25+N50	1.00^{g}	1.05^{ij}	1.10^{k}	1.25^{klm}	1.53^{lmn}	1.70^{klm}	1.90^{l-o}
	A25+N75	1.00^{g}	1.03^{j}	1.10^{k}	1.23^{klm}	1.50^{lmn}	1.78^{kl}	2.05^{k-o}
	A50+N25	1.03^{g}	1.05^{ij}	1.18^{k}	1.58^{jk}	1.78^{jkl}	2.50^{hij}	2.73^{ijk}
	A50+N50	1.03^{g}	1.00^{j}	1.10^{k}	1.25^{klm}	1.43^{lmn}	1.60^{klmn}	1.78^{m-p}
	A50+N75	1.05^{fg}	1.03^{j}	1.05^{k}	1.00^{m}	1.08^{mn}	1.10^{mn}	1.33^{op}
	A75+N25	1.05^{fg}	1.00^{j}	1.00^{k}	1.00^{m}	1.15^{mn}	1.30^{lmn}	1.53^{nop}
	A75+N50	1.00^{g}	1.00^{j}	1.00^{k}	0.98^{m}	1.00^{n}	1.00^{n}	1.03^{p}
	A75+N75	1.15^{de}	1.05^{ij}	1.05^{k}	1.05^{lm}	1.08^{mn}	1.20^{lmn}	1.45^{nop}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 5 show the growth inhibition (cm) of *Aspergillus tamarii* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation. The results showed that 75% of Neem extracts had more effect on the growth of the fungus when compared to the control as well as other concentrations while 25% *Aloe vera* had the most effect on the fungus when compared to the control.

Table 5: Growth inhibition (cm) of *Aspergillus tamarii* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.38^{bcde}	2.38^{b}	2.98^{abc}	3.00^{cd}	3.15^{c}	3.05^{cde}	3.18^{efg}
	50%	1.18^{ghij}	1.50^{b}	1.58^{ijk}	1.68^{i-m}	1.73^{jklm}	1.85^{ijkl}	1.78^{klmn}
	75%	1.10^{hijk}	1.28^{b}	1.33^{jkl}	1.35^{k-q}	1.35^{lmno}	1.43^{klm}	1.43^{lmn}
Aloe vera	25%	1.30^{defg}	2.05^{b}	2.43^{ef}	2.73^{de}	3.05^{cd}	2.48^{e-i}	2.73^{efghij}
	50%	1.43^{bcd}	2.35^{b}	2.93^{abcd}	3.43^{abc}	3.85^{b}	4.48^{ab}	4.73^{bc}
	75%	1.35^{cdef}	2.20^{b}	3.03^{ab}	3.68^{a}	4.25^{ab}	4.15^{b}	4.60^{bc}
	Control	1.25^{efg}	1.80^{b}	2.15^{fg}	2.55^{ef}	2.95^{cde}	3.25^{cd}	3.65^{de}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 6 shows the growth inhibition (cm) of *Aspergillus tamarii* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation. 50% *Azadirachta indica* extract had more effect on the fungus in comparison to the control while 75% *Aloe vera* had a significant effect on inhibiting the growth of the fungus when compared to the control.

Table 6: Growth inhibition (cm) of *Aspergillus tamarii* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.20^{ghi}	1.30^{b}	1.43^{ijk}	1.80^{hijk}	2.45^{efgh}	2.85^{cdef}	3.00^{efgh}
	50%	1.08^{ijk}	1.05^{b}	1.05^{l}	1.00^{q}	1.00^{o}	1.08^{m}	1.40^{lmn}
	75%	0.98^{k}	0.95^{b}	1.08^{l}	1.25^{l-q}	1.40^{k-o}	1.53^{jklm}	1.80^{j-n}
Aloe vera	25%	1.00^{k}	1.10^{b}	1.30^{kl}	1.50^{j-p}	1.85^{ijkl}	2.05^{g-k}	2.25^{g-l}
	50%	1.05^{jk}	1.05^{b}	1.05^{l}	1.03^{pq}	1.03^{no}	1.05^{m}	1.18^{mn}
	75%	1.00^{k}	1.08^{b}	1.03^{l}	1.08^{pq}	1.03^{no}	1.08^{m}	1.05^{n}
	Control	1.05^{jk}	1.03^{b}	1.03^{l}	1.10^{opq}	1.13^{no}	1.30^{lm}	1.50^{lmn}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 7 shows the synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Aspergillus tamarii*. When compared with other interactions, the results showed that combination of 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50) had the most inhibitory effect on the fungus after 7 days, followed by the combinations of 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50). Combinations of 25% *Aloe vera* with 25% *Azadirachta indica* (A25+N25), 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50) and 25% *Aloe vera* with 75% *Azadirachta indica* (A25+N75) had effect on the fungus till day 4 when compared with other interactions. The synergy of methanol extracts of both plants showed that the best combinations is 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) and 50% *Aloe vera* with 50% *Azadirachta indica* (A50+N50) after 7 days.

Table 7: Synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Aspergillus tamarii*

	Level of interaction	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	A25+N25	1.25^{efg}	1.15^{a}	1.70^{hi}	1.65^{jklmn}	2.38^{fghi}	2.60^{c-i}	3.08^{efgh}
	A25+N50	1.25^{efg}	1.53^{b}	1.70^{hi}	1.73^{ijkl}	2.28^{ghi}	2.60^{c-i}	2.60^{f-k}
	A25+N75	1.23^{fgh}	1.70^{b}	1.75^{hi}	1.93^{ghij}	2.55^{defg}	2.55^{d-i}	2.63^{f-k}
	A50+N25	1.30^{defg}	2.33^{b}	2.90^{abcd}	3.53^{ab}	4.43^{a}	5.13^{a}	5.75^{a}
	A50+N50	1.38^{bcde}	2.35^{b}	2.73^{bcde}	3.15^{bcd}	3.98^{ab}	4.20^{b}	5.08^{ab}
	A50+N75	1.73^{a}	2.50^{b}	3.08^{a}	3.63^{a}	3.90^{b}	4.08^{b}	4.15^{cd}
	A75+N25	1.38^{bcde}	2.28^{b}	3.00^{ab}	3.60^{a}	4.23^{ab}	4.70^{ab}	5.30^{ab}
	A75+N50	1.35^{cdef}	1.95^{b}	2.20^{fg}	2.28^{fg}	2.85^{cdef}	2.78^{defg}	2.88^{efghi}
	A75+N75	1.45^{bc}	2.38^{b}	2.68^{cde}	3.05^{cd}	3.30^{c}	3.30^{c}	3.30^{ef}
Methanol	A25+N25	1.08^{ijk}	1.35^{b}	1.05^{l}	2.15^{fghi}	2.55^{defg}	2.85^{cdef}	3.18^{efg}
	A25+N50	1.05^{jk}	1.30^{b}	1.90^{gh}	1.88^{ghij}	2.18^{ghij}	2.50^{d-i}	2.73^{e-j}
	A25+N75	1.03^{jk}	1.18^{b}	1.63^{hij}	1.68^{ijklm}	2.13^{ghij}	2.65^{c-h}	2.90^{efghi}
	A50+N25	1.10^{hijk}	1.30^{b}	1.43^{ijk}	1.98^{ghij}	2.35^{fghi}	2.63^{c-h}	2.88^{efghi}
	A50+N50	1.03^{jk}	1.03^{b}	1.70^{hi}	1.58^{j-o}	1.93^{hijk}	2.18^{fghij}	2.45^{f-k}
	A50+N75	1.05^{jk}	1.08^{b}	1.43^{ijk}	1.58^{j-o}	1.85^{ijkl}	2.20^{fghij}	2.53^{f-k}
	A75+N25	1.08^{ijk}	1.20^{b}	1.28^{kl}	1.83^{ghijk}	2.13^{ghij}	2.53^{d-i}	2.75^{efghi}
	A75+N50	1.02^{k}	1.02^{b}	1.48^{ijk}	1.20^{m-q}	1.54^{klmno}	1.94^{hijkl}	2.28^{g-l}
	A75+N75	1.10^{hijk}	1.07^{b}	1.06^{l}	1.20^{mnopq}	1.57^{klmn}	1.93^{hijkl}	2.53^{f-k}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 8 shows the growth inhibition (cm) of *Aspergillus flavus* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation. In comparison to the control, extracts containing 75% *Azadirachta indica* and 25% *Aloe vera* had more effect on reducing the growth of *A. flavus*, while other concentrations of both extracts had little or no effect.

Table 8: Growth inhibition (cm) of *Aspergillus flavus* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.23^{cde}	2.23^{bcde}	2.85^{abcd}	3.30^{bcdef}	4.13^{abcd}	5.38^{a}	5.70^{abc}
	50%	1.25^{cde}	2.30^{abc}	2.95^{abc}	3.75^{abc}	4.30^{abc}	4.83^{ab}	5.23^{abcd}
	75%	1.25^{cd}	1.73^{gh}	2.28^{fghi}	2.58^{ghi}	3.03^{fghi}	3.40^{fg}	3.53^{fgh}
Aloe vera	25%	1.18^{defg}	1.80^{fg}	2.35^{efghi}	2.78^{fghi}	3.28^{efgh}	3.53^{efg}	3.83^{fg}
	50%	1.30^{bc}	2.08^{cde}	2.53^{defgh}	2.95^{efgh}	3.53^{def}	3.98^{cdef}	4.38^{def}
	75%	1.38^{b}	2.20^{bcde}	2.68^{bcde}	3.23^{bcdef}	3.90^{bcde}	4.25^{bcde}	4.80^{cde}
	Control	1.25^{cd}	2.00^{ef}	2.60^{cdef}	3.15^{cdefg}	3.80^{cde}	4.35^{bcd}	4.90^{bcde}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 9 shows the growth inhibition (cm) of *Aspergillus flavus* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation. After 7 days of incubation, all levels of treatments had no inhibitory effect against the fungus when compared to the control. However, 50% and 75% of *Azadirachta indica* had reduced the growth of the fungus up to the 4th day. 50% and 75% of *Aloe vera* had high effect on the fungi after 7 days compared to 25% of the extract.

Table 9: Growth inhibition (cm) of *Aspergillus flavus* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.08^{hi}	1.13^{j}	1.28^{jklm}	1.45^{klm}	1.63^{lmn}	1.93^{hij}	2.23^{ijk}
	50%	1.08^{hi}	1.00^{j}	0.98^{m}	1.03^{m}	1.10^{mn}	1.40^{ijk}	1.40^{klm}
	75%	1.00^{i}	1.00^{j}	1.00^{lm}	1.00^{m}	1.18^{mn}	1.53^{hijk}	1.98^{ijkl}
Aloe vera	25%	1.05^{hi}	1.03^{j}	1.13^{jklm}	1.20^{lm}	1.33^{lmn}	1.48^{ijk}	1.60^{ijklm}
	50%	1.00^{i}	1.00^{j}	1.00^{lm}	1.00^{m}	1.00^{n}	1.00^{k}	1.03^{m}
	75%	1.00^{i}	1.00^{j}	1.00^{lm}	1.00^{m}	1.00^{n}	1.00^{k}	0.98^{m}
	Control	1.00^{i}	1.03^{j}	1.03^{lm}	1.03^{m}	1.08^{mn}	1.15^{jk}	1.30^{lm}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 10 shows the synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Aspergillus flavus*. The combinations of 25% *Aloe vera* with 75% *Azadirachta indica* (A25+N75) and 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) had the most effect in inhibiting the fungus, compared with the rest of the combinations after 7 days. After 3 days of incubation, combinations of 25% *Aloe vera* with 25% *Azadirachta indica* (A25+N25) and 25% *Aloe vera* with 75% *Azadirachta indica* (A25+N75) had means lower than the rest of the combinations. The synergy of both methanol extracts on *A. flavus* showed that combination of 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) had the lowest means after 7 days, signifying a high inhibition of the fungus, compared with other combinations. However, all interactions recorded low means on the 2nd day.

Table 10: Synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Aspergillus flavus*

Solvent	Level of interaction	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	A25+N25	1.25^{cde}	1.53^{hi}	1.98^{i}	2.38^{hij}	2.75^{ghi}	3.15^{fg}	3.73^{fg}
	A25+N50	1.15^{efgh}	1.60^{ghi}	2.15^{hi}	2.55^{ghi}	2.88^{fghi}	3.23^{fg}	3.68^{fg}
	A25+N75	1.15^{efgh}	1.45^{i}	1.98^{i}	2.30^{ij}	2.68^{hij}	3.10^{g}	3.48^{fgh}
	A50+N25	1.13^{fgh}	2.05^{de}	2.55^{defg}	3.08^{defg}	3.75^{cde}	4.68^{abc}	5.45^{abc}
	A50+N50	1.20^{def}	2.27^{abcd}	2.97^{ab}	3.80^{ab}	4.43^{abc}	4.93^{ab}	5.38^{abc}
	A50+N75	1.63^{a}	2.48^{a}	3.10^{a}	3.63^{abcd}	4.60^{ab}	5.20^{a}	5.45^{abc}
	A75+N25	1.10^{ghi}	2.33^{ab}	3.03^{ab}	3.93^{a}	4.68^{a}	5.20^{a}	5.90^{a}
	A75+N50	1.18^{defg}	1.75^{gh}	2.18^{ghi}	2.60^{ghi}	3.00^{fghi}	3.28^{fg}	3.43^{gh}
	A75+N75	1.13^{fgh}	1.83^{fg}	2.43^{efgh}	2.85^{fghi}	3.45^{defg}	3.83^{defg}	4.18^{efg}
Methanol	A25+N25	1.05^{hi}	1.15^{j}	1.50^{j}	1.73^{kl}	2.05^{jkl}	2.35^{h}	2.68^{hi}
	A25+N50	1.05^{hi}	1.10^{j}	1.38^{jkl}	1.48^{klm}	1.80^{klm}	2.10^{hi}	2.35^{ij}
	A25+N75	1.05^{hi}	1.03^{j}	1.28^{jklm}	1.38^{klm}	1.73^{klmn}	2.03^{hi}	2.33^{ij}
	A50+N25	1.10^{ghi}	1.08^{j}	1.35^{jklm}	1.50^{klm}	1.80^{klm}	2.13^{hi}	2.38^{ij}
	A50+N50	1.00^{i}	1.03^{j}	1.18^{jklm}	1.43^{klm}	1.78^{klm}	2.13^{hi}	2.53^{ij}
	A50+N75	1.00^{i}	1.03^{j}	1.25^{jklm}	1.53^{klm}	1.80^{klm}	2.18^{hi}	2.68^{hi}
	A75+N25	1.05^{hi}	1.13^{j}	1.43^{jk}	1.88^{jk}	2.43^{ijk}	3.13^{g}	3.78^{fg}
	A75+N50	1.00^{i}	1.00^{j}	1.13^{jklm}	1.15^{lm}	1.38^{lmn}	1.70^{hijk}	1.98^{ijkl}
	A75+N75	1.00^{i}	1.08^{j}	1.00^{lm}	1.13^{m}	1.40^{lmn}	1.78^{hijk}	2.55^{i}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 11 shows the growth inhibition (cm) of *Botrytis cinerea* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation. When compared to the control, there is no effect of both extracts on inhibiting the fungus, except 25% *Aloe vera* extract which recorded the lowest mean after 7 days. In comparison to other extracts. 75% *Azadirachta indica* and 25% *Aloe vera* had the best inhibitions at day 3 and 4.

Table 11: Growth inhibition (cm) of *Botrytis cinerea* by different concentrations of *Azadirachta indica* and *Aloe vera* aqueous extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.55^{d}	6.88^{a}	8.45^{a}	8.50^{a}	8.50^{a}	8.50^{a}	8.50^{a}
	50%	1.48^{d}	5.60^{b}	8.50^{a}	8.50^{a}	8.50^{a}	8.50^{a}	8.50^{a}
	75%	1.83^{bc}	3.28^{de}	3.10^{k}	3.48^{h}	3.58^{f}	8.50^{a}	8.50^{a}
Aloe vera	25%	1.00^{fg}	1.58^{h}	2.00^{l}	2.83^{i}	4.18^{e}	4.83^{d}	5.45^{d}
	50%	1.50^{d}	3.48^{de}	5.90^{ef}	8.13^{ab}	8.50^{a}	8.50^{a}	8.50^{a}
	75%	1.73^{c}	3.30^{de}	5.33^{gh}	7.93^{bc}	8.50^{a}	8.50^{a}	8.50^{a}
	Control	1.50^{d}	3.60^{ed}	6.35^{de}	8.40^{a}	8.40^{a}	8.40^{a}	8.40^{a}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 12 shows the growth inhibition (cm) of *Botrytis cinerea* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation. Except 25% *Azadirachta indica* extracts, all extracts (Aloe and Neem) showed inhibitory effects on the fungus, with *Aloe vera* at 75% having the lowest mean after 7 days in comparison with the control. However, 25% *Azadirachta indica* extract showed inhibition up to day 3.

Table 12: Growth inhibition (cm) of *Botrytis cinerea* by different concentrations of *Azadirachta indica* and *Aloe vera* methanol extracts at different days of incubation

	Treatment levels	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Extracts								
Azadirachta indica	25%	1.13^{f}	1.0^{i}	1.0^{m}	1.05^{j}	1.33^{hij}	2.18^{e}	3.00^{e}
	50%	1.03^{fg}	0.98^{i}	1.03^{m}	1.03^{j}	1.03^{j}	1.0^{i}	1.03^{jk}
	75%	1.0^{fg}	1.0^{i}	1.0^{m}	1.0^{j}	0.98^{j}	1.0^{i}	1.25^{ijk}
Aloe vera	25%	1.0^{fg}	1.0^{i}	1.0^{m}	1.0^{j}	1.05^{j}	1.18^{hi}	1.40^{hijk}
	50%	1.0^{fg}	1.03^{i}	1.0^{m}	1.08^{j}	1.0^{j}	1.05^{hi}	1.00^{jk}
	75%	1.0^{fg}	1.0^{i}	1.0^{m}	1.0^{j}	1.0^{j}	1.0^{i}	0.98^{k}
	Control	$1.0f^{g}$	0.98^{i}	0.98^{m}	1.03^{j}	1.05^{j}	1.28^{ghi}	1.70^{ghi}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 13 shows the synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Botrytis cinerea*. In the aqueous synergy, the lowest mean was recorded at the combination of 25% *Aloe vera* with 25% *Azadirachta indica* (A25+N25) after 7 days compared to the others. However, combinations of 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50), 25% *Aloe vera* with 75% *Azadirachta indica* (A25+N75), 50% *Aloe vera* with 50% *Azadirachta indica* (A50+N50) and 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) all had lowest means on day 2. In the synergy between *Azadirachta indica* and *Aloe vera* methanol extracts on *B. cinerea* showed an overall high effect compared to the aqueous interaction, with combination of 75% *Aloe vera* with 75% *Azadirachta indica* (A75+N75) having the lowest mean after 7 days.

Table 13: Synergistic effect of *Azadirachta indica* and *Aloe vera* extracts (aqueous and methanol) on *Botrytis cinerea*

Solvent	Level of interaction	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	A25+N25	1.33^{e}	2.63^{f}	3.58^{j}	3.90^{h}	4.58^{d}	5.13^{d}	5.90^{d}
	A25+N50	1.58^{d}	2.85^{f}	5.80^{fg}	6.78^{e}	7.33^{b}	7.43^{c}	8.08^{ab}
	A25+N75	1.48^{d}	2.70^{f}	4.63^{i}	5.58^{g}	6.65^{c}	7.15^{c}	7.63^{bc}
	A50+N25	1.50^{d}	4.45^{c}	6.70^{cd}	7.73^{bcd}	8.50^{a}	8.50^{a}	8.50^{a}
	A50+N50	1.28^{e}	2.85^{f}	4.25^{i}	6.08^{f}	7.10^{b}	7.33^{c}	7.80^{bc}
	A50+N75	2.10^{a}	3.33^{de}	5.55^{fgh}	7.40^{d}	8.50^{a}	8.50^{a}	8.50^{a}
	A75+N25	1.93^{b}	5.60^{b}	7.80^{b}	8.50^{a}	8.50^{a}	8.50^{a}	8.50^{a}
	A75+N50	1.73^{c}	2.23^{g}	5.33^{gh}	7.53^{cd}	8.50^{a}	8.50^{a}	8.50^{a}
	A75+N75	1.73^{c}	4.30^{c}	7.08^{c}	8.50^{a}	8.50^{a}	8.50^{a}	8.50^{a}
Methanol	A25+N25	1.0^{fg}	1.05^{i}	1.20^{m}	1.25^{j}	1.50^{ghj}	1.68^{fg}	1.85^{fghi}
	A25+N50	1.0^{fg}	1.0^{i}	1.20^{m}	1.43^{j}	1.85^{g}	2.23^{e}	2.48^{ef}
	A25+N75	1.03^{fg}	1.0^{i}	1.0^{m}	1.23^{j}	1.58^{gh}	1.95^{ef}	2.33^{fg}
	A50+N25	1.05^{fg}	1.05^{i}	1.08^{m}	1.15^{j}	1.38^{hij}	1.73^{fg}	1.93^{fgh}
	A50+N50	1.03^{fg}	1.0^{i}	1.0^{m}	1.05^{j}	1.13^{ij}	1.38^{ghi}	1.63^{hij}
	A50+N75	1.0^{fg}	1.0^{i}	1.10^{m}	1.10^{j}	1.30^{hij}	1.50^{fgh}	1.84^{fghi}
	A75+N25	1.08^{fg}	1.0^{i}	1.0^{m}	1.13^{j}	1.25^{hij}	1.45^{ghi}	1.73^{ghi}
	A75+N50	1.0^{fg}	0.90^{i}	0.95^{m}	1.05^{j}	1.30^{hij}	1.65^{fg}	1.90^{fghi}
	A75+N75	1.0^{fg}	1.0^{i}	0.98^{m}	1.0^{j}	1.15^{ij}	1.25^{ghi}	1.58^{hijk}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 14 shows the overall growth inhibition (cm) of the isolated fungi by aqueous and methanol extracts of *Azadirachta indica*. The results showed 75% aqueous Neem extract has the best effect in inhibiting the fungi isolated while all methanol treatments were more effective, with 25% being the least effective.

Table 14: Overall growth inhibition (cm) of the isolated fungi by aqueous and methanol extracts of *Azadirachta indica*

Solvent	Concentration	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	25%	1.37^{bcd}	3.36^{a}	4.21^{ab}	4.33^{ab}	4.65^{bcde}	5.00^{cde}	5.21^{bcdef}
	50%	1.29^{cde}	2.88^{abcd}	3.98^{abc}	4.38^{ab}	4.69^{bcd}	5.00^{cde}	5.16^{cdef}
	75%	1.36^{bcd}	1.96^{efg}	2.08^{ji}	2.26^{gh}	2.40^{ij}	3.74^{fg}	3.76^{h}
Methanol	25%	1.10^{gh}	1.11^{h}	1.17^{k}	1.33^{i}	1.61^{jk}	2.03^{hij}	2.43^{i}
	50%	1.05^{h}	1.01^{h}	1.01^{k}	1.01^{i}	1.03^{k}	1.12^{ij}	1.21^{klm}
	75%	0.99^{h}	0.97^{h}	1.01^{k}	1.06^{i}	1.14^{k}	1.26^{hij}	1.51^{ijklm}
	Control	1.30^{cde}	2.21^{defg}	3.19^{defg}	4.08^{bc}	4.32^{bcdef}	4.61^{def}	4.89^{cdefg}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 15 shows overall growth inhibition (cm) of the isolated fungi by aqueous and methanol extracts of *Aloe vera*. In comparison to the control, 25% aqueous *Aloe vera* had more effect on all isolated fungi while 50% and 75% methanol *Aloe vera* was significant after 7 days of incubation.

Table 15: Overall growth inhibition (cm) of the isolated fungi by aqueous and methanol extracts of *Aloe vera*

Solvent	Concentrations	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aqueous	25%	1.16^{fg}	2.00^{efg}	2.41^{hi}	2.79^{efg}	3.34^{gh}	3.43^{g}	4.08^{gh}
	50%	1.36^{bcd}	2.54^{bcdef}	3.45^{cdef}	4.43^{ab}	4.91a^{bc}	5.20^{bcd}	5.38^{bcd}
	75%	1.44^{b}	2.43^{cdefg}	3.31^{cdef}	4.37^{ab}	4.99^{abc}	5.19^{bcd}	5.51^{abc}
Methanol	25%	1.10^{h}	1.03^{h}	1.14^{k}	1.24^{i}	1.39^{k}	1.53^{hij}	1.71^{ijklm}
	50%	1.02^{h}	1.02^{h}	1.01^{k}	1.03^{i}	1.01^{k}	1.03^{j}	1.05^{lm}
	75%	1.00^{h}	1.02^{h}	1.01^{k}	1.02^{i}	1.01^{k}	1.02^{j}	1.00^{m}
	Control	1.30^{cde}	2.21^{defg}	3.19^{defg}	4.08^{bc}	4.32^{bcdef}	4.61^{def}	4.89^{cdefg}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 16 shows synergistic effects of *Azadirachta indica* and *Aloe vera* aqueous extracts on growth (cm) of the isolated fungi. Combinations of 25% *Aloe vera* with 25% *Azadirachta indica* (A25+N25) and 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) had the lowest means after 7 days of incubation, which makes the interaction most effective in inhibiting all the fungi isolated. However, after 2 days of incubation, combinations of 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50), 25% *Aloe vera* with 75% *Azadirachta indica* (A25+N75) and 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) inhibited all fungi compared with other interactions.

Table 16: Synergistic effects of *Azadirachta indica* and *Aloe vera* aqueous extracts on growth (cm) of the isolated fungi

Concentrations	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
A25+N25	1.23^{ef}	2.64^{bcde}	2.45^{ghi}	2.62^{fg}	3.12^{hi}	3.43^{g}	4.02^{h}
A25+N50	1.26^{de}	2.05^{efg}	3.02^{efgh}	3.36^{cdef}	3.73^{efgh}	3.94^{fg}	4.31^{efgh}
A25+N75	1.24^{ef}	1.84^{g}	2.71f^{ghi}	2.91^{defg}	3.53^{fgh}	4.06^{efg}	4.46^{defgh}
A50+N25	1.31^{cde}	2.93^{abc}	3.86^{abcd}	4.46^{ab}	5.13^{ab}	5.64^{abc}	6.16^{ab}
A50+N50	1.24^{ef}	2.40^{cdefg}	3.06^{efgh}	3.74^{bcd}	4.37^{bcdef}	4.73^{cdef}	5.29^{bcde}
A50+N75	1.80^{a}	2.81^{abcd}	3.97^{abc}	5.18^{a}	5.78^{a}	6.26^{a}	6.41^{a}
A75+N25	1.36^{bcd}	3.19^{ab}	4.38^{a}	5.21^{a}	5.68^{a}	6.04^{ab}	6.40^{a}
A75+N50	1.34^{bcd}	1.93^{fg}	2.98^{efgh}	3.63^{bcde}	4.14^{cdefg}	4.18^{efg}	4.25^{fgh}
A75+N75	1.35^{bcd}	2.62^{bcdef}	3.58^{bcde}	4.18^{bc}	4.38^{bcdef}	4.47^{def}	4.58^{cdefgh}

Means with same letters in each column are not significantly different ($p \leq 0.05$)

Table 17 shows synergistic effects of *Azadirachta indica* and *Aloe vera* methanol extracts on growth (cm) of the isolated fungi. Combinations of 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) and 75% *Aloe vera* with 75% *Azadirachta indica* (A75+N75) had the lowest means after 7 days.

Table 17: Synergistic effects of *Azadirachta indica* and *Aloe vera* methanol extracts on growth (cm) of the isolated fungi

Concentrations	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
A25+N25	1.06^{gh}	1.17^{h}	1.46^{jk}	1.66^{hi}	1.99^{jk}	2.26^{h}	2.54^{i}
A25+N50	1.03^{h}	1.11^{h}	1.33^{k}	1.51^{hi}	1.84^{jk}	2.13^{hi}	2.36^{ij}
A25+N75	1.03^{h}	1.06^{h}	1.20^{k}	1.38^{hi}	1.73^{jk}	2.10^{hi}	2.40^{ij}
A50+N25	1.07^{gh}	1.19^{h}	1.33^{k}	1.55^{hi}	1.83^{jk}	2.24^{j}	2.48^{i}
A50+N50	1.02^{h}	1.01^{h}	1.18^{k}	1.33^{i}	1.56^{jk}	1.82^{hij}	2.09^{ijk}
A50+N75	1.03^{h}	1.03^{h}	1.16^{k}	1.27^{i}	1.48^{jk}	1.70h^{ij}	2.06^{ijkl}
A75+N25	1.06^{gh}	1.08^{h}	1.23^{k}	1.46^{hi}	1.74^{jk}	2.10^{hi}	2.44^{i}
A75+N50	1.00^{h}	0.98^{h}	1.03^{k}	1.10^{i}	1.32^{k}	1.59^{hij}	1.82^{ijklm}
A75+N75	1.06^{gh}	1.05^{h}	1.01^{k}	1.09^{i}	1.28^{k}	1.51^{hij}	1.99^{ijkl}

Means with same letters in each column are not significantly different ($p>0.05$)

Table 18 shows the overall effects of concentration (aqueous and methanol) on the fungal growth inhibition potential of the plant extracts. Combinations of 75% *Aloe vera* with 50% *Azadirachta indica* (A75+N50) showed the lowest means after 7 days. However, on day 4, combinations of 25% *Aloe vera* with 25% *Azadirachta indica* (A25+N25) and 25% *Aloe vera* with 50% *Azadirachta indica* (A25+N50) had effects on all fungi, when compared with other concentrations.

Table 18: Overall effects of concentration (aqueous and methanol) on the fungal growth inhibition potential of the plant extracts

Concentration	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
A25+N25	1.15^{cde}	1.90^{abcd}	1.96^{def}	2.14^{def}	2.56^{de}	2.84^{cde}	3.28^{cdef}
A25+N50	1.14^{cde}	1.58^{cd}	2.17^{bcde}	2.43^{cde}	2.78^{cde}	3.03^{cde}	3.33^{cdef}
A25+N75	1.13^{de}	1.45^{d}	1.95^{def}	2.14^{def}	2.63^{de}	3.08^{cde}	3.43^{cde}
A50+N25	1.19^{bcd}	2.03^{abc}	2.60^{abc}	3.01^{abc}	3.48^{abc}	3.94^{ab}	4.32^{ab}
A50+N50	1.13^{de}	1.71^{bcd}	2.12^{bcde}	2.53^{bcde}	2.97^{bcde}	3.27^{bcd}	3.68^{bcd}
A50+N75	1.41^{a}	1.92^{abcd}	2.56^{abc}	3.22^{ab}	3.63^{ab}	3.98^{a}	4.22^{ab}
A75+N25	1.21^{bcd}	2.14^{ab}	2.80^{a}	3.34^{a}	3.71^{a}	4.07^{a}	4.42^{a}
A75+N50	1.17^{bcd}	1.45^{d}	1.98^{def}	2.36^{cde}	2.72^{de}	2.88^{cde}	3.02^{def}
A75+N75	1.20^{bcd}	1.83^{abcd}	2.30^{adcde}	2.63^{bcde}	2.84^{cde}	3.00^{cde}	3.30^{cdef}

Means with same letters in each column are not significantly different ($p>0.05$)

Table 19 shows the overall growth inhibition of the isolated fungi by all extracts at different incubation days. *Aspergillus tamarii* and *A. flavus* were inhibited the most at day 3, while *Penicillium digitatum* and *Botrytis cinerea* was inhibited the most at day 4 and 1 respectively.

Table 19: Overall growth inhibition of the isolated fungi by all extracts at different incubation days

Organism	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Aspergillus tamarii	1.19^{b}	1.17^{b}	1.83^{b}	2.06^{b}	2.39^{bc}	2.59^{c}	2.83^{c}
Penicillium digitatum	1.13^{c}	1.52^{b}	1.78^{b}	1.98^{b}	2.14^{c}	2.36^{c}	2.61^{c}
Aspergillus flavus	1.14^{c}	1.49^{b}	1.82^{b}	2.13^{b}	2.54^{b}	2.93^{b}	3.28^{b}
Botrytis cinerea	1.29^{a}	2.20^{a}	3.33^{a}	3.95a	4.30^{a}	4.63^{a}	4.84^{a}

Means with same letters in each column are not significantly different (p>0.05)

Table 20 shows the overall comparisons of fungal inhibitions by the aqueous and methanol extracts. Methanol extracts inhibited the fungi isolated more than the aqueous media.

Table 20: Overall comparisons of fungal inhibitions by the aqueous and methanol extracts

Extract	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Aqueous	1.34^{a}	2.46^{a}	3.25^{a}	3.83^{a}	4.28^{a}	4.63^{a}
Methanol	1.03^{b}	1.04^{b}	1.13^{b}	1.23^{b}	1.40^{b}	1.62^{b}

Means with same letters in each column are not significantly different (p>0.05)

4. DISCUSSION

The increase in growth inhibition of *Penicillium digitatum* with increase in concentration of aqueous Neem extract corroborated the work Suleiman (2011). The results obtained with the extracts of *Aloe vera* against the fungus also agrees with the reports of Rosca-Casian *et al.* (2007). Results obtained with the methanol and aqueous extracts of *Aloe vera* against *Aspergillus flavus* is similar to the reports of Babaei *et al*. (2013). The significant F value (P>0.0001) for concentration means that growth inhibition of the fungi depends on the concentration of the extract, the effect of which varies from one fungus to the other. The significant F value (P>0.0001) for day also means that growth inhibition of the fungi differed significantly from one incubation day to the other. The F value (P>0.0001) for organism means that growth inhibition of all the isolated fungi differed significantly from each other. The highly significant F value (P>0.0001) for interaction between day and concentration means that growth inhibition of the fungi by any particular concentration of the plant extract differed significantly from one incubation period to the other.

This underscores the significant impact of exposure period on the effectiveness of the extracts in inhibiting growth of the pathogens. The significant F value (P>0.0001) for interaction between day and organism means that growth inhibition of any particular fungus by the extracts differed significantly from one day of incubation to the other. The significant F value (P>0.0001) for interaction among day, organism and concentration means that growth inhibition of any particular fungus by a specific concentration of the plant extract differed significantly from one incubation period to the other.

The growth inhibition of *Aspergillus tamarii*, *Aspergillus flavus* and *Penicillium digitatum* by the combination of extracts of aqueous Neem leaf and Aloe leaf shows the higher mycotoxic impact of their synergy on the isolated fungi compared to their individual impacts, especially the combinations of A75+N50, A25+N25, A75+N50 and A75+N75). Sharmita (2015), in an experiment to evaluate the possibility of a new pharmaceutical, also recorded a positive synergy between Neem leaf and *Aloe vera* leaf against *E. coli* with antibiotics.

5. CONCLUSION

Extracts of *Azadirachta indica* and *Aloe vera* possess promising mycotoxic potentials against fungi associated with rotting pepper, especially *A. flavus*, A. *tamarii*, *P. digitatum* and *B. cinerea*. Growth inhibition of these fungi is significantly boosted by the combination of both extracts, especially at A75+N50.

Further work, however, needs to be carried out to ascertain the effectiveness of these findings in the field.

REFERENCES

Ademoh, O. F., Afolabi, A. M., Orisasona, B. A. and Olowolaju, E. D. (2018) Isolation and Identification of Rot Fungi on Post-Harvest of Pepper (*Capsicum annuum* L.) Fruits. *AASCIT Journal of Biology*. 3(5): 24-29.

Babaei, A., Manafi, M., & Tavafi, H. (2013) Study on effect of Aloe vera leaf extracts on growth of Aspergillus flavus. *Annual Review & Research in Biology*. 3(4): 1091-1097.

Black, L. L., Green, S. K., Hartma, G. L. and Poulos, J. M. (1991) Pepper diseases: A field guide. AVRDC publication No 91-347.

Dagnoko, S., Yaro-Diarisso, N., Sanogo, P.N., Adetula, O., Dolo-Nantoume, A., GambyToure, K., Traore-Thera, A., Katile, S. and Diallo-Ba, D. (2013) Overview of pepper (*Capsicum* spp.) breeding in West Africa. *African Journal of Agricultural Research*. 8(13): 1108-1114.

Daodu, T. (2000) *Aloe vera*, the miracle healing plant. Health Field Corporation, Lagos, p. 36.

Dias, G. B., Gomes, V. M., Moraes, T. M. S., Zottich, U. P., Rabelo, G. R., Carvalho, A. O., Moulin, M., Gonçalves, L. S. A., Rodrigues, R. and Da Cunha, M. (2013). Characterization of Capsicum species using anatomical and molecular data. *Genetics and Molecular Research Online Journal*, 6488-6501.

Dutta, S. *Rhizopus* rot of Jackfruit and its control. (Phd . Thesis. 2001).

FAO Statistics, 2009. Statistics Division, FAO online database. Rome, Italy: Food and Agriculture Organization of the UN (FAO). http://faostat.fao.org/

Hegger, J. P. (1996) Beneficial effect of Aloe on wounds healing in an excisional wound healing. *Model J. Altern. Complement. Med*. 20(2):271-277.

Howard, R. J., Garland, J. A. and Seaman, W. L. (1994) Diseases and pests of vegetable crops in Canada.

Katoch, A., and Kapoor, P. (2014) Fungal Diseases of Capsicum and their management. *Popular Kheti*. 2(2): 100-103.

Lin, Q., Kanchana-udomkan, C., Jaunet, T. and Mongkolporn, O. (2002) Genetic analysis of resistance to pepper anthracnose caused by *Colletotrichum capsici*. *Thai Journal of Agricultural Science* 35: 259– 64

Muthomi, J. W., Lengai, G. M. W., Wagacha, M. J. and Narla, R. D. (2017) In vitro activity of plant extracts against some important plant pathogenic fungi of tomato. Australian journal of science 11(06): 683-689

Olusegun, A. (2000) One hundred medicinal uses of *Aloe vera*. Goodhealth Inc. Lagos, p. 76.

Pandey, A., and Singh, S. (2016) *Aloe vera*: A Systematic Review of its Industrial and Ethno-Medicinal Efficacy. *International Journal of Pharmaceutical Research & Allied Sciences,* 5(1)

Pickersgill, B. (1997) Genetic resources and breeding of *Capsicum* spp. *Euphytica*, 96: 129-133

Rosca-Casian, O., Parvu, M., Vlase, L. and Tamas, M. (2007) Antifungal activity of Aloe vera leaves. *Fitoterapia*. 78(2007): 219-222.

Sharmita G.. K. L. (2015) Synergistic Effect Of *Azadirachta indica* L., *Aloe vera* L. and Antibiotics against *Escherichia coli* bacterium. *International Journal Of Pharmaceutical Research And Bio-Science*, 291-304.

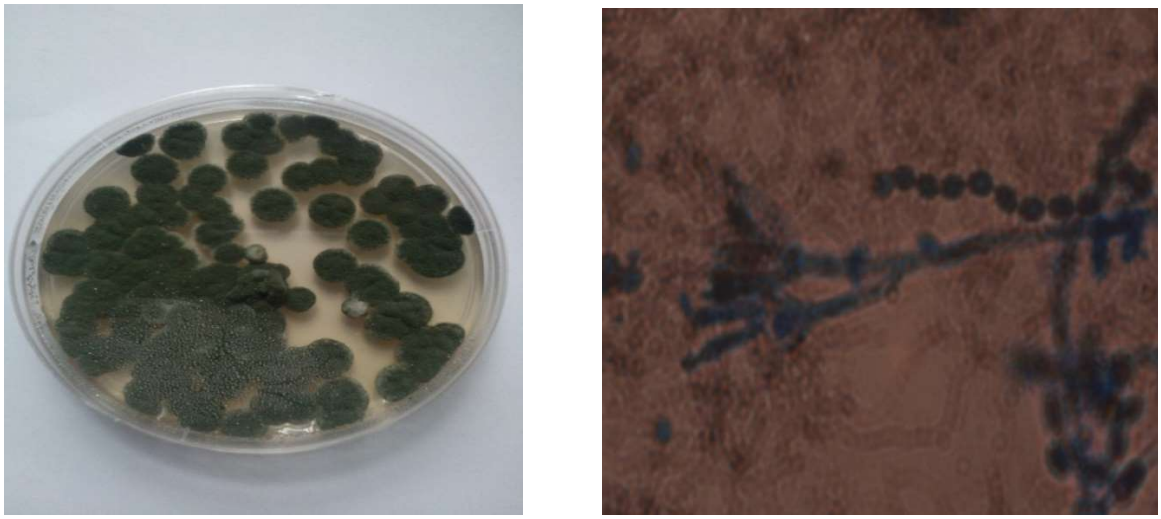
Simhadri V. S. D. N. A. Nagesh, Muniappan, M., Kannan, I., Viswanathan, S. and Jayachandra, K. (2017) Antifungal activity of various extracts of *Azadirachta indica* leaf- An in vitro study. *International Journal of ChemTech Research*. 10(15): 305-311

Suleiman, M. N. (2011) Antifungal properties of leaf extract of Neem and tobacco on three fungal pathogens of tomato (Lycopersicon Esculentum Mill). *Advances in Applied Science Research*. 2(4): 217-220.

Than, P. P., Jeewon, R., Hyde K. D., Pongsupasamit, S., Mongkolporn, O. and Taylor, P. W. J. (2008) Characterization and pathogenicity of Colletotrichum species with anthracnose on chilli (Capsicum spp.) in Thailand. *Plant Pathology*

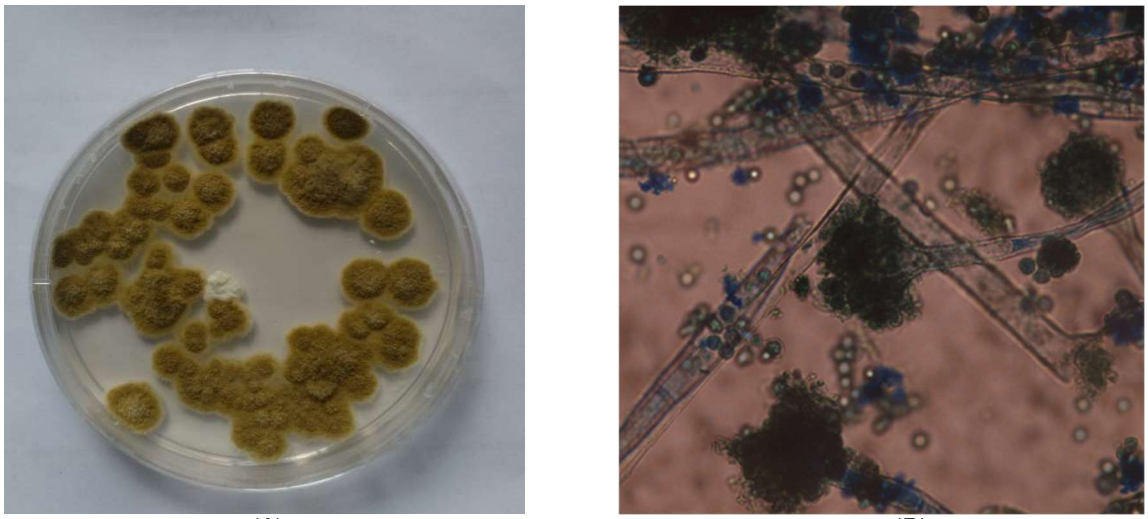
Wada, N., Sani, H. B., and Sani, Z. (2015) Isolation and Identification of fungi associated with fruit rot of sweet pepper (Capsicum annuum L.) in Sokoto, Nigeria. *Katsina Journal of Natural and Applies Sciences.* 4(1), 107-112.

APPENDIX



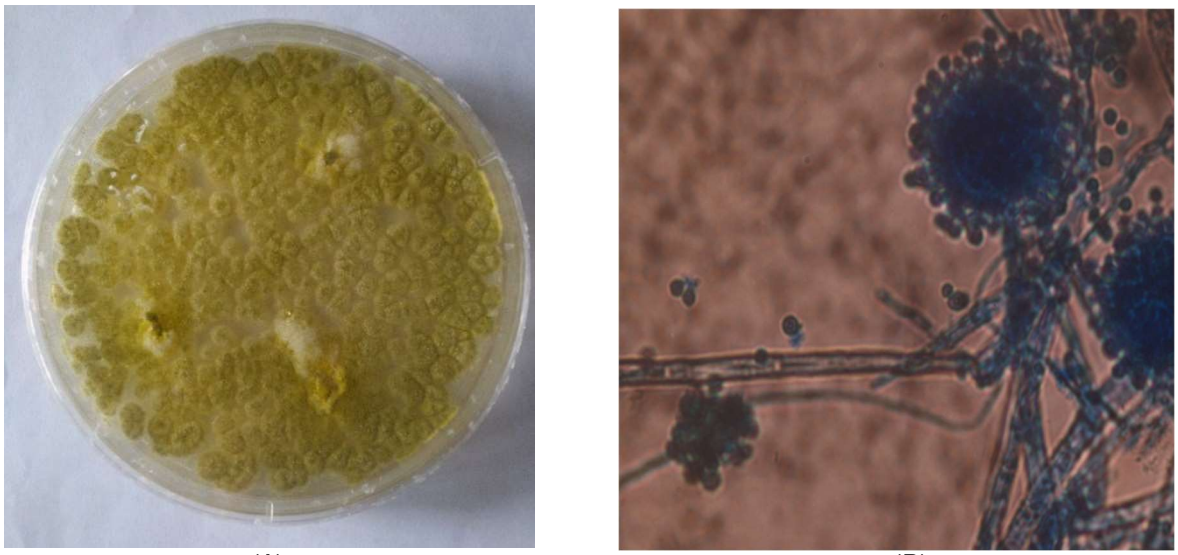
(A) (B)

Plate 1: Pure culture (A) and photomicrograph (B) of *Penicillium digitatum*.



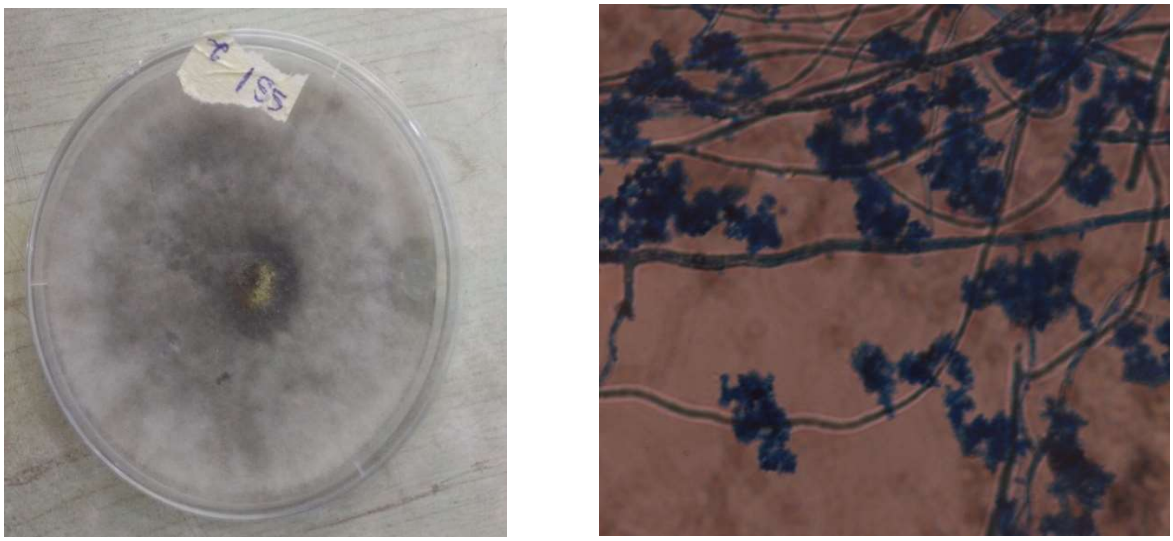
(A) (B)

Plate 2: Pure culture (A) and photomicrograph (B) of *Aspergillus tamarii*



(A) (B)

Plate 3: Pure culture (A) and photomicrograph (B) of *Aspergillus flavus*.



(A) (B)

Plate 4: Pure culture (A) and photomicrograph (B) of *Botrytis cinerea*.

‘