



Antifungal Activity of Hydroethanolic Extract of *Annona muricata* Leaves against Plant Pathogenic Fungi: A Potential Alternative to Synthetic Chemical Preservatives

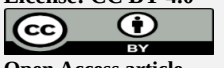
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Abstract	Article History
This study was undertaken to determine antifungal activities of hydro - ethanolic extract of soursop leaves against plant pathogens as an alternative to chemicals being used for preservation. Pour plate method was used in the isolation of microorganisms from the fruits used while disc diffusion and food poisoning technique were adopted for antifungal screening. The results revealed that the dominant fungi isolated and identified from the various spoilt fruits were <i>Fusarium solani</i> TOM1, <i>Aspergillus niger</i> TOM2, and <i>Rhizopus stolonifer</i> MAN1. The results showed that the percentage growth inhibition of <i>Fusarium solani</i> TOM1 by the soursop leaf extracts was 46 % at 5 % concentration, 49 % at 10 % concentration and 61% at 15% concentrations, respectively. The percentage growth inhibition of <i>Aspergillus niger</i> TOM2 was 17 %, 18 % and 53 % at 5 %, 10 % and 15 % concentrations, respectively. Also, growth inhibitions of 32 %, 35 % and 43% on <i>Rhizopus stolonifer</i> MAN1 at 5 %, 10% and 15 % concentrations of the ethanolic extracts were observed, respectively. Thus, soursop leaves possess the capabilities of being a good candidate in the search for a natural preservative agent against fungal plants infections and/or diseases caused by <i>Fusarium solani</i> TOM1, <i>Aspergillus niger</i> TOM2, and <i>Rhizopus stolonifer</i> phytopathogens. Keywords: <i>Annona muricata</i>, Antifungal activity, Growth inhibition, Natural preservative, Plant pathogens	Received: 25 Apr 2026 Accepted: 26 May 2026 Published: 14 Jun 2026  Scan QR code to view* License: CC BY 4.0*  Open Access article.
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Introduction

Use of substances with antimicrobial properties is known to have been common practice for at least 2000 years. Ancient Egyptians and ancient Greeks used specific molds and plant extracts to treat infection. More recently, microbiologists such as Louis Pasteur and Jules Francois Joubert observed antagonism for some *bacteria* and discussed the merits of controlling these interactions in medicine. In 1928, Alexander Fleming became the first to discover a natural powerful antimicrobial fungus known as *Penicillium Rubens*. The substance extracted from the fungus he named Penicillin and in 1942 it was successfully used to treat a *Streptococcus* infection (Zoetendal *et al.*, 2016; Dokubo and Uba 2023; Ezenwata *et al.* 2022a; 2022b). But nowadays, all over the world treatment of using antimicrobial agents is currently

facing its own limitation, due to the development of resistance by the microbes over the period of time. *Bacteria* are involved in many aspects of ecology and health. It seems likely that all species both benefit and suffer from interactions with *bacteria*. For example, we use *bacteria* for making yoghurt, curd, cheese and other fermented foods and also large number of *bacteria* lives on the skin and in the digestive tract. The human gut contains more than 1000 *bacterial species* which are beneficial (cooper and Robert, 2013; Umeh *et al.*, 2020; 2021; Ele *et al.* 2025).

Food spoilage is a metabolic process that causes foods and food materials to be undesirable or unacceptable for human consumption due to changes in sensory characteristics. Microbiological damages which lead to safety and quality

losses are very important due to two reasons: first, they constitute a hazard for consumers by the possible presence of microbial toxins or pathogenic microorganisms in the product, and second, by economic losses as a result of microbial spoilage. Environmentally friendly plant extracts agents have shown to be great potential as an alternative to synthetic fungicides. This is because, the plant extracts are cheap, locally available, non-toxic and easily biodegradable. The use of plant extracts to treat infection is practiced in the most part of the world, especially in developing countries, where there is a dependence on traditional medicine for a variety of diseases. Some plants contain components that are toxic to pathogens and when extracted from the plant and applied on infested crops, are called botanical pesticides or botanicals (Igbo-dika *et al.*, 2014; Ubani *et al.* 2024a; 2024b; 2025).

The use of natural antimicrobials helps in the reduction of pest and pathogen injury, with the use of resistant varieties or integrated cropping strategies in which plant secondary metabolites may improve crop protection. The use of natural antimicrobials as phytochemicals, organic acids, essential oils, or plant extracts could be a good alternative to ensure food safety (Mostafa *et al.*, 2018; Uba 2018; 2019a; 2019b; Egrefa *et al.*, 2020a; 2020b). The antimicrobial activities exhibited by plant extracts against food poisoning bacteria and fungi have been demonstrated by several researchers (Negi *et al.*, 2012; Uba *et al.*, 2016, Oso *et al.*, 2018; Mostafa *et al.* 2018; Alisa *et al.*, 2020; Uba *et al.* 2020a; 2020b Umennadi *et al.* 2026a; 2026b).

Soursop, also known as *Annona muricata* has gained tremendous fame owing to its rich nutritional profile (Menezes *et al.* 2019; Uba and Okonkwo, 2025; Okonkwo *et al.* 2026; Uba *et al.* 2026). The term *Annona* means annual harvest in Latin. It belongs to the Annonaceae family. This plant thrives in hot environments throughout the USA, Europe, India, and Africa. The soursop fruit is bright green, spiny, spherical, sweet, sour, creamy and delicious (Gyesi *et al.*, 2019; Anukam *et al.*, 2020a; Anukam *et al.*, 2020b; Uba and Umennadi, 2026). There are around 119 different species of this fruit found around the globe. Currently, seven species and one crossbreed of this fruit are globally cultivated for domestic purpose (Sanchez *et al.*, 2018; Ekwenze *et al.*, 2025; Mere *et al.*, 2025; Ubajekwe *et al.*, 2025).

The fruit is gaining interest owing to bioactive compounds possessing nutraceutical properties. The soursop pulp is a wonderful source of fiber and contains several intriguing compounds that may have health advantages if consumed in moderation. The polyphenol found in the soursop, for example, are natural chemicals with antioxidant activity that defend cells against free radical damage (Gonzalez *et al.*, 2017; Uba *et al.*, 2018a; 2018b; 2019a; 2019b; Uba and Anidu, 2023; Uba and Obiefuna 2023). More than 200 different bioactive compounds have been found in this plant, the majority of which are alkaloids, phenols, and acetogenins (Gyesi *et al.*, 2019; Uba *et al.*, 2020c; 2020d; 2020e). The phytochemicals have been used in herbal therapy for a long time. They can be used to treat medical conditions, such as bacterial or parasite infections, fever, hyperglycemia, hypertension, inflammation, anxiety and cancer. Soursop

extract has demonstrated antibacterial, anti-protozoan, anti-inflammatory, antioxidant, and antitumor properties in different scientific intervention (Gyesi *et al.*, 2019; Uba *et al.*, 2020f; 2018g; 2019h). Due to the medicinal features of this various fruits in the control/elimination of some diseases causing agents, it makes it possible to explore on this fruits to detect more of its inhibitory nature using silver trioxonitrate (IV) to form silver nanoparticles. The aim of this study is to evaluate the antifungal activities of hydro - ethanolic extract of soursop leaves against plant fungal pathogens.

Materials and Methods

Sample collection

The fresh leaves of soursop as well as randomly selected fungal infected and blemished mango and tomato fruit and vegetable were purchased from Ogwashi Ukwu Delta State by adopting the method of Akintobi *et al.* (2011) and Mere *et al.* (2025).

Isolation of test fungi from spoilt mango and tomato fruit

Fruits were surface sterilized by exposing them in 1 min 90 % ethanol and then 3 min to 1% sodium hypochlorite and then rinsed three times in sterile distilled water. Segments (3 - 5cm) of tissues from the margins of the rotted areas were cut out with a sterile scalpel and serial dilutions were carried out with the spoilt parts dissolved in the water inside the test tube. The middle tube (10-2) of three tubes containing bad mangoes and bad (spoilt) tomatoes respectively was taken and 1 mL was dropped onto previously prepared Potato Dextrose Agar (three Petri-dishes respectively) and incubated at $28 \pm 1^\circ\text{C}$ for 5 days under 12 h photoperiod. After 3 - 5 days, emerging colonies were observed and was noted (Uba *et al.*, 2016; Oso *et al.*, 2018; Uba *et al.*, 2018c).

Characterization and identification of the phytopathogens

The fungal isolates were characterized using their colonial morphology on the plates. Parameters such as colour of the colonies, nature of the hyphae, appearance of the colonies, and the growth rates were considered for proper characterization of the isolates. Microscopic examination of the isolates was also carried out. Reproductive and vegetative structures were observed. Nature of spores, nature of sporangia, branching of the hyphae, and presence of septa were all considered during microscopy. Microscopic examination of the fungi was done following the procedures of Obunkwu *et al.* (2018). Appropriate text books and fungal colour atlas were also consulted for the identification of the fungal isolates (Barnett and Hunter, 1972; Willey *et al.*, 2008; Oyeyiola *et al.*, 2013).

Preparation of the plant extract

Fresh leaves of soursop were thoroughly washed with distilled water (sterile and air-dried at 28°C for 2 hours). The washed leaves were cut into small pieces using a sharp sterilized knife. They were grounded into powder using pestle and mortar. Exactly 10 g of each of the pulverized soursop leaves were introduced into 100 mL of cold distilled water and 100 mL of ethanol for 48 hours at room temperature to allow for maximum extraction of the components. This was followed by evaporation of the filtrate to eliminate the solvent. The residue

was used as crude extract for each of the test plants (Wabale and Kharde, 2010).

Inocula preparation

Each fungal strain was sub-cultured overnight at 35 °C in Potato Dextrose Agar (PDA) slants. The fungal growth was harvested using 5 mL of sterile saline water; its absorbance was adjusted at 600 nm and diluted to attain viable cell count of 1.5 X 10⁸ CFU/mL using spectrophotometer (Mostafa *et al.*, 2018).

Antifungal sensitivity testing

The disc diffusion method, according to the Clinical and Laboratory Standards Institute (CLSI M60-Ed1) performance standards was used for the antifungal susceptibility test (CLSI, 2008). The viable cell counts of 1.5 × 10⁸ CFU/mL for the selected phytopathogens were inoculated onto the surface of Potato Dextrose Agar (PDA) using sterile swab sticks. The antifungal agents tested were 1 mg/mL of fluconazole, griseofulvin, miconazole, itraconazole, ketoconazole and nystatin antifungal agents as constituted. These were aseptically placed on the surface of the inoculated agar plates against the respective test organisms. After 30 mins of applying the discs, the agar plates were inverted and incubated for 72 hrs at room temperature (Uba *et al.*, 2018; Okoye *et al.*, 2024a; Okoye *et al.*, 2024b). The clear zones that developed around each disc were measured as the zones of inhibition on the basis of CLSI guidelines.

Antifungal assay against fungal phytopathogens

The food poisoning technique was adopted in this study according to the description by Uba *et al.* (2016). Different concentrations of the extracts were prepared (5 % means 1 mL of extract + 19 mL PDA; 10 % means 2 mL of extract + 18 mL

of PDA and 15 % means 3 mL of extract + 17 mL of PDA). The control contained 20 mL of PDA without addition of extracts, but contained the fungal pathogen. The agar extract mixture was allowed to solidify and then inoculated centrally with a 6 mm diameter mycelia disc obtained from the colony of 14 days old cultures of each of the test mycopathogens using a sterile cork - borer. The PDA plates inoculated with the test fungi but without the extract served as the control. All the plates were incubated at 27 °C after which the zones of inhibition were measured and percentage growth inhibition was determined using the formula below:

Percentage Growth Inhibition (%) = $\frac{C - T}{C} \times 100$

Where C= Growth of pathogen in control after incubation
T = Growth of pathogen in treatment after incubation

Data analysis

The data was presented in tables and charts, and the means statistically analyzed using GraphPad Prism version 9.0 by adopting Analysis of Variance (ANOVA). Values less 0.05 are considered significant (Uba *et al.* 2024; 2025; Chude *et al.*, 2021).

Results and Discussion

The results of the morphological features of mycophytopathogens are presented in Table 1, while the results of the antifungal sensitivity patterns (mm) against test fungal phytopathogens are presented in Table 2. Additionally, growth inhibitions of *Fusarium solani* TOM1, *Aspergillus niger* TOM2 and *Rhizopus stolonifera* MAN1 by hydro-ethanolic extracts of soursop leaves are presented in Tables 3, 4 and 5, respectively.

Table 1: Morphological features of mycophytopathogens

Isolate code	Culture morphology	Microscopic description	Tentative organism
TOM1	Greyish - white thin hyphae and mycelia characterized with sluggish developing and evolving colonial growth	Branched conidiophores formed with abundant elongated and ovoid micro - conidia	<i>Fusarium solani</i> TOM1
TOM2	White colonies gradually turned into brown and black hyphae and mycelia	Bright yellowish - brown vesicles containing fastly developing phialides alongside the entire edges of the conidiophore.	<i>Aspergillus niger</i> TOM2
MAN1	Light grey fast emerging colonies characterized with confluent mycelia.	Light brown, non – septate flat walled clusters of sporangiophore characterized with white to black no - motile aplanospores contained in a globose or sub-globose sporangia	<i>Rhizopus stolonifera</i> MAN1

Table 2: Antifungal sensitivity patterns (mm) against of the test fungal phytopathogens

Antifungal agent	<i>Fusarium solani</i> TOM1	<i>Aspergillus niger</i> TOM2	<i>Rhizopus stolonifera</i> MAN1
Fluconazole	4.00±0.10	2.50±0.10	1.00±0.00
Griseofulvin	13.10±0.70	11.00±0.50	9.00±0.20
Itraconazole	13.00±0.40	13.00±0.20	7.00±0.10
Miconazole	23.00±0.45	19.00±0.35	16.00±0.15
Ketoconazole	25.50±0.45	20.50±0.60	18.50±0.35
Nystatin	18.00±0.30	17.00±0.30	15.50±0.40

Key: - = No zone of inhibition

Table 3: Growth inhibition of *Fusarium solani* TOM1 by hydro - ethanolic extract of soursop leaf

	5% Conc. Average Colony Diameter (mm)	Growth inhibition %	10% Conc. Average Colony Diameter (mm)	Growth inhibition %	15% Conc. Average Colony Diameter (mm)	Growth inhibition %
	11.33	46	10.67	49	8.00	61
	12.00	56	6.67	75	6.33	77
	8.00	14	6.00	35	4.33	53
Control	21.00		27.67		9.33	

Table 4: Growth inhibition of *Aspergillus niger* TOM2 by hydro - ethanolic extract of soursop leaf

	5 % Conc. Average Colony Diameter (mm)	Growth Inhibition %	10 % Conc. Average Colony Diameter (mm)	Growth Inhibition %	15 % Conc. Average Colony Diameter (mm)	Growth Inhibition %
	18.00	17	17.67	18	10.00	53
	11.67	16	8.00	42	8.00	42
	19.67	29	8.00	71	7.00	75
Control	21.67		14.00		28.00	

Table 5: Growth inhibition of *Rhizopus stolonifera* MAN1 by hydro-ethanolic extract of soursop leaf

	5 % Conc. Average Colony Diameter (mm)	Growth Inhibition %	10 % Conc. Average Colony Diameter (mm)	Growth Inhibition %	15 % Conc. Average Colony Diameter (mm)	Growth Inhibition %
	8.33	32	8.00	35	7.00	43
	19.67	2	17.00	15	4.33	78
	9.00	56	8.33	60	3.67	82
Control	12.33		20.00		20.67	

Discussion

The Table 1 presents the morphological features of mycophytopathogens, including culture morphology and microscopic descriptions. The isolates exhibited distinct morphological features, including differences in culture colour, hyphal structure, and conidiophore morphology. Based on morphological characteristics, the isolates were tentatively identified as *Fusarium solani* TOM1, *Aspergillus niger* TOM2 and *Rhizopus stolonifera* MAN1. The results suggest that the morphological features observed can be used to identify and distinguish between different fungal species. These fungal strains have been implicated as potential fungal phytopathogens by several researchers (Okoye *et al.*, 2016a; 2016b; Uba *et al.*, 2021; Anameze *et al.* 2023; Obiefoka *et al.*, 2023; Ezeamama *et al.* 2025a; 2025b; Afulukwe *et al.* 2025).

The Table 2 presents the antifungal sensitivity patterns of three test fungal phytopathogens (*Fusarium solani* TOM1, *Aspergillus niger* TOM2, and *Rhizopus stolonifera* MAN1) against six antifungal agents. The fungal phytopathogens exhibited varying sensitivity patterns to different antifungal agents. Ketoconazole and Miconazole showed the highest efficacy against all three fungal phytopathogens while fluconazole showed the lowest efficacy against all three fungal phytopathogens. The results suggest that the fungal phytopathogens exhibit different levels of resistance to various antifungal agents and corroborated with studies of Afulukwe *et al.* (2026); Okoye *et al.* (2020a); (2020b) and (2020c).

The Table 3 presents the growth inhibition of *Fusarium solani* TOM1 by hydro-ethanolic extract of soursop leaf at different concentrations. The growth inhibition of *Fusarium solani* TOM1 increases with increasing concentrations of soursop leaf extract. At 15 % concentration, the growth inhibition is substantial, ranging from 53 to 77 %. The results suggest that the hydro-ethanolic extract of soursop leaf exhibits antifungal activity against *Fusarium solani* TOM1 and corroborated with studies of Okoye *et al.* (2013) and Okoye *et al.* (2014).

The Table 4 presents the growth inhibition of *Aspergillus niger* TOM2 by hydro-ethanolic extract of soursop leaf at different concentrations. The growth inhibition of *Aspergillus niger* TOM2 increases with increasing concentrations of soursop leaf extract. At 15 % concentration, the growth inhibition is substantial, ranging from 42 % to 75 %. The results suggest that the ethanolic extract of soursop leaf exhibits antifungal activity against *Aspergillus niger* TOM2 and corroborated with studies of several researchers (Iheukwumere *et al.*, 2012a; 2012b; Mundi *et al.*, 2013; 2014).

The Table 5 presents the growth inhibition of *Rhizopus stolonifera* MAN1 by hydro-ethanolic extract of soursop leaf at different concentrations. The growth inhibition of *Rhizopus stolonifera* MAN1 increases with increasing concentrations of soursop leaf extract. At 15% concentration, the growth inhibition is substantial, ranging from 43 % to 82 %. The results suggest that the hydro-ethanolic extract of soursop leaf exhibits antifungal activity against *Rhizopus stolonifera* MAN1. The findings highlight the potential of soursop leaf extract as

a natural fungicide for controlling *Rhizopus stolonifer* infections. Similar trends of Uba *et al.* (2019c) reported that actinomycetes extracts of *Actinomyces viscosus* 2 had the strongest significant ($P < 0.05$) inhibition of 91.60 % on *Penicillium digitatum* O1 while *Streptomyces yaneus* MAB13 had the weakest significant ($P < 0.05$) inhibition of 33.30 % on *Fusarium solani* T2 mycelial growths.

Conclusion

The presence of different fungal species highlights the diversity of mycophytopathogens that can infect plants. The selection of antifungal agents should be based on the specific fungal phytopathogen and its sensitivity pattern. The findings highlight the potential of soursop leaf extract as a natural fungicide for controlling *Fusarium solani*, *Aspergillus niger* and *Rhizopus stolonifer* infections. The study recommends that further research could confirm the identifies of the fungal isolates using molecular techniques such as DNA sequencing, and investigate the pathogenicity oof the isolates on specific plant hosts to understand their potential impact on plant health. In addition, optimizing the concentration of soursop leaf extracts for maximum growth inhibition and identifying the bioactive compounds responsible for the antifungal activity of soursop leaf extract are recommended.

References

- Acar, J. (1997). Broad- and narrow-spectrum antibiotics: An unhelpful categorization. *Clinical Microbiology and Infection*, 3:395–396.
- Adzitey, F. (2015). Antibiotic classes and antibiotic susceptibility of bacterial isolates from selected poultry. *World's Veterinary Journal*, 5:36–41.
- Afulukwe, S. C., Uba, B. O., Okemadu, O. C., Akulue, J. C., Akudu, L. S., & Anaebonam, E. C. (2025). Histopathological Examination of Liver and Kidney Tissues of Albino Wistar Rats Treated with Albendazole Drug. *Health Science Research International*, 2(1): 10 – 22. <https://doi.org/10.54117/hsri.v2i1.54>.
- Afulukwe, S. C., Emmy-Egbe, I. O., Anyaegbulam, L. C., Uba, B. O., ObiEzeani, C. N., Akulue, J. C., Egbe, P. A., & Nnoruka, O. E. (2026). Evaluation of Biochemical Indices of Liver and Kidney Tissues of Albino Wistar Rats Treated with Anthelmintic Drug (Albendazole). *IPS Interdisciplinary Journal of Biological Sciences*, 6 (1): 211 – 220. <https://doi.org/10.54117/ijbbs.v6i1.120>.
- Akintobi, A.O., Okonko, I.O., Agunbiade, S.O., Akano, O.R. and Onianwa, O. (2011). Isolation and Identification of Fungi Associated with The Spoilage of Some Selected Fruits in Ibadan, South Western Nigeria. *Academia Arena*, 3(11):1–7.
- Alisa, O. C., Anukam, N. B., Ogukwe, N. C., Chinwuba, J. A. and Uba, B. O. (2020). Determination of compost humification and other constituents that can be used as stability index. *International Research Journal of Modernization in Engineering Technology and Science*, 2 (12): 139 – 147. <https://www.irjmet.com/paperdetail.php?paperId=47fd0a18a604b911124f7def72690f1c>.
- Aminov, R.I. (2010). A brief history of the antibiotic era: Lessons learned and challenges for the future. *Frontiers in Microbiology*, 1:1 – 5.
- Anameze, C.I., Emmy-Egbe, I.O., Anyaegbunam, L.C., Ogomaka, I.J., Uba, B.O., Odumodu, O.A., Ezeigwe, C., Kamalu, N.L., Chukwubude, C.B., Akogu, O., Ezekwueme, E., Emmy-Egbe, C.C., Obiefoka, O.S., Ezenwata, S.I. and Ilechukwu, C.C. (2023). Qualitative and quantitative phytochemical analysis of Gongronema latifolium leaf extract. *IPS Journal of Applied Microbiology and Biotechnology* 2 (1): 16 – 19. <https://doi.org/10.54117/ijamb.v2i1.10>.
- Anukam, N. B., Alisa, O. C., Ogukwe, N. C., Chinwuba, J. A., Uba, B. O. and Ogukwe, E. C. (2020a). Physico-chemical evaluation of agro-waste formulated compost from five different waste source. *American Journal of Applied Chemistry*, 8 (6): 130 – 134. oi: <https://dx.doi.org/10.11648/j.ajac.20200806.11>.
- Anukam, N. B., Alisa, O. C., Ogukwe, N. C., Chinwuba, J. A., Uba, B. O. and Ogukwe, E. C. (2020b). Phyto – toxicity evaluation of agro – waste formulated compost on five different plant seeds. *The International Journal of Engineering and Science*, 9 (12): 21 -26. [C0912012126.pdf](https://doi.org/10.9790/1813-0912012126) Or <https://dx.doi.org/10.9790/1813-0912012126>.
- Barnett, H.L. and Hunter, B.B. (1972). *Illustrated Genera of Imperfect fungi*, 3rd ed. Burgess Publishing Company, Minneapolis, Minnesota, P. 208.
- Chude, C. O., Nwagbo, C. C., Okpalanma, E. F. and Uba, B. O. (2021). Functional and rheological profile of LAB – fermented bambara groundnut (*Vigna subterranean* L.) flour. *Journal of Advances in Microbiology*, 21 (10): 1 – 9. <https://dx.doi.org/10.9734/JAMB/2021/v21i1030387>.
- Crandall, M.A. (2010). Pharmaceuticals: Antifungal Drugs, Technologies and *Global Markets*. *BBC Research*, 23; 462.
- Clinical and Laboratory Standards Institute (CLSI) (2008). Reference methods for broth dilution antifungal susceptibility testing of filamentous fungi; Approved Standard 2nd ed. Informational Supplement (CLSI M60-Ed1), Wayne, PA: Clinical and Laboratory Standards Institute.
- Croze, M.L. and Soulage, C.O. (2013). Potential role and therapeutic interests of myo-inositol in metabolic diseases. *Biochimie*. 95(10):1811–1827.
- Cunha, B.A. (1992). Aminopenicillins in urology. *Urology*, 40:186–190. DOI: 10.1016/0090-4295(92)90525-2
- Dibua, N.A., Chude, C.O., Okoye, E.C.S., Nwajiobi, F.O., Eze, M.O., Eleanya, L.C., Agbo, B.C., Nwakor, H.C. and Nzeribe, O. (2025). Effect of temperature and pH on the utilization of agricultural wastes for biogas production. *Journal of Applied Physical Science International*, 17(1):32–41.
- Dibua, N.A., Okoye, E.C.S., Egudu, N.A., Chibueze, C.B., Azuka, C.P., Ojeh, I.K. and Nwosu, K.O. (2025). Assessment of physicochemical parameters and heavy metals concentration of leachates from dumpsite around Idemili River, Obosi Nigeria. *Archives of Agricultural and Environmental Sciences*, 10(2):364–373.
- Dibua, N.A., Ezeanwu, B.A., Chude, C.O., Eleanya, L.C., Okoye, E.C.S., Adamu, J.E., Agbo, B.C., Okpala, V.C., Oradubanya, O.K. and Ngonadi, U.J. (2025). Heavy metal assessment of *Claris angullaris* and *Tilapia zilli* from Omambala River, Anambra State, Nigeria. *Journal of Global Agriculture and Ecology*, 17(3):19–30.
- Díaz-de-Cerio, E., Verardo, V., Gómez-Caravaca, A.M., Fernández-Gutiérrez, A. and Segura-Carretero, A. (2017). Health Effects of *Psidium guajava* L. Leaves: An Overview of the Last Decade: Review. *International Journal of Molecular Sciences*, 18:897. DOI:10.3390/ijms1804089
- Dibua, N.A., Nwose, C.V., Chude, C.O., Eleanya, L.C., Okoye, E.C.S., Agbo, B.C. and Nwerenkem, O.S. (2025). Physicochemical and bacteriological qualities of borehole water near dumpsites in student hostels, Uli Campus, Nigeria. *Asian Journal of Microbiology and Biotechnology*, 10(2):1–10.
- Dokubo, C.U. and Uba, B.O. (2023). Assessment of the decontamination and disinfecting potentials of Ocimum gratissimum synthesized silver nanoparticles on water and wastewater samples. *IPS Journal of Public Health*, 3 (2): 58 – 65. <https://doi.org/10.54117/ijph.v3i2.20>.
- Egurefa, S.O., Orji, M.U. and Uba, B.O. (2020a). Toxic effect of refinery industrial effluent using three toxicity bioassays. *South*

- Asian Journal of Research in Microbiology, 6 (2): 10 – 23. <https://doi.org/10.9734/SAJRM/2020/v6i230145>.
- Egurefa, S.O., Orji, M.U. and Uba, B.O. (2020b). Toxicological evaluation of two Nigerian refinery effluents using natural biomonitor. *Research & Reviews: A Journal of Toxicology*, 10 (2): 22 – 31.
- Ekwenze, T. N., Uba, B. O., Dibua, N. A., Ike, V. E., Mere, C. A., & Chikwendu, J. C. (2025). Effect of Biosynthesized Nanoparticles on the Germination Profile of Zea mays under Salinity Stress. *IPS Journal of Agriculture, Food Technology and Security*, 2 (1): 53 – 59. <https://doi.org/10.54117/ijafts.v2i1.72>.
- Ele, E.E., Okoye, E.L., Uba, B.O., Aniekwu, C.C., Iheukwumere, C.M., Obumseli, H. and Okoye, P.A. (2024). Antibacterial effects of phytobiosynthesized silver nanoparticles against some selected bacteria. *International Journal of Research and Innovation in Applied Science* 9 (10): 460 – 467. <https://doi.org/10.51584/IJRIAS..>
- [EI Zoerby, A., Sanschagrin, F. and Levesque, R.C. \(2013\). Structure and function of the Mur enzymes: development of novel inhibitors. *Molecular Microbiology*, 47\(1\):1–12.](#)
- Ezeamama, M. M. C., Chukwura, E. I., Uba, B. O., Chikwendu, J. C., Ubajekwe, C. C., Ike, V. E. & Egbe, P. A. (2025a). Evaluation of the Urease Inhibitory, Antiulcer and Acute Toxicity Effects of Ethanolic Seed Extracts of Garcinia Kola against Chemically Induced Ulcers. *IPS Journal of Phytochemistry and Medicinal Plant Research*, 1 (2): 20 – 26. <https://doi.org/10.54117/ijpmpr.v1i2.4>.
- Ezeamama, M. M. C., Chukwura, E. I., Uba, B. O., Iheukwumere, I. H., Awari, V. G., Ike, V. E., & Agu, K. C. (2025b). Assessment of the Phytochemical and Antibacterial Profiles of Aqueous and Ethanolic Extracts of Garcinia Kola Seed. *IPS Journal of Drug Discovery Research and Reviews*, 3(2): 51 – 56. <https://doi.org/10.54117/ijddr.v3i2.39>.
- Ezenwata I.S., Anyanele, W.C., Idigo M.A., Afulukwe S.C., and Onyemeka R.M. (2022a) Analysis of soil water relationship of Ogbujilekwe stream watershed in Nimo Njikoka L.G.A. of Anambra State. *GCS Biological and Pharmaceutical Science* 19(01): 045 - 049.
- Ezenwata I.S., Anyanele, W.C., Idigo M.A., Afulukwe S.C. and Onyemeka R.M. (2022b). Assessment of heavy metal composition of Ogbujilekwe stream watershed in Nimo Njikoka L.G.A. of Anambra State. *World Journal of Biology Pharmacy and Health Sciences* 10(02): 011-014
- Gupte, M., Kulkarni, P. and Ganguli, B.N. (2012). Antifungal antibiotics. *Applied Microbiology and Biotechnology*, 58(1):46–57.
- Hamilton, M.J.M.T. (1999). Beta-Lactams: Variations on a chemical theme, with some surprising biological results. *Journal of Antimicrobial Chemotherapy*, 44:729–734. DOI: 10.1093/jac/44.6.729
- Hof, H. (1994). Macrolides, a group of antibiotics with a broad spectrum of activity. *Immunität und Infektion*, 22:66–71
- Igbodika, M.C., Ekesiobi, A.O. Nwosu, M.C., Ibemenuga, K.N., and Obianika, S.C., (2014). Placental malaria infection among pregnant women in Tropical Rural Community, Anambra State Nigeria. *Tropical Journal of Applied Natural Sciences* 1(1): 77–83.
- Iheukwumere, I., Uba, B.O. and Ubajekwe, C.C (2012). Antibacterial activity of Annoria muricata jmmmn and Persca americana leaves extracts against ampicillin resistant S. aureus. *Journal of Science, Engineering Technology*, 19(2): 10786-10798
- Iheukwumere, I., Uba, B.O. and Ubajekwe, C.C (2012). Anti-fungal, haematological and wound healing activity of Mucuna pruriens leaves extracts. *Journal of Applied Science*, 15(2): 10541 – 10550
- Lin, J., Puckree, T. and Mvelase, T.P. (2022). Anti-diarrhoeal evaluation of some medicinal plants used by Zulu traditional healers. *Journal of Ethnopharmacology*, 79(1):53–56.
- Mast, Y. and Wohlleben, W. (2014). Streptogramins – Two are better than one. *International Journal of Medical Microbiology*, 304:44–50. DOI: 10.1016/j.ijmm.2013.08.008
- Mere, C. A., Uba, B. O. and Dim, C. N. (2025). Reducing Potentials of Pennisetum Glaucom and Sorghum bicolor. *Tropical Journal of Applied Natural Sciences*, 3 (1): 9.
- Mostafa, A. A., Al-Askar, A.A., Almaary, K.S., Dawoud, T.M., Sholkamy, E.N. and Bakri, M.M. (2018). Antimicrobial activity of some plant extracts against bacterial strains causing food poisoning diseases. *Saudi Journal of Biological Sciences*, 25: 361–366.
- Mundi, K.S., Okoye, E.L., Uba, B.O., Esimone, C.O. and Attama, A.A. (2013). Evaluation of the antibacterial activity of some commercial disinfectants against methicillin-resistant Staphylococcus aureus. *International Journal of Applied Science and Engineering* 1 (1): 19 – 22. <http://dx.doi.org/10.2139/ssrn.3448993>.
- Mundi, S.K; Okoye, E.L., Uba, B.O., Esimone, C.O. and Attama, A.A. (2014). The combined antibacterial activity of face cleaning agent and Psidium guajava leaf extract on methicillin resistant Staphylococcus aureus. *International Journal of Agriculture and Biosciences* 3 (2): 77 – 81. <https://www.ijagbio.com/pdf/volume-3-no-2-2014/77-81.pdf>
- Negi, P.S. (2012). Plant extracts for the control of bacterial growth: Efficacy, stability and safety issues for food application. *International Journal Food and Microbiology*, 156:7–17.
- Obiefoka, S.O., Emmy-Egbe, I.O., Anyaegbunam, L.C., Uba, B.O., Anameze, C.I., Ogoamaka, I.J., Kamala, N.L., Ezeigwe, C., Akaogu, O., Odumodu, O.A., Emmy-Egbe, C.C., Ezenwata, O.S. and Chukwubude, C.B. (2023). The Prevalence of Lymphatic Filariasis Infection among Primary School Children (5-9 Years) of Infected Adults in Ihiala Local Government Area of Anambra State, Nigeria. *IPS Journal of Public Health*, 3 (2): 66 - 72.
- Obunukwu, G.N., Dike, K.S. and Nwkwasi, G.E. (2018). Isolation and identification of microbial deteriorogens of fresh tomatoes stored at ambient temperature. *Microbial Research Journal International*, 26(1):1–8.
- Okonkwo, O. P., Uba, B. O., Ifemeje, J. C., Ozochi, C. A., Okongwu, D. J., & Anaebonam, E. C. (2026). Green Synthesis of Silver Nanoparticles from Aqueous Seed Extract of C. papaya and its Application in Surface Water Resources Decontamination. *IPS Journal of Plant, Animal, and Environmental Sciences*, 2(1): 22–31. <https://doi.org/10.54117/ijpae.v2i1.121>.
- Okoye, E.L., Uba, B.O. and Obiukah, O. (2013). Microbial quality of some commercial yoghurt samples in Awka metropolis, Anambra State, Nigeria. *Journal of Pharmaceutical and Allied Sciences*, 10 (1): 1677 – 1683.
- Okoye, E.L., Uba, B.O., Uhobo, P.C., Oli, A.N. and Ikegbunam, M.N. (2014). Evaluation of the antibacterial activity of methanol and chloroform extracts of Alchornea cordifolia leaves. *Journal of Scientific Research and Report* 3 (1):255 – 262. <https://journaljsrr.com/index.php/JSRR/article/view/1692/3353>.
- Okoye, E.L., Obiweleozor, C.J., Uba, B.O. and Odunukwe, F.N. (2016a). Epidemiological survey of tonsillitis caused by Streptococcus pyogenes among children in Awka Metropolis (A case study of hospitals in Awka Community, Anambra State). *IOSR Journal of Pharmacy and Biological Sciences*, 11 (3): 54 – 58.
- Okoye, E.L., Ozumba, A.I., Uba, B.O. and Odunukwe, F.N. (2016b). Prevalence of Hepatitis B Virus among immunocompromised individuals attending Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi. *Journal of Pharmaceutical and Allied Sciences*, 13 (2):2407 - 2413.
- Okoye, E. L., Uba, B. O., Dike, U. C. and Eziefule, U. J. (2020a). Growth rate and antifungal activities of acetone extracts of Ocimum gratissimum (Scent Leaf) and Allium sativum (Garlic)

- on cassava and banana peels formulated media. *Journal of Advances in Microbiology*, 20 (4): 19 – 29.
- Okoye, E. L., Uba, B. O. and Ugwuoke, C. J. (2020b). Determination of the growth rate and susceptibility pattern of fungi using agro-waste formulated media. *Nigerian Journal of Microbiology*, 34(2): - 5258 – 5268.
- Okoye, E. L., Uba, B. O. and Onwunyili, C. E. (2020c). Antibacterial activity and protein sequences of actinomycetes isolated from coastal area of Niger Delta against human and fish pathogens. *International Journal of Biosciences and Technology*, 13 (1): 1 – 1
- Okoye, E.C.S., Egudu, N.A., Dibua, N.A. and Okoye, L.C. (2024). Seasonal variation and antibiotic susceptibility patterns of bacteriological parameters in groundwater sources in Oyi LGA, Anambra State, Nigeria. *Journal of Advances in Microbiology*, 24(5):40–55.
- Okoye, E.C.S., Onuorah, S.C., Agu, C.G., Okoye, L.C., Eleanya, L.C., Okafor, U.C. and Egudu, N.A. (2024). Physicochemical characteristics and antibiotic resistance patterns of enteric bacteria from rooftop harvested rainwater (HRW) in Oraukwu, Anambra State, Nigeria. *Archives of Agriculture and Environmental Sciences*, 9(3):73–84.
- Okoye, L.C., Ugwu, M.C., Oli, A.N., Okoye, E.C.S., Ekpunobi, N.F., Okezie, U.M. and Mgbodo, U.G. (2024). Genotypic detection of metallo-beta-lactamases among multidrug resistant *Klebsiella pneumoniae* isolated from urine samples of UTI patients. *GSC Biological and Pharmaceutical Sciences*, 29(03):248–255.
- Oso, B.A., Ogunnusi, T.A. and Fagbemi, M.E. (2018). Antimicrobial effect of some plant extracts on plant pathogens that cause food spoilage. *Microbiology Research Journal International*, 24(5):1–15.
- Oyeyiola, G.P., Agbaje, A.B. and Adetunji, C.O. (2013). Determination of the soil microflora of a soil near microbiology laboratory at the University of Ilorin Main Campus. *Egyptian Academy Journal of Biological Sciences*, 5(1):35–41.
- Pankey, G.A. and Sabath, L.D. (2013). Clinical relevance of bacteriostatic versus bactericidal mechanisms of action in the treatment of Gram-positive bacterial infections. *Clinical and Infectious Disease*, 38(6):864–870.
- Rai, J., Randhawa, G.K. and Kaur, M. (2013). Recent advances in antibacterial drugs. *International Journal of Applied and Basic Medical Research*, 3:3–10. DOI: 10.4103/2229-516X.112229
- Ruhnke, M. and Maschmeyer, G. (2002). Management of mycoses in patients with hematologic disease and cancer—review of the literature. *European Journal of Medical Research*, 7 (5): 227 – 235.
- Sanches, N.R., Cortez, D.A.G., Schiavini, M.S., Nakamura, C.V. and Filho, B.P.D. (2005). An evaluation of antibacterial activities of *Psidium guajava* (L.). *Brazilian Archives of Biology and Technology*, 48(3):429–436
- Sanglard, D. (2012) Modern Fungicides and Antifungal Compounds. *Current Opinion in Microbiology*, 5:379–385.
- Uba, B.O., Okoye, E. L. and Udeajah, O.P. (2016). Emm Antimicrobial Activities of *A. sativum*, *Z. officinale* and *O. gratissimum* Extracts on Plant and Fish Pathogens. *African Journal of Education, Science and Technology*, 3(2):213–221.
- Uba, B. O. (2018). Growth profile and catabolic pathways involved in degradation of aromatic hydrocarbons by marine bacteria isolated from Niger Delta. *Microbiology Research Journal International*, 26 (5): 1 – 18. <https://doi.org/10.9734/MRJI/2018/v26i530075>.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Umebosi, A.A., Agbapulonwu, U. F., Muogbo, O. C., Okoye, C. L., Oranta, L.O., Odunukwe, A.M., Ndurue, C. P. and Ehirim, O. S. (2018a). Biofilm and biosurfactant mediated aromatic hydrocarbons degradation by marine bacteria isolated from contaminated marine environments of Niger Delta. *Journal of Applied Life Sciences International*, 19 (4): 1 –17. <https://doi.org/10.9734/JALSI/2018/v19i430069>.
- Uba, B. O., Okoye, E. L., Dokubo, C.U., Azuanichie, T. and Nworah, O.M. (2018b). Biostimulatory effect of organic and inorganic nutrients on soil biological indicators in diesel contaminated soil. *Journal of Bioscience and Biotechnology*, 3(6): 121 – 135. <https://doi.org/10.31248/JBBD2018.087>.
- Uba, B. O., Okoye, E. L., Etoniru, I. S., Anene, D.K. and Ogbuagu, S. (2018c). Investigation of the antibiotic's susceptibility patterns and pathogenic potential of bacteria isolated from poultry wastes. *Journal of Public Health and Diseases*, 1(3):56–65.
- Uba, B.O. (2019a). Phylogenetic framework and metabolic genes expression analysis of bacteria isolated from contaminated marine environments of Niger Delta. *Annual Research & Review in Biology*, 30 (5): 1 – 16. 10.9734/arrb/2018/v30i530024.
- Uba, B.O. (2019b). Aromatic hydrocarbons degradation and plasmid profile of marine bacterial isolates obtained from petroleum contaminated marine environments of Niger Delta, Nigeria. *Microbiology Research Journal International*, 27 (1): 1 – 20. <https://doi.org/10.9734/MRJI/2019/v27i130087>.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Ubani, O., Chude, C.O. and Akabueze, U. C. (2019a). In vitro degradation and reduction of aromatic hydrocarbons by marine bacteria isolated from contaminated marine environments of Niger Delta. *Advances in Research*, 18 (3): 1 - 17.
- Uba, B.O., Akunna, M.C., Okemadu, O. C. and Umeh, C. J. (2019b). Kinetics of Biodegradation of total petroleum hydrocarbon in diesel contaminated soil as mediated by organic and inorganic nutrients. *Animal Research International*, 16 (2): 3295 – 3307. <https://www.ajol.info/index.php/ari/article/view/189516>.
- Uba, B. O., Okoye, E. L., Anyaeji, O.J. and Ogbonnaya, O.C. (2019c). Antagonistic Potentials of actinomycetes isolated from coastal area of Niger Delta against *Citrus sinensis* (Sweet Orange) and *Lycopersicum esculentum* (Tomato) fungal pathogens. *Research and Reviews: A Journal of Biotechnology*, 8 (3): 4 – 15
- Uba, B. O., Chukwura, E. I., Iheukwumere, I.H., Okeke, J.J. and Akaun, I.P. (2020a). Evaluation of marine waste water and aromatic hydrocarbons toxicity using a battery of assays. *Research & Reviews: A Journal of Toxicology*, 10 (2): 1 – 13.
- Uba, B. O., Okoye, E. L., Nnanna, O. E., Dibua, N. A., Vivian N. Anakwenze, V.N. and Ifediegwu, M. C. (2020b). Testing for the environmental fate and safety of e-waste using *Nitrobacter* and mice model. *International Journal of Environment, Agriculture and Biotechnology*, 5(6): 1 – 8.
- Uba, B.O., Okoye, E.L., Chude, C.O. and Ogamba, J.O. (2020c). Assessment of the toxicity potentials of spent laptop battery wastes on essential soil microbes and plant bioindicators. *Asian Journal of Biology*, 9(2): 33 – 46. <https://doi.org/10.9734/AJOB/2020/v9i230085>.
- Uba, B.O., Okoye, E.L., Nweke, B.G. and Ibeneme, C.P. (2020d). Evaluation of the ecotoxicity potentials of e-waste using *Selenastrum capricornutum* (microalga), *Eisenia fetida* (earth worm) and *Allium cepa* (onion bulb) as bioindicators. *Asian Journal of Biotechnology and Genetic Engineering*, 3(2): 20 – 31. <https://journalajbge.com/index.php/AJBGE/article/view/24>.
- Uba, B. O., Okoye, E. L., Nnanna, O. E., Dibua, N. A., Vivian, N. Anakwenze, V.N. and Ifediegwu, M. C. (2020e). Testing for the environmental fate and safety of e-waste using *Nitrobacter* and mice model. *International Journal of Environment, Agriculture and Biotechnology*, 5(6): 1 – 8.
- Uba, B. O., Udeh, C.A., Nduneri, C. F. and Akaun, I. P. (2020f). Potentials of carrot (*Daucus carota*) and cocoyam (*Colocasia esculenta*) peels as suitable mycological culture media. *Research & Reviews: A Journal of Life Sciences*, 10(3): 22 – 29.
- Uba, B. O., Chukwura, E. I., Iheukwumere, I.H., Okeke, J.J. and Akaun, I.P. (2020g). Evaluation of marine waste water and

- aromatic hydrocarbons toxicity using a battery of assays. *Research & Reviews: A Journal of Toxicology*, 10 (2): 1 – 13.
- Uba, B. O., Obidike, K.N., Dokubo, C.U. and Nnaodi, I.D. (2020h). Bioelectricity generation using marine sediment and cow dung. *EC Microbiology*, 16 (10): 1 – 12.
- Uba, B. O., Chukwura, E. I., Okoye, E. L., Ubani, O. and Odibo, F.J.C. (2021). Toxicological evaluation of aromatic hydrocarbons using toxi-chromo test and mice model. *Indian Journal of Ecology*, 48 (5): 1533 – 1541. Uba, B. O. and Anidu, F. N. (2023). Evaluation of the characterization and heavy metals remediation potential of biosurfactant produced by *Aeromonas hydrophila* S62A. *Archives of Agriculture and Environmental Science*, 8(2), 116– 124. <https://dx.doi.org/10.26832/24566632.2023.080204>
- Uba, B. O. and Obiefuna, G. O. (2023). Aerobically enhanced nanobioremediation of diesel oil contaminated soil and water using mycosynthesized silver nanoparticle as biostimulating agent. *Science World Journal*, 18 (1): 75 – 82. <https://scienceworldjournal.org/article/view/23510>.
- Uba, B.O., Okoye, E.L., Anyichie, J.C., Dokubo, C.U. and Ugwuoji, E.T. (2024). Synthesis, characterization and application of biogenic silver nanoparticles as antibacterial and antifungal agents. *Journal of Advances in Microbiology*, 24 (3): 65 – 78. <https://doi.org/10.9734/JAMB/2024/v24i3809>.
- Uba, B.O. and Okonkwo, O.P. (2025). Surface water treatment potentials of silver nanoparticles biosynthesized from *Moringa oleifera* seed extract. *African Journal of Health, Safety and Environment*, 6 (2): 01 – 18. <https://doi.org/10.52417/ajhse.v6i2.622>.
- Uba, B. O., Okonkwo, O. P., Idigo, M. A., Igiri, V.C., Okongwu, D. J., Okemadu, O.C. & Anaebonam, E. C. (2026). Disinfecting Potentials and Eco-Safety Evaluation of Nano-treated Surface Water Resources by Biogenic Silver Nanoparticles Using Bacterial and Phytotoxicity Indices. (2026). *African Journal of Applied Research & Sustainable Development*, 4(1): 47-58. <https://doi.org/10.54117/ijqae873>.
- Ubajekwe, C. C., Chukwura, E. N., Dimejesi, S. N., Uba, B. O., Eleanya, L., Ezendianafo, J. N., & Dibua, N. A. (2025). Screening for Lipase Enzyme Producing Potentials of *Bacillus* Species Isolated from Different Automobile Workshops in Anambra State. *IPS Journal of Advanced and Applied Biochemistry*, 1(2), 51–56. <https://doi.org/10.54117/ijaab.v1i2.71>.
- Uba, B. O. and Umennadi, P.O. (2026). Kinetics, Zymographic Analysis, and Industrial Evaluation of Alkaline Protease from *Bacillus tropicus* Isolated from Environmental Water Samples. *IPS Interdisciplinary Journal of Biological Sciences*, 6(2): 289 – 298.
- Ubani, O., Uba, B.O., Modise, S. J., Okoye, E. L., Omeazu, S. C., Ndibe, C.R., Umeh, O. R. and Dokubo, C. U. (2024a). Responses of *Selenastrum capricornutum*, *Eisenia fetida*, *Brassica nigra* and *Sorghum bicolor* to spent phone battery toxicity. *Multidisciplinary Science Journal*, 6 (7): 2024107 - 2024107. <https://doi.org/10.31893/multiscience.2024107>.
- Ubani, O., Obiefuna, G.O., Uba, B.O., Dokubo, C.U., Mere, C. A. and Akaun, I.P. (2024b). Kinetic modelling and half-life study on bioremediation of diesel oil contaminated soil and water using nano - remediation strategy: kinetic modelling and half-life study on bioremediation of diesel oil. *Multidisciplinary Science Journal*, 7:e2025182. <https://doi.org/10.31893/multiscience.2025182>.
- Ubani, O., Uba, B. O., Modise, S. J., Egurefa, S. O., Orji, M. U. and Dokubo, C. U. (2025). A characterization and evaluation of the ecotoxicity of petroleum refinery effluents using a battery of bioassays. *Multidisciplinary Science Journal* 8 (3): 2026159. <https://doi.org/10.31893/multiscience.2026159>.
- Umeh, S.O., Okpalla, J. and Okafor, J.N.C. (2019). Novel sources of *Saccharomyces* species as leavening agent in bread making. *International Journal of Trends in Scientific Research and Development (IJTSRD)*, 3(2):827–832.
- Umeh, O.R., Chukwura, E.I., Ibo, E.M. and Uba, B.O. (2020). Evaluation of physicochemical, bacteriological and parasitological quality of selected well water samples in Awka and its environment, Anambra State, Nigeria. *Archives of Agriculture and Environmental Science* 5 (2): 73 – 88. <https://doi.org/10.26832/24566632.2020.050201>.
- Umeh, O.R., Chukwura, E.I., Okoye, E.L., Ibo, E.M., Egwuatu, P. I. and Uba, B.O. (2021). Phytochemical Screening and Antibacterial Evaluation of Conventional Antibiotics, Garlic and Ginger on Isolates from Fish Pond Water Samples in Awka, Anambra State, Nigeria. *Journal of Pharmaceutical Research International* 33(30B): 118-132. <https://doi.org/10.9734/jpri/2021/v33i30B31646>.
- Wabale, A.S. and Kharde, M.N. (2010). Effect of plant extracts on the fungal pathogen causing wilt of sugarcane in vitro. *International Journal of Plant Sciences*, 5 (2): 445-447.
- Willey, J.M., Sherwood, I.M. and Woolverton, C.J. (2008). Prescott, Harley and Kleins Microbiology, 7th ed. McGraw-Hill companies, New York. Pp. 537 – 813.
- Williams, D.A. and Lemke, T.L. (2012). Foye's Principles of Medicinal Chemistry, 5th edn., Williams and Wilkins, Philadelphia, USA, pp. 712.
- Zhanell, G.G., Wiebe, R., Dilay, L., Thomson, K., Rubinstein, E., Hoban, D.J., Noreddin, A.M., Karlowsky, J.A., Hoban, D.J., Noreddin, A.M. and Karlowsky, J.A.. Comparative review of the carbapenems. *Drugs*, 67:1027–1052.
- Zhu, Z.J., Krasnykh, O., Pan, D., Petukhova, V., Yu, G., Liu, Y., Liu, H., Hong, S., Wang, Y., Wan, B., Liang, W. and Franzblau, S.G. (2008). Structure activity relationships of macrolides against *Mycobacterium tuberculosis*. *Tuberculosis*, 88:49–63. DOI: 10.1016/S1472-9792(08)70036-2
- Zoetendal E.G., Vauhan E.E. and de Vos, W.M.A. (2016). Microbial world within us. *Molecular Microbiology* 59(6):1639–1650.

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