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A Systematic Review and Meta-analysis on the Prevalence of Fungi Associated with dry Smoked catfish Sold in Nigeria

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Summary
An increase in fungal infectious agents has posed a serious public health threat. Smoked dry fish have remained a natural source of protein globally and can be a reservoir that harbored different microbial communities. Fish attracts a vast array of microorganisms (mold and yeast) which represent a major sector of Microbiota and thus can lead to toxicological implications if ingested. The aim of this review is to evaluate the occurrence of fungi isolates on smoked dry fish from different research work done in Nigeria. A quantitative method (Meta-analysis) design was used to summarize pooled results of primary studies. Different databases [Google Scholar and Researchgate] were searched for relevant studies. Meta-analysis was done using inclusion and exclusion criteria to ascertain heterogeneity and publication bias evaluation. Five reliable observational studies were selected and the pooled prevalence of fungi on smoked dry fish has revealed *Aspergillus spp* to be most prevalent (50%), followed by *penicillium spp* (40%) with *candida spp* the least (5%). The Meta-analysis of the prevalence of fungi on smoked *dry fish* required great attention on its safety during processing and packaging process. This will assist in the prevention of possible invasive aspergillosis or other fungi infections outbreaks

Keywords: "Nigeria" "prevalence" "fungi," and "smoked dry fish"

Introduction

Fish is a very nutrient-dense food and a source of fatty acids, proteins, vitamins, and minerals (Surya, 2020). One of the best sources of protein is fish meat, because of muscle fibers that are kept together by fibrous substance when cooked (Hamzat *et al*., 2022). It digests more easily as compared to beef or other forms of protein with 10% calories (Komira, 2019). Communities in Nigeria consume of fish meat than others and this could be due to a variety of reasons including individual variance, age, gender, socioeconomic status, adaptability, and religious beliefs (Sabo, *et al*., 2022). About 37% of Nigeria's total protein intake comes from fish, which is also the most affordable and significant source of animal protein (Oko *et al.,* 2020).

The earliest techniques for preserving fish that are still in use today include salting, smoking, and drying. These traditional methods are still utilized, despite advancements in techniques over time (Chukwura *et al*., 2024). To produce a fish product that is stable for transport and storage, smoked fish is typically processed using a combination of curing/salting, smoking, and drying steps (Chukwurah, *et al.*, 2024). Raw fish is either dry salted, pickled, or boiled in salted water before being smoked at temperatures between 40 and 100 °C and dried. However, the process can vary significantly depending on the species of fish, the desired product, and local customs in various regions (Fitri *et al*., 2022).

The smoking processes of fish are of two forms viz. wet hot smoking and dry hot smoking (Anoh, 2024).

Both processes are carried out at temperatures high enough to cook the fish. Wet hot smoking usually takes about 1 - 2 hours and yields a moist,

versatile product with about 40 - 55 percent moisture content, while dry hot smoking, which is usually preceded by the former process, takes about 10 - 18 hours, sometimes days and yields fish with 10 - 15 percent moisture content (Akwoubu *et al*., 2019). In the tropical countries such as Nigeria, smoke-drying of fish is one of the oldest available local forms of preservation methods essentially employed by most fishing communities (Assoba *et al*., 2019). Smoke-drying, apart from giving the product desirable taste and odor, preserves and prolongs the shelf-life of fish products conveniently at ambient conditions through its antibacterial and oxidative effects, lowering of pH, imparting desirable coloration, accelerating the drying process and acting as antagonist to spoilage agents (Sani *et al*., 2016).

Consumption of smoked and smoke-dried fish without further cooking is common among sub-Saharan countries like Nigeria. It has been reported that smoke-dried fish are often contaminated with microorganisms such as bacteria, yeasts and molds from the processing units to market centers (Sani *et al*., 2016). Good storage practices are not observed by most wholesalers of smoked and smoke-dried fishes such as improper ventilation and easy access of pest into the storage environment (Akintola *et al*., 2022). Most of the post processing microbial contaminants originate from poor handling practices, while some could be from the air, the source of the fish, or from other degrading substances (Sikorsiki *et al*., 2020). In humid tropical conditions, dry smoked fish with low moisture contents are prone to insect infestation, while others having medium to high moisture contents are predisposed to both bacterial and fungal contaminations (Ikeh *et al.,* 2024).Deterioration of fish occurs as a result of complex enzymatic, microbial, chemical and physical changes (Andhikawati and Pratiwi 2021). In Nigeria, fish preservation is done to prevent spoilage during storage and taste addition.

Fungal contamination is a serious challenge faced by fish farmers and consumers in Africa. Some infections may be caused by fungi as the initial deterioration agents or as a secondary contaminant due to mechanical damage (Ajimati, 2023). Several molds have been implicated in fish spoilage, which is also harmful to consumer's health because of their ability to produce mycotoxins. Fungal fish spoilage has also resulted in food insecurity, shortage of essential nutrients and low-income generation in developing countries (Ajimati, 2023)

Methodology

Out of these databases (Research-gate, PubMed, ScienceDirect, Web of Science and Google-scholar), only two databases (Research-gate and Google-scholar) presented effectively with the required relevant research work that met the inclusion and exclusion criteria as at 16th September 2024. After selection based on the sample type of fish on which this review is strongly focus, this led to the further reduction to more than 90% of the research works done by so many researchers. From the Google-scholar database we were able to retrieve a total of 2,030 research work were able to retrieve, also the results obtained from Research-gate database was 2477 papers at that moment. The presentation below highlighted the diagrammatic depiction of the methodology applied for the review.

Table 1: Characteristics for inclusion of studies with pathogenic fungi contaminant on African catfish, (*clarias gariepinus)*.

Author/year	Study area	Method of identification	Fungi isolated	No of isolate	Method applied
Aliyu et al., (2018)	Minna (North Central)	Microscopic and Macroscopic with the aid of Tex book of mycolofgy	*Mucor sp, Aspergillus flavus, Trichophyton verrucosum, Aspergillus niger, Aspergillus fumigatus, Penicillin* sp, *Candida albicans and Rhizopus* spp	8	Phenotypic
Adetuwo et al.; (2023)	Ondo Akure (South West)	Microscopic and Macroscopic with the aid of Tex book of mycolofgy	*Penicillium spp, Aspergillus flavus Aspergillus niger*, *Candida spp*, *Fusarium species*, *Mucor spp*, *Rhodotorula spp* and *Rhizopus stolonifer*	7	Phenotypic
Ikeh et al., (2024)	Anambra (south East)	Microscopic and Macroscopic with the aid of Tex book of mycology	*Mucor spp Aspergillus niger Aspergillus flavus Penicillium spp Fusarium spp Rhizopusspp*	5	Phenotypic
Akomolede and Onifade et al., (2019)	Ado- Ekiti (SouthWewst)	Microscopic and Macroscopic with the aid of Tex book of mycolofgy	*Aspergillus spp*, *Mucor spp*, *Penicillium spp* and *Rhizopusspp*	4	Phenotypic
Uduak *et al.,* (2018)	Umuahia (south East)	Microscopic and Macroscopic with the aid of Tex book of mycology	*Aspergillus* spp, *Penicillium* spp, *Paecilomyces* spp, *Phialophora* spp, *Cladosporium* spp, yeast spp, *Saprolegnia* spp, *Scedosporium* spp.	7	Phenotypic

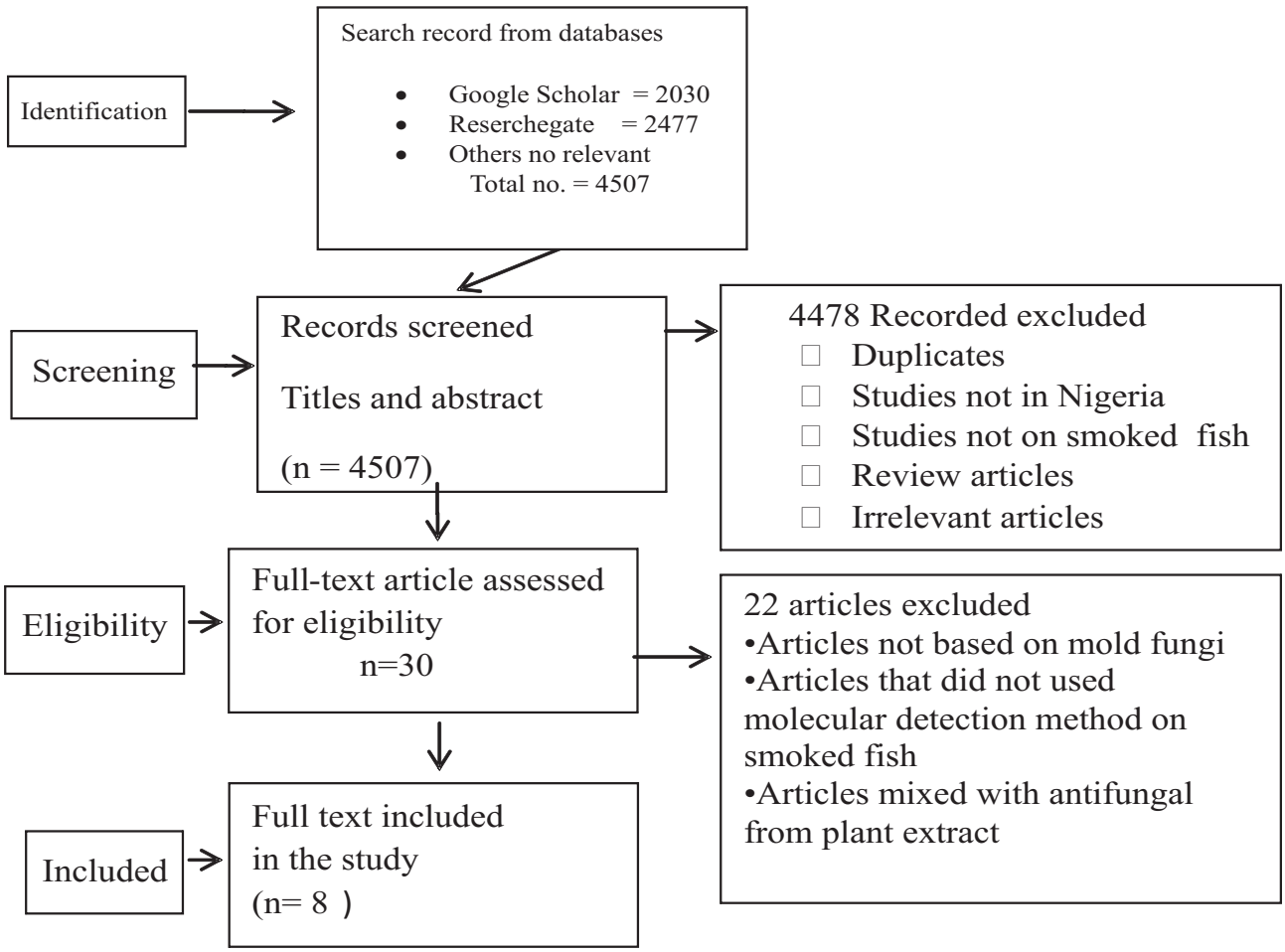

Figure 1: PRISMA flowchart for the selection and screening of eligible studies

Prevalence of Fungi on Smoked Fish in Nigeria

Many research works on the isolation and identification of fungi have been done on different species of fish which include smoked dry cat fish (*Clarias gariepinus*). *A* report by Aliyu *et al*. (2018) in Minna North Central Nigeria reveled that *Mucor* sp*, Aspergillus flavus, Trichophyton verrucosum, Aspergillus niger, Aspergillus fumigatus, Penicillin* sp*, Candida albicans and Rhizopus* sp fungi contaminants on smoked-dried fish of Clarias *gariepinus* (Catfish) and *Tilapia zilli* (Tilapia fish). It was observed that *Mucor* sp 62 (53%) had the highest rate of occurrence followed by *Penicillium* sp 20 (17.1%) *Candida albicans* 8(6.8), *Rhizopus* sp 7 (6.0%), *A niger* and *A. fumigatus* 6 (5.1%), *A. flavus* 5(4.3), while *Trichophyton verucosum* has the lowest 3 (2.6%) frequency respectively.

Olagunju *et al*. (2023) also carried out research titled "Safety Concerns on Microbes Associated with Fresh and Smoked Fish Sold in Igbokoda Fish Market, Ondo State South-Western Nigeria". Samples were taken at random from different un-named smoked dried fish species. Their main aim was to evaluate microbes associated with fresh and smoked fishes on sales at Igbokoda fish market and their antimicrobial susceptibility profiles. Among the fungal isolates isolated from fish samples showed that all the isolates were susceptible to all the antifungal agents used except *Candida* species that showed little resistance to clotrimazole. The fungi isolated and their percentage of occurrence were*; Penicillium species* (16.2%), *Aspergillus flavus* (8.4%), *Aspergillus niger* (25.5%), *Candida species (*16.4%*)*, *Fusarium species* (6.5%), *Mucor species* (8.6%), *Rhodotorula species* (7.2%) and *Rhizopus stolonifer* (11.2%).

According to Ikeh *et al*. (2024) on the study of fungal organisms associated with smoked and

dried fish sold in Awka Markets, Anambra State, South- East Nigeria reveled *Mucor spp,* Aspergillus niger, Aspergillus flavus, Penicillium spp, Fusarium spp and Rhizopus spp as fungi isolated on four different species. Aspergillus niger was the highest mean fungal count of 9.00 ± 5.568, followed by Mucor spp (8.00 ± 1.732), while Aspergillus flavus was the lowest (3.67±1.528). In the dried fish samples, Gardus morhua (stock fish) had the highest infestation with fungi (1.08±1.083), while in smoked fish; Clarias gariepinus (catfish) had the highest infestation.

Akomolede *et al*. (2019) reported a work titled "Isolation of Fungi Population in Commercially Smoked Fishes from Markets in Ado-Ekiti Metropolis, South-West Nigeria". *Clarias garipenus* ("Aro") or catfish was among the selected smoked fish for the analysis. Different fungi isolates were recorded from 23 positive samples. *Aspergillus spp* (29.3%), *Mucor spp* (20.7%), *Penicillium spp* (18.2%) and *Rhizopus spp* (15.8%) were the dominant fungi detected, while *Fusarium* (9.1%) and *Candida* (6.9%) occurred less frequently. From this report, it is noticed that fungi infestation was prominent in fishes smoked across all the markets.

Akpabio et al. (2018) also carried out research on smoked fish titled "Mycological Evaluation of Smoked-Dried Fishes Sold in Umuahia Markets, Abia State, Nigeria. The study was to identify the fungi commonly involved in contamination and deteriorations of smoked-dried fishes, the smoked fish involved African catfish (*Clarias gariepinus*) among others that are available in Umuahia metropolis, Eastern Nigeria. The associated fungi where *Aspergillus* spp*, Penicillium* spp, *Paecilomyces* spp, *Phialophora* spp, *Cladosporium* spp, yeast spp*, Saprolegnia* spp, *Scedosporium* spp. *Aspergillus* spp had the highest rate of occurrence followed by yeast spp, *Penicillium* spp*, Saprolegnia* spp, *Phialophora* spp, *Paecilomyces* spp and *Scedosporium* spp, respectively.

Discussion

Researchers have tried to ascertain the level of fungi contamination on smoked fish using different microbiological approaches. Few studies from Nigeria reported fungi contamination on fish especially African Catfish *Clarias gariepinus,* this may be attributed to locations.

The major fungal contaminant according to our review are as follows, *Aspergillus spp* followed by *Fusariun spp*. and *Penicillium spp* the *Candida spp* percentage was very rare. None of the available research work combined the two methods molecular and antifungal studies on pathogenic fungi on African Catfish *Clarias gariepinus* in Nigeria. The methods involved were phenotypic identification using Microscope and mycology color Atlas textbook, therefore this review is prepared to exposed the need for these research to be expanded up to molecular level to rule out the exact fungal species using genotypes method which comprises PCR, Gel electrophoreses and to sensitizes the isolate with different antifungal drugs to be able to detect the resistance gene among the isolate for future reference. From the journals it was also difficult for the researcher to retrieve the combined tilted of this review done on smoked fish within Sokoto State, North-western part of Nigeria, this is very necessary due to the high consumption of African Catfish (*Clarias gariepinus*), Jabo et al. (2020).

Conclusion

The researcher has tried all the possible ways to see if there is any available research titled "Molecular Identification and Antifungal studies on pathogenic fungi associated with African Catfish (*Clarias gariepinus)* in Nigeria have ever been done but could not be possible up to the time of this review, therefore this is so crucial at the moment because of the public health hazard attributed to these smoked-fish Ikeh et al., (2024). Some of the danger posed by these molds include invasive aspergillosis which may invade the lungs sometimes may lead to the surgery but is of rare Machado *et al*. (2024). Therefore, designing an effective drug may only be achieved by knowing fully if there is a gene of resistance to the available drugs by these pathogenic isolates.

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Conflict of interest declaration
No conflict of interest to declare.

References

Ajimati, F.M. (2023). *Mycological, Mycotoxin and Heavy Metals Composition of Dried Fish From Ilorin Markets in Nigeria* (Master's thesis, Kwara State University (Nigeria).

Akani Nedie Patience, and Nwankwo Chidiebele Emmanuel Ikechukwu. (2019). "Mycoflora and Public Health Risks of Smoked Fish Sold in Port Harcourt Markets, Nigeria." *American Journal of Microbiological Research;* **7(3)**: 78-82. doi: 10.12691/ajmr-7-3-2.

Akintola, S. L., Fakoya, K. A., Elegbede, I. O., Odunsi, E., & Jolaosho, T. (2022). Postharvest practices in small-scale fisheries. In *Sustainable Fish Production and Processing*: 79-110). Academic Press.

Akwuobu, C.A., Antiev, W.S. and Ofukwu, R.A.-P. (2019) Fungal Contaminants of Smoke-Dried Fish Sold in Open Markets in Makurdi, Benue State, North-Central Nigeria. *Food and Nutrition Sciences*; **10**: 290-297.

Akomolede, Olumide Olawole and Onifade, Olajumoke Evelyn (2019). Isolation of Fungi Population in Commercially Smoked Fishes from Markets in Ado-Ekiti Metropolis, Nigeria. *Journal of Science, Technology, and Engineering Research; 2(3): 13-18, 2019; Article no.DJ/JSTER.12896.*

Akpabio. U., Nweke, K.C., Kwaga, J.K.P., Okolocha, E.C., Ozioko, C.A., and Ikpendu, C.N. *(2018).* Mycological Evaluation of Smoked-Dried Fishes Sold in Umuahia Markets, Abia State, Nigeria. *World Journal of Fish and Marine Sciences;* **10 (4)**: 40-45, DOI: 10.5829/idosi.wjfms .2018. 40.45

Alastruey-Izquierdo, A.; Melhem, M.S.C.; Bonfietti, L.X. & Rodriguez-Tudela, J.L. **(2015).** Susceptibility Test For Fungi: Clinical And Laboratorial Correlations In Medical Mycology. Revista do. Instituto de. Medicina. Tropical. Sao Paulo; **57(19)**:57-64, DOI.org/10.1590/S0036-46652015000700011

Aliyu, M. A., Wartu, J. R. and Hussaini M. A. (2018). Fungal Contamination of Smoked-Dried Fish in Minna Nigeria. *Bayero Jornal of Medical Laboratory Science; **3(1)**: 199 – 206*

Alshehri, B., & Palanisamy, M. (2020). Evaluation of molecular identification of Aspergillus species causing fungal keratitis. *Saudi Journal of Biological Sciences; **27*(2)**: 751-756.

Andhikawati, A., & Pratiwi, D. Y. (2021). A Review: Methods of Smoking for the Quality of Smoked Fish. *Asian Journal of Fisheries and Aquatic Research; **13*(4)**: 37-43.

Anie, C. O., Jemikalajah, D. J., & Eke, C. N. (2019). Determination of microbial load of selected smoked fish sold in abraka markets Delta State. *Nigerian Journal of Pure and Applied Science; **32 (1)**:* 3281-3288.

Anihouvi, D. G. H., Henriet, O., Kpoclou, Y. E., Scippo, M., Hounhouigan, D. J., Anihouvi, V. B., & Mahillon, J. (2021, September 7). Bacterial diversity of smoked and smoked dried fish from West Africa: A metagenomic approach. *Journal of Food Processing and Preservation; **45*(11)**.

Assogba, M. F., Anihouvi, D. G. H., Iko Afé, O. H., Kpoclou, Y. E., Mahillon, J., Scippo, M. L., ... & Anihouvi, V.B. (2019). Processing methods, preservation practices and quality attributes of smoked and smoked-dried fishes consumed in Benin. *Cogent Food & Agriculture; **5*(1)**: 1641255.

Ayeloja, A., George, F., Jimoh, W., & Adebisi, G. (2020). Effect of insect infestation on the economic value of smoked fish sold in selected markets in Nigeria. *Agricultural Science and Technology; **12*(1)**: 82–86.

Bienkiewicz, G., Tokarczyk, G., & Biernacka, P. (2022). Influence of storage time and method of smoking on the content of EPA and DHA acids and lipid quality of Atlantic salmon (Salmo salar) meat. *International Journal of Food Science: 2022*.

Berkow EL, Lockhart SR, Ostrosky- Zeichner L. 2020. Antifungal susceptibility testing: current approaches. *Clinical Microbiology Review*: **33**:e00069-19. doi.org/10.1128/CMR .00069-19.

Chukwurah, U., Ekwealor, C., & Ekpunobi, N. (2024). Assessment of the Fungal Contaminants of Dried Fishes Sold in Open Markets in Awka, Nigeria.

Darwish, W., Mohamed, A. S., & Abdallah, K. M. (2023). Mould Contamination of Fish and Fish Products with a Special Reference to its Public Health Significance: A Review. *Journal of Advanced Veterinary Research;* ***13*****(8)**:1726-1729.

Denning David, Emily E. Hammond, Charles S. McDonald (2020). The Global impact on Aspergillus infection on Chronic Obstructive Pulmonary Diseases. *Research Square* **3**:rs-20363/vol1.

Espinel-Ingroff A. (2001). In vitro fungicidal activities of voriconazole, itraconazole, and amphotericin B against opportunistic moniliaceous and dematiaceous fungi. *Journal of Clinical Microbiology*; ***39*****(3)**: 954–958.

FAO (2011). Rapport 2010 sur la situation mondiale des pêches et de l'aquaculture (SOFIA 2010). Archives de documents de la FAO, Rome.

Fiorentini, Martina, Amanda J. Kinchla, and Alissa A. Nolden (2020). "Role of Sensory Evaluation in Consumer Acceptance of Plant-Based Meat Analogs and Meat Extenders: A Scoping Review *Foods*;**9(9)**: 1334.

Fitri, N., Chan, S. X. Y., Che Lah, N. H., Jam, F. A., Misnan, N. M., Kamal, N., ... & Abas, F. (2022). A comprehensive review on the processing of dried fish and the associated chemical and nutritional changes. *Foods;****11*****(19)**: 2938.

Gupta, A. K., & Kohli, Y. (2003). In vitro susceptibility testing of ciclopirox, terbinafine, ketoconazole and itraconazole against dermatophytes and nondermatophytes, and in vitro evaluation of combination antifungal activity. *British Journal of Dermatology;* ***149*****(2)**: 296-305.

Hamza, B.S., *et al*. (2022). Isolation and Identification of Fungi from Lungs and Rumens of Small Ruminants. *Basrah Journal of Veterinary Research;* ***21*****(2)**: 61–76.

Ikeh, M.I., Ishar, C.O., Chiakwelu, P.C., Okeke, O.A., Okeke, C.J., Offor, V.O., Obiakor, U.A., Oraneli, U.B., Benedict, A.G. (2024), Study of Fungal Organisms Associated with Smoked and Dried Fish Sold in Awka Markets, Anambra State. *African Journal of Agriculture and Food Science*; **7(4)**: 87-98.DOI: 10.52589/AJAFS-TO1SSGZU

Khairulbariyyah Zakaria, Sudau EH Teet, Nor Hazwani Hamzah, Alia Syafiqah Aznan, Mohamed Tajuddin Abdul Manaf, Wan Nurhafizah Wan Ibrahim, Lee Kok Leong, Nurul Aqilah Iberahim, Nadirah Musa, Laith Abdulrazzak, Hassan Mohd Daud, Mariam Taib, Kishio Hatai, Akbar John B., Jalal K.C.A., Hassan I. Sheikh, and Najiah Musa (2020). Isolation and Identification of fungi associated with diseased freshwater fishes in Terengganu, Malaysia. *Journal of Science and Technology*. **43 (4)**: 1131-1139.

Korkmaz, K., & Tokur, B. (2022). Investigation of the quality parameters of hydrolysates obtained from fish by products using response surface methodology. *Journal of Food Processing and Preservation;* ***46*****(3)**: DOI: 10.1111/jfpp.16296

Leistner, L., & Gould, G. W. (2002). Hurdle Technologies: Combination Treatments for Food Stability, Safety and Quality: Combination Treatments for Food Stability, Safety, and Quality. Springer Science & Business Media.

Mishra Surya Prakash. (2020). Monogenetic Trematode Infentations in Indian Cat Fishes of River Gomati at District Sultanpur Uttar Pradesh, India. *International Journal for Modern Trends in Science and Technology;* ***8****:* 120–124.

Morshdy, A.E.M., Hussein, M.A., Mohamed, M.A.A., Hamed, E., El-Murr, A. E., Darwish, W. S., 2022. Tetracycline residues in tilapia and catfish tissue and the effect of different cooking methods on oxytetracycline and doxycycline residues. *Journal of Conservation Protection and Food Safety*; **17**: 387-393.

Muhammad, J.M.S., Abatcha, M., Abubakar, M.I., & Argungu, L.A. (2020). Structure and performance of catfish marketing in Dankure market Sokoto, Sokoto State, Nigeria. *Equity Journal of Science and Technology;* ***7*****(1)**: 60-60.

National Committee for Clinical Laboratory Standards (1998). Reference method for broth dilution antifungal susceptibility

testing of conidium-forming filamentous fungi. Proposed standard M38-P. *National Committee for Clinical Laboratory Standards, Wayne, Pa.*

Oko, O. J., & Okoye, C. O. B. (2020). Evaluation of PAH Contamination from Smoke in Smoked Fish Obtained from Northern Nigeria. Advances in Food Science and Engineering; 4(1): https://dx.doi.org /10.22606/afse.2020.41001

Olagunju Johnson Adetuwo, Kehinde Tope Adegbehingbe and Omodara Tolani Rachael (2023). Safety Concerns on Microbes Associated with Fresh and Smoked Fish Sold in Igbokoda Fish Market, Nigeria. *Journal of Advances in Microbiology;23(10): 72-82.*

Olutimehin Isaac. O. (2019). Effects of Handling and Storage Systems on the Lipid Oxidation and Fatty Acid Level of the African Snakehead Fish (Parachanna Obscura). *International Journal of Engineering Research;* ***08(07)****:82-90*.

Ozoh, C.N and Orji, M.U. (2022). Comparative study of Bacteriological Contents of Commercially Smoked Fish and Aseptically Smoked Fish sold in Awka and Environs, Anambra State Nigeria. *International Journal of Agriculture, Biology & Environment;* ***03*****(02)**:01–08.DOI:10.47504/ IJAGRI.2022.3.2.1

Ravi Kumar, Sandeep Kumar Shrivastava and Arunaaloke Chakraborti (2010). Comparison of Broth Dilution and Disc Diffusion Method for the Antifungal Susceptibility Testing of *Aspergillus flavus. American Journal of Biomedical Science*; **2(3)**: 202-208; doi: 10.5099/aj100300202

Rezaei K. Dorostkar and. Mabodian P. (2011). Mycoflora of smoke-dried fishes sold in Guilan Province, Iran. *Journal of Food and Agriculture Science;* **1(2)**:31-35,

Sabo, E., Akintunde, M. O., Emmanuel, G., Zubairu, A. I., & Akintunde, A. R. (2022). Economic Analysis Of Fish Value Chain In Taraba State, Nigeria. *Journal of Agripreneurship and Sustainable Development;* ***5*****(4)**: 10–18.

Santos, D.A., & Hamdan, J.S. (2005). Evaluation of broth microdilution antifungal susceptibility testing conditions for Trichophyton rubrum. *Journal of Clinical Microbiology;* ***43*****(4)**:1917-1920.

Segun, A.D.S., Musa, I. O.A., Musa, M.A., Ijabo, O. S., Mohammed, S., Mercy, O. P., & Chisom, N. (2022). Assessment of post-harvest fish losses among artisanal fishers in northeast Nigeria. *Bangladesh Journal of Fisheries;****34*****(1)**: 131–141.

Sikorski, Z. E., Kołakowska, A., & Burt, J. R. (2020). Postharvest biochemical and microbial changes. In *Seafood*: 55-75.

Segun, A.D.S., Musa, I.O.A., Musa, M.A., Ijabo, O.S., Mohammed, S., Mercy, O. P., & Chisom, N. (2022). Assessment of post-harvest fish losses among artisanal fishers in northeast Nigeria. *Bangladesh Journal of Fisheries;* ***34*****(1)**: 131-141.

Surya Prakash Mishra (2020). Significance of fish nutrients for human health. ISSN: 2456-7248; Impact Factor: RJIF 5.44. *International Journal of Fisheries and Aquatic Research;* **5(3)**:47-49.

Tedersoo, L., Bahram, M., Zinger, L., Nilsson, R. H., Kennedy, P. G., Yang, T., ... & Mikryukov, V. (2022). Best practices in metabarcoding of fungi: from experimental design to results. *Molecular Ecology;* ***31*****(10)**: 2769-2795.

Teke E. C., Immanuel O. M., Oku I. Y. and Okafor H. C. (2022). Microbiological Assessment of Smoked *Clarias gariepinus* Sold in Yenagoa. *South Asian Journal of Research in Microbiology;14(1): 25-30. Article No. SAJRM.94420.*

Temitope Ojuolape Fadipe (2022). Molecular Characterization of Fungi Associated with Smoked Micromesistius poutassou (Blue whiting) from Different Markets in Lagos, Nigeria. *Egyptian Journal Of Experimental Biology (Botany)*.doi:10.5455/202206 23095227

Uduak Akpabio, *K.C., Nweke, J.K.P. Kwaga, E.C., Okolocha, C.A. Ozioko and Ikpendu, C.N.* (2018). Mycological Evaluation of Smoked-Dried Fishes Sold in Umuahia Markets, Abia State, Nigeria. *World Journal of Fish and Marine Sciences* DOI: 10 (4): 40-45, ISSN 2078-4589.

Umar, D. M., Saje, W. S., & Abbati, M. A. (2021). Nutritive Value of Fresh and Smoked Fish (Clarias gariepinus and Oreochromis niloticus) from Dadin Kowa Dam Gombe.

Greener Journal of Biological Sciences; **11(2)**: 54-64

Valizadeh, S., Naseri, M., Babaei, S., & Hosseini, S. M. H. (2020). Shelf-life extension of fish patty using biopolymer-coated active paper sheets. *Food Packaging and Shelf Life; **26**:* 100603.

Ward, E. D., Thomasson, K., & Fischer, K. R. (2021, May 6). Analysis of Omega-3 Fatty Acid Content in Fish Oil Products. *Journal of Pharmacy Practice; **35(6)***: 870–873.

Worldfish Center, Penang W.F.C, (2005) Le poisson et la sécurité alimentaire en Afrique. WorldFish Center: Penang Malaisie: 12.

Yeside Adesiyun (2021). Street Food Spotlight: Eja Yoyo (Fried whitebait in Nigeria. *African Journal of Agriculture and Food Science;*7(4):87-98.

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