



BELLS UNIVERSITY OF TECHNOLOGY
OTA, OGUN STATE, NIGERIA

FROM WATER TO THE TABLE: SECURING SAFE AND WHOLESOME FISH FOR PUBLIC HEALTH

An Inaugural Lecture

By

JOHN ABIODUN DARAMOLA, MFISON, MAFS
*Professor of Fish Post-Harvest Quality and Utilisation
HOD, Department of Agriculture and Agricultural Technology*

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PROF. JOHN ABIODUN DARAMOLA, MFISON, MAFS

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HOD, Department of Agriculture and Agricultural Technology
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CITATION OF PROFESSOR JOHN ABIODUN DARAMOLA

John Abiodun Daramola was born in Abeokuta, Ogun State, over five decades ago; a breed of Ekiti and Ogun State Parents.

He began his formative education at St. Joseph's Primary School, Igbara-Oke, Ondo State, between 1980 and 1986, and subsequently attended Anglican Grammar School, Igbara-Oke, from 1987 to 1993. He proceeded to the Federal University of Technology, Akure (FUTA), where he obtained Bachelor of Agriculture Technology in Fisheries and Wildlife in 2000; Master of Agriculture Technology in Fisheries in 2005 and a Doctor of Philosophy in Fish Processing and Utilisation in 2012.

Professor Daramola is a professionally certified member of both the Fisheries Society of Nigeria and the American Fisheries Society. His academic journey has been distinguished by several scholarships and awards, including member of the beneficiary team for a FUTA grant on the design and construction of a model Fish Smoking Kiln in 2006; Ekiti State Government Postgraduate Scholarship for doctoral studies in 2008; member of the Education Collaborative Team assessing faculty teaching gaps in West African higher education institutions in 2024; beneficiary of the Ekiti Future Agenda Awards 2025 and more recently, one of the recipients of meritorious service award at the Bells University of Technology, Ota 20th Anniversary in 2025. He has attended relevant local and international conferences and received the award as the best paper presentation at the 10th London International Conference on Agriculture, Biological, Environmental and Medical Sciences (ABEMS-2018).

His university work experience began as a Teaching Assistant at FUTA in July 2005. In October 2005, he joined Bells University of Technology, Ota, where he has served as a Lecturer and risen to become a Professor of Fish Post-Harvest Quality and Utilisation, a position he has held since 1st October, 2023. Professor Daramola has served as external examiner to the Department of Fisheries, Lagos State University, Ojo and Department of Entrepreneurship, National Open University of Nigeria (NOUN). Outside Bells University of Technology, Ota, he has been a Resource Contact: Academic Coordinator and Biology Tutor at the Centre for the Gifted, Abuja and Fisheries Officer with the Federal Department of Fisheries, Ado-Ekiti. He

has also served as a Management Consultant at the Centre for Fish Processing and Value Addition, University of Lagos, and as a Visiting Lecturer at Covenant University, Ota.

Professor Daramola has taught numerous courses and supervised many students at both undergraduate and postgraduate levels. He has published extensively, including journal articles and co-authored books. His research focuses on fish post-harvest technology, quality, and utilisation, encompassing quality assurance (HACCP), biotoxins, additives, preservatives, value addition, thermal processing, by-product utilisation, heavy metal contamination, fish-borne pathogens, microbiological examination, and shelf-life assessment. He has also studied traditional and improved smoking techniques, the profitability of the smoked fish market, and the physical, biochemical, and sensory attributes of processed fish.

In Bells University of Technology, Ota, Professor John Abiodun Daramola is a University Orator and has served with outstanding qualities, unparalleled commitment in many academic, administrative committees and positions of responsibilities; these include:

S/N	ACADEMIC AND ADMINISTRATIVE POSITIONS	YEAR
1.	Pioneer Head, Department of Agriculture and Agricultural Technology	2023 - Date
2.	Ag. Dean, College of Food, Agricultural Science and Technology	Mar-Aug 2024
3.	Member, Academic Staff Appointment and Promotion Committee (ASAPC)	2025 - Date
4.	Technical Committee Member and Coordinator Bellstech, Education Collaborative, West Africa Hub	2024 – Date
5.	Member of Senate, Bells University of Technology, Ota	2012 - 2013 2016 – Date
6.	Chairman, Sub-Committee on Security, Health and Environment Chairman, Ceremonials Committee	2016 – 2025 2025 – Date
7.	Course Co-ordinator, Practical Animal Biology-BIO 104, Department of Biological Sciences	2010 – 2024
8.	Editor, Bells University Journal of Applied Sciences and Environment	2017 – 2022
9.	Co-Chair, Steering Committee for Centre for Agricultural Technology and Entrepreneurial Studies	2019
10.	Pioneer Director, Centre for Agricultural Technology and Entrepreneurial Studies (CATES)	2019 – 2025
11.	Member, Committee of Deans and Directors (Codd)	2016 – 2025
12.	2nd Vice-Chairman (Vice-Chancellor’s Representative) Bells University Parent Forum (BUPF)	2017 – 2023
13.	Member, Ad-hoc Coordinating Committee on Kano State Sponsored Students	2016 - 2022
14.	Member, Inter-Religious Committee, Bellstech	2015 -2019

15.	Member, Task Force for the Recovery of School Fees, Bellstech	2016 -2019
16.	Member, Comm. on Examinations for the Promotion and Appointment of Non-Teaching Staff	2016 -2019
17.	Acting Dean, Student Affairs Chairman, Student Orientation Committee Chairman, Students Welfare Board	2016 – 2019
18.	Member, Joint Consultative Committee on Student Life and Discipline	2015 – 2016
19.	Member, Security Monitoring Committee, Bells University of Technology, Ota	2011 - 2012 2015 – 2019
20.	Member, Mock Accreditation Team to Food Technology/Food Science with Business	Mar., 2017
21.	Member, Tribunal on Examination Malpractice	2016 – 2017
22.	Member and Contributor, Committee of Bellstech @ 10 Publication	2015 – 2016
23.	Member, Ad-hoc Committee Strategic Plan-Implementation Member, Committee on Repositioning Bellstech, Ota for Global Competitiveness	2014 – 2016
24.	Member, Centre for Foundation Education (CENFED) Promotion and Review Panel	2015
25.	Chairman, College Wide Course Committee, College of Natural and Applied Sciences	2014 – 2015
26.	Member, Bells Steering Committee on CHS/IACIU-OOPL Forum	2013
27.	COLNAS Representative to COLMANS board of Examiners and Review	2013 – 2015
28.	Assistant and Hall Warden, Male Halls of Residence, Bellstech	2012 – 2016
29.	Member, Students' Disciplinary Committee	2013 – 2019
30.	Member, Bells University Quality Assurance Committee on Examination to COLENV	2013
31.	Member, Bells Mock Accreditation Committee to COLENV/COLENG	2012
32.	Member, University Website Improvement and Administration Committee/Management Ad-hoc Committee for the Computer Centre	2012 – 2013
33.	Member, Bells University Linkage Committee	2012 – 2014
34.	Member, Committee on Draft and Review of Student Information Handbook	2011 - 2012 and 2016
35.	Vice-Chairman and Chairman, Bells University of Technology (Student) Electoral Committee –BUTECO	2012 - 2019
36.	Member, Pre-degree and Summer School Committee	2011 – 2014
37.	Member, SIWES/SWEP Team on Industrial Visitation	2011 – 2015
38.	Member, Departmental Curriculum Review and Committee on New Programmes for Department of Biological Sciences	2011 – 2014
39.	Pioneer Staff Adviser, Bells University Student Association (BUSA)	2010 – 2016
40.	Member, College Lecture Committee, COLNAS	2010 – 2015
41.	Chairman, College Lecture Committee, COLNAS	2022
42.	Member, University Timetable Committee and Examinations Monitoring Team	2010 – 2015
43.	Course Registration/Level Adviser, 400 Level students (final year) Department of Biological Sciences	2010 -2015
44.	Social Secretary Bells University Staff Cooperative I. C. S. Ltd, Ota	2010 – 2014
45.	Chairman, Electoral & Constitution Review Committee, Bells C.I.C.S.	2016

46.	Examination Officer, Department of Biological Sciences/Representative to Business Committee of Senate	2010 – 2014
47.	Staff Adviser, National Association of Microbiology, Department of Biological Sciences	2010 – 2014
48.	Member, Bells University Beautification Committee	2010 -2012
49.	Member, Undergraduate Admission Screening/Central Admissions Committee	2009 -2019
50.	Secretary, Departmental Welfare Committee and Aquaculture and Fisheries Unit	2009 – 2014

Beyond academia, Professor Daramola is actively involved in current affairs, football and gospel music. He is an ordained Minister and Pastor in the Redeemed Christian Church of God, having served as Pastor-in-Charge of Parish and Area at RCCG, City of Miracle between 2014 and 2019; RCCG, Abundant Testimony from 2019 to 2023 and currently as Pastor-in-Charge of Parish, Area, and Zone, RCCG, King's Chapel since 2023. Also, he is a member of the Research and Development (R&D) of RCCG, Ogun Province 14, Ota. He is happily married to Mrs. Bolanle Esther Daramola and they are blessed with children.

FROM WATER TO THE TABLE: SECURING SAFE AND WHOLESOME FISH FOR PUBLIC HEALTH

Preamble

“All the glory must be to the Lord, no man on earth should give glory to himself; all the glory must be to the Lord”

May I start by appreciating God for divine sustenance, protection, provision and for making this day a reality. To Him alone be all the glory.

Protocol and Welcome

Standing on the already well-established protocol, good afternoon, Mr. Vice-Chancellor, members of the University Management, colleagues, my spiritual fathers, friends, guests, men of the fourth estate, distinguished ladies and gentlemen.

I welcome you all to my Inaugural lecture titled: **From Water to the Table: Securing Safe and Wholesome Fish for Public Health**. This Inaugural Lecture is the second from the Department of Agriculture and Agricultural Technology, third in the College of Food, Agricultural Science and Technology and the tenth in our great citadel of learning, Bells University of Technology, Ota, Ogun State; the first private University of Technology in Nigeria. I must say tenth is symbolic, it is a figure of completeness and in the spiritual realm represents double grace.

My Educational Trajectory

Mr. Vice-Chancellor sir, before I go on, permit me to share my educational journey and how I became an expert in Fisheries Technology. I started from Saint Joseph's Primary School, then Anglican Grammar School both in Igbara-Oke and later got admission into the Federal University of Technology, Akure (FUTA), Ondo State in the 1993/1994 academic session.

I must say that because of my love for Biology in my secondary school, I had set out to read Medicine! However, I didn't meet the cut-off mark in my first attempt of the Joint Admission Matriculation Board's (JAMB) examination. I had to settle for admission in FUTA through my former English Teacher, Mrs. Ilori. She is a friend and colleague to my mother, and the then Headmistress of FUTA Staff Primary School. I gave her my documents and was waiting for admission in a choice course of study. During, the admission process, I was told my name will come out under another batch in Storage Technology, Department of Biology. This news made me happy going by my affinity for Biology but alas, I was given admission to study Fisheries and Wildlife! Let me confess that it was my first

time of getting to hear about the course, though literally the words Fish and Wildlife separately were not completely new. Initially, I thought of rejecting the admission, but on a second thought decided to go ahead with it while giving JAMB another shot. Eventually, I took JAMB examination the following year and was offered admission by University of Ilorin in Kwara State, to study Geology. At the screening stage, I was dropped because I had Ordinary Level pass in Physics (this became an issue at a point in my academics!). At this stage, I resorted to fate, and continued my studies in Fisheries and Wildlife; believing that was the line that I was destined to tow. I later progressed to be the Financial Secretary and President of the Society of Fisheries and Wildlife Students (SOFAWS). This was how I ended and graduated with colleagues (Co-Fish) in the Department of Fisheries and Wildlife, FUTA.

Mr. Vice-Chancellor sir, also, there was never any plan to be a Lecturer! I can vividly remember that at the send forth of my graduating set, a question was posed to us **“How many of you wish to be Lecturers”?** Expectedly at that time, no one signified intention to be a Lecturer. The reason was not far-fetched, because we believed there was a better life out there than that of a Lecturer! After my National Youth Service Corp (NYSC) in 2001, I was encouraged to go for Masters by my lecturers who saw a bright future ahead of me. Coincidentally, since there was no better job in sight, I decided to occupy myself with the Postgraduate studies. By this time, I had decided to specialise in Fisheries Technology; this marked the beginning of my journey to becoming a Lecturer. Upon completion of my Master's degree, I was offered a job in the Department of Fisheries and Aquaculture Technology as a Teaching Assistant in 2005. Later that year, I was employed as part of the pioneer lecturers in the Department of Biological Sciences to teach Marine Biology and Fisheries and Aquaculture. Hence, looking back, I can say that my initial reluctance to be a Lecturer was just a waste of time. This is because, all my life, I had been a Teacher! From Graceland Nursery and Primary School, Igbara-Oke to Olufunmilayo Secondary School, Akure to Federal University of Technology, Akure, Ondo State and now Bells University of Technology, Ota, Ogun State, Nigeria.

May I confess that I became a Fish Expert and Lecturer by accident. Wale Adenuga's assertion that “we are pencils in the hands of the creator” clearly comes to mind when I look back at my career trajectory. This also aligns with the Biblical verses in Jeremiah 1:5; “before I formed thee in the belly, I knew thee” and Jeremiah 29:11 “For I know the thoughts that I think toward you, saith the Lord, thoughts of peace, and not of evil, to give you an expected end”.

Therefore, God knows the end from the beginning!

As we all know, being a Lecturer without a Ph.D. is like an apprentice whose job is not secure. The journey to my doctoral degree was not just a walk in the park. I applied for Ph.D. in Fish Post-harvest Technology in the 2004/2005 academic session in the Department of Fisheries and Aquaculture Technology, where I had my first and second degrees but was denied! It was then that my Pass in Physics was brought up and that as a University of Technology, having a credit in O'Level Physics is a must, to progress to Ph.D. degree. I had no choice but to sit for Private NECO that year and ensure I pass in order to be eligible for admission. The interesting thing was that as a Teaching Assistant in FUTA, I sat for the NECO Examination with some of my undergraduate students who also had one deficiency or the other in their O'Level results! Surprised, one of them walked up to me and asked “Oga kile n se nibi?” meaning “Boss, what are you doing here?”. I told him why I was there, but I could tell from his facial expression that he was not convinced; the impression was that I came to sit for someone, as mercenary or impersonator. Whatever, the case, I passed my physics paper and was able to commence my Ph.D. Studies.

Therefore, I can say that I was formed and made as a scholar in the Federal University of Technology, Akure but blossomed and flourished in Bells University of Technology, Ota.

Introduction

Mr. Vice-Chancellor sir, as a prelude to the title for the day: **From water to the table: Securing safe and wholesome fish for public health**, I will explain the term “Fish”.

1. What is Fish?

1.1 Fish has been defined broadly as:

- a. A collection of edible animals harvested from water bodies, serving as primary source of protein and micronutrients for human consumption.
- b. Fish are a collection of edible aquatic animals (vertebrates and invertebrates) harvested from fresh, brackish, or marine waters for human nutrition, livelihood, and cultural practices. (FAO and World Fish, 2022).
- c. All edible aquatic animals — including finfish, crustaceans, molluscs, and echinoderms — harvested or cultured from any water body, intended for human consumption as a source of protein, fat, and micronutrients (World Fish, 2024; EAT-Lancet 2.0, 2024 and UN

Nutrition, 2025)

- d. Any aquatic animal (vertebrate or invertebrate) that is captured or cultivated in fresh, brackish, or marine waters, and which is intended for direct human consumption as a whole, fillet, or processed product, providing dietary protein, long-chain omega-3 fatty acids, and essential minerals.

This definition includes eight (8) major phyla (Chordata-bony and cartilaginous fishes, Mollusca, Arthropoda, Echinodermata, Cnidaria, Annelida, Mammals and Reptiles.

Hence, from these definitions, the term fish can be technically stated to represent the totality of aquatic animals- creatures that spend their entire lives or significant portions of them in water and range from microscopic plankton and tiny invertebrates to the massive blue whale.

Also, these animals cut across different aquatic habitats- marine animals (ocean and saltwater, freshwater animals (lakes, rivers and streams) and include:

- **Finfish**
- **Marine Fish:** Salmon, tuna, cod, halibut, mackerel, and sardines.
- **Freshwater Fish:** Tilapia, trout, carp, and catfish.
- **Crustaceans:** Shrimp, prawns, crabs, lobsters, and crayfish.
- **Molluscs**
- **Bivalves:** Oysters, clams, mussels, and scallops.
- **Gastropods:** Edible sea snails (like escargot) and abalone.
- **Cephalopods:** Octopus, squid (calamari), and cuttlefish.
- **Echinoderms:** Sea urchins (the edible roe is known as uni).
- **Cnidarians:** Certain species of jellyfish.
- **Reptiles:** Sea Turtle, Sea Snake.
- **Amphibians:** Axolotl, Frog, Toad, Newt.
- **Mammals:** Blue Whale, River Dolphin, Humpback Whale, Orca, Sea Otter, Manatee, Walrus, Dugongs, Beaver, Platypus.
- **Aquatic Insects:** Dragonflies, water bugs, and diving beetles are consumed in specific regions, such as parts of Asia and Mexico.

Aquatic Animals



Globally, over 3 billion people rely on edible aquatic animals for 20% of their animal protein (FAO, 2022). Micronutrients like vitamin B12, selenium, and omega-3 are found in finfish and invertebrates (Nutrition, (2021)).

Importantly, fishes are highly nutritive foods and are good source of:
Omega-3 (DHA/EPA) polyunsaturated fatty acids

- Protein
- Zinc
- Iron
- Magnesium
- Selenium
- Iodine
- Copper
- Vitamin A
- Vitamins B6, B12
- Vitamin D

Distinguished audience, the table below compares the edible nutrient composition per 100g of aquatic food taken.

Table 1: Nutritional equivalence across taxonomic boundaries

Nutrient (per 100g)	Atlantic (Vertebrate	Salmon ('true fish')	Whiteleg (Crustacean)	Shrimp	Common (Mollusc)	Octopus
Protein (g)	20.4		20.3		18.2	
Omega-3 (mg)	2,150		320		210	
Vitamin B12 (µg)	3.2		1.1		20.5	
Selenium (µg)	36.5		38.0		44.8	

Source: USDA Food Data Central (2023).

1.1 Contribution of Fishery to Global Economy

Classifying only finfish as “fish” underestimates economic value. According to the World Bank report of 2023, which reveals:

- a. Global first-sale value of finfish: \$180 billion
- b. Global first-sale value of crustaceans + molluscs: \$98 billion

c. Combined edible aquatic animal value: \$278 billion (45% is from invertebrates)

The global capture by edible category of fish in 2022 is as follows:

- i. Finfish (vertebrates): 54 million tonnes
- ii. Crustaceans (shrimp, crab, lobster): 11 million tonnes
- iii. Molluscs (clam, squid, octopus): 9 million tonnes
- iv. Other (sea cucumbers, jellyfish): 2 million tonnes (Source: FAO, 2022)

Hence, if crustaceans and molluscs are excluded from the definition of “fish”, we lose 27% of total edible aquatic animals intended for human consumption.

Also, it has been recorded that small-scale fishers in Southeast Asia and West Africa often land more invertebrate fish such as crab, prawn, squid than finfish by weight (Byrd *et al.*, 2022).

1.2 Health Benefits of Eating Fishes (Aquatic Foods)

1.2.1 Cardiovascular Disease

Seafood intake is associated with reduced inflammation and blood pressure, and is protective from stroke and other cardiovascular diseases (CVD). Eating just 1-2 servings of fish weekly reduces the risk of death from heart disease by 36% (Shahidi & Ambigaipalan, 2018). This is not solely due to the omega-3 fatty acids, EPA and DHA, but to other components in seafoods, such as vitamins B6 and B12 that maintain normal levels of homocysteine (Mozaffarian & Rimm, 2006). Omega-3s are also well-researched in their ability to prevent arrhythmias, in which the heart beats abnormally and erratically.

1.2.2 Cognitive Health

Epidemiological studies show that lower intakes of omega-3s are associated with an increased risk of cognitive decline and dementia. Fatty membranes of the brain are rich in DHA, which is associated with optimal functioning of the brain. Some studies show 30-50% lower DHA levels in the hippocampus region (the brain's “memory bank”) in patients with Alzheimer's disease (Cunnane *et al.* 2009). Lower DHA levels are associated with amyloidosis, a build-up of protein deposits called amyloids, which is believed to progress Alzheimer's disease (Yassine *et al.*, 2016). Both DHA and EPA can also help regulate inflammation and elevated triglycerides, which are associated with an increased risk of cognitive decline and dementia.

1.2.3 Foetal Development

Dietary omega-3s play a role in brain development and growth of the foetus during pregnancy and into infancy. DHA is also found in high amounts in the

retina, which develops rapidly in the foetus during the last trimester. Cohort studies show that a higher intake of seafood containing DHA (about 8 ounces weekly) is associated with healthier infants. Research following a cohort of mothers and infants found that higher fish consumption during pregnancy (2+ servings fish weekly) compared with no fish intake was associated with higher cognitive scores in infants and young children 3-5 years old, though higher mercury intake was linked with lower scores.

1.2.4 Risk of Diseases and Premature Death

Research has also found that swapping red and processed meat with fish and seafood can lower the risk of diseases and premature death. One reason may be differences in types of fat: mostly saturated fat in red meat versus unsaturated fat in seafood. Data from six U.S. cohort studies found that higher intakes of red meat and processed meat were associated with an increased risk of cardiovascular disease and early death, whereas fish was not (Zhong *et. al.*, 2020). Research from a large Danish cohort study found that replacing red and/or processed red meat with fish or poultry lowered the risk of type 2 diabetes and early death. **So, consider swapping red meat in some recipes for aquatic foods!**

1.3 The Health Impact of Aquatic Foods in Developing Countries

According to Golden *et. al.* (2021), more than 3.5 billion people around the world are malnourished, with at least half of all children suffering from micronutrient deficiencies in 2019. Cardiovascular diseases (CVD) are the greatest contributor to worldwide deaths. Aquatic foods may help to improve health by reducing both issues of nutrient deficiencies and CVD rates. Increasing global production and availability of aquatic foods will help reduce their cost by 26% and increase their consumption, which may then reduce consumption of red and processed meats that are associated with diet-related chronic diseases such as CVD. It is also estimated that this shift to aquatic foods may prevent about 166 million micronutrient deficiencies that place people at increased risk for communicable diseases (e.g., bacterial infections, viruses) due to a weakened immune system.

1.4 Examining the Future of Aquatic Food Systems

In 2021, a series of scientific studies from the Blue Food Assessment—an international joint initiative including over 100 scientists from more than 25 institutions—found that global demand for aquatic foods is likely to double by 2050, which would be met primarily through increased aquaculture production rather than capture fisheries.

2.0 FISH SPOILAGE, PRESERVATION AND PROCESSING TECHNIQUES: MECHANISMS AND ADVANCES

The global fish sector continues to expand in economic and nutritional significance. According to the Food and Agriculture Organisation of the United Nations (FAO), world fish production has consistently exceeded 200 million tonnes annually, and projections suggest output could approach 196 million tonnes by 2025 (Ali *et. al.*, 2022). Fish remains one of the most important single sources of high-quality complete protein in the human diet, alongside omega-3 polyunsaturated fatty acids (PUFAs), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) whose roles in cardiovascular health, neurological development, and inflammatory regulation are well-established in the nutritional literature (Kontominas *et. al.*, 2021).

Yet this nutritional richness is simultaneously the source of fish's greatest commercial liability: its extreme perishability. Under refrigeration (0–4°C), the shelf life of fresh fish is typically not more than five to seven days, extending to approximately nine to twelve months under frozen conditions (Tavares *et. al.*, 2021). At ambient temperatures, which are the norm in many developing economies with inadequate cold-chain infrastructure, spoilage can commence within hours of capture. The resulting post-harvest losses are estimated at between 10 and 12 percent of global fish production, with figures exceeding 30 percent in Sub-Saharan Africa and parts of South and Southeast Asia (FAO, 2021).

These losses are not merely economic. They undermine food security, deprive coastal communities of income, and generate substantial environmental costs. This context has intensified academic and industrial interest in preservation and processing strategies that are simultaneously effective, safe, affordable, and minimally disruptive to the sensory and nutritional quality that consumers demand. Contemporary consumers, in particular, increasingly seek fresh or fresh-like, minimally processed products free of synthetic additives a demand that is partly at odds with the requirements of conventional chemical preservation but that has stimulated a productive wave of investigation into non-thermal technologies and natural antimicrobials (Speranza *et. al.*, 2021; Kontominas *et. al.*, 2021).

This review synthesises recent advances in the field, grounding each preservation strategy in its underlying biochemistry and microbiology before evaluating its practical efficacy, limitations, and regulatory status.

2.1 Mechanisms of Fish Spoilage

An understanding of preservation strategies requires prior knowledge of the biological and chemical processes driving deterioration. Fish spoilage is a multifactorial process involving three principal and interacting mechanisms: enzymatic autolysis, microbial growth, and chemical oxidation of lipids (Tavares *et. al.*, 2021; Nie *et. al.*, 2022).

2.1.1 Enzymatic Autolysis

Immediately after death, endogenous enzymes present in muscle tissue and the digestive system remain active in the absence of metabolic regulation. Cathepsins, calpains, and collagenases attack myofibrillar and connective tissue proteins, producing the textural softening and moisture exudation that characterise early-stage deterioration. Simultaneously, nucleotide catabolism proceeds through a well-characterised sequence: adenosine triphosphate (ATP) is degraded through adenosine diphosphate (ADP) and adenosine monophosphate (AMP) to inosine monophosphate (IMP), inosine (Ino), hypoxanthine (Hx), and xanthine (Xa). The K-value index ratio of Ino and Hx to total ATP-related compounds provides an established measure of post-mortem freshness, with values above 60 percent typically indicating advanced autolytic deterioration (Zhuang *et. al.*, 2023). Autolysis also generates amino acid substrates that are subsequently metabolised by spoilage bacteria, creating a biochemical bridge between enzymatic and microbial spoilage pathways.

2.1.2 Microbial Spoilage

Microbial activity is the dominant spoilage factor in fresh and lightly preserved fish (Tavares *et. al.*, 2021). The skin, gills, and gastrointestinal tract of freshly caught fish harbour a natural microbiota whose composition reflects the aquatic environment psychrotrophic Gram-negative bacteria such as *Pseudomonas* spp., *Shewanella putrefaciens*, and *Photobacterium phosphoreum* are among the principal specific spoilage organisms (SSOs) at low temperatures (Zhuang *et. al.*, 2023). These organisms metabolize non-protein nitrogenous compounds, most notably trimethylamine oxide (TMAO) to trimethylamine (TMA), the compound primarily responsible for the characteristic "fishy" malodour of spoiled marine species. Total volatile base nitrogen (TVB-N), which aggregates TMA and other volatile amines such as ammonia and dimethylamine, serves as the standard regulatory spoilage index in the European Union; a TVB-N limit of 25–35 mg per 100 g, depending on species, is widely enforced (Regulation (EC) No. 2074/2005).

Table 2 : The main microbial spoilage organisms

S/N	Name of Microbe and Examples	Key Features	References
1	<i>Pseudomonas</i> spp. <i>Pseudomonas fluorescens</i> and <i>Pseudomonas fragi</i>	- Dominant SSOs in chilled aerobically stored marine and freshwater fish. - Capacity to proliferate at temperatures approaching 0°C	International Journal of Microbiology and Biotechnology, 2025 PMC, 2024
2	<i>Shewanella putrefaciens</i>	Typical SSO for iced marine fish from temperate waters and has been described as the primary spoilage bacterium in chilled fish regardless of species origin	Gram <i>et al.</i> , 1996, as cited in Wu <i>et al.</i> , 2025 Dietetics Academy, 2025 Zhang <i>et al.</i> , 2021 PMC, 2024
3	<i>Photobacterium phosphoreum</i>	Bioluminescent gram-negative bacterium of increasing significance as an SSO in modified atmosphere-packaged (MAP) marine fish from temperate waters.	Gram and Dalgaard, 2002, as cited in International Journal of Microbiology and Biotechnology, 2025
4	<i>Aeromonas</i> , <i>Vibrio</i> , and Other Species	<i>Aeromonas</i> species are important SSOs particularly in freshwater and tropical marine fish, where they contribute to proteolytic and lipolytic spoilage under both chilled and ambient temperature conditions.	PMC, 2024 International Journal of Microbiology and Biotechnology, 2025 Biology Notes Online, 2024

2.1.3 Lipid Oxidation

Fish, particularly fatty species such as mackerel, herring, sardine, and salmon, are especially vulnerable to lipid oxidation owing to the abundance of long-chain PUFAs in their phospholipid membranes. Oxidation proceeds through three mechanistic phases. Primary oxidation involves the formation of hydroperoxides through auto-oxidation, photo-oxidation, or enzymatic pathways (lipoxygenase activity). These hydroperoxides decompose in secondary reactions to produce aldehydes (hexanal, malondialdehyde), ketones, and alcohols that generate rancid off-flavours detectable at very low threshold concentrations. Tertiary reactions produce novel compounds through interactions between secondary oxidation products and nucleophilic tissue constituents including proteins and carbohydrates (Tavares *et. al.*, 2021). Thiobarbituric acid reactive substances (TBARS) measurement, which detects malondialdehyde, remains the most widely used proxy indicator of lipid oxidation status in fish products.

2.2 Intrinsic Properties of Fish that Predispose it to Spoilage

Before examining specific spoilage mechanisms, it is necessary to understand the compositional and structural characteristics of fish muscle that render it uniquely susceptible to rapid deterioration. These intrinsic factors do not cause

spoilage directly but establish the physicochemical environment within which spoilage processes operate.

2.2.1 High Moisture Content and Water Activity

Fish muscle typically contains 60–85% water by weight, conferring a water activity (*a_w*) of approximately 0.98–0.99 well above the threshold for bacterial, yeast, and mould growth (Hussain *et. al.*, 2021). This high moisture content not only supports microbial metabolism but also facilitates the diffusion of enzymatic substrates and oxidative reactants throughout the muscle tissue. Processing interventions such as drying and salting reduce water activity and thereby retard microbial spoilage, though they introduce other quality challenges (Biology Notes Online, 2024).

2.2.2 pH and Buffering Capacity

Unlike red meats, where post-mortem glycolysis substantially reduces muscle pH to approximately 5.4–5.6, the low glycogen reserves of fish result in minimal lactic acid production following death. Consequently, the pH of fish muscle rarely drops below 6.0 and typically remains between 6.2 and 6.8 (Dietetics Academy, 2025). This relatively neutral pH is buffered effectively by the high concentration of free amino acids and organic phosphates inherent to fish flesh, maintaining conditions that are permissive for a wide range of spoilage microorganisms, including acid-sensitive species that would be inhibited in red meat environments.

2.2.3 Free Amino Acids and Nitrogenous Compounds

Fish muscle is characterised by an unusually high concentration of free amino acids, dipeptides, and other non-protein nitrogenous compounds, including trimethylamine oxide (TMAO), creatine, and inosine. These compounds serve as readily accessible substrates for both endogenous enzymes and microbial metabolism. The abundance of soluble nitrogenous material accelerates spoilage and contributes directly to the formation of biogenic amines, volatile basic compounds, and malodorous off-products (Food Quality and Safety, Oxford Academic, 2024). In marine fish, TMAO is particularly significant, as its microbial reduction to trimethylamine (TMA) is one of the best-known and most readily detectable markers of fish spoilage.

2.2.4 Polyunsaturated Fatty Acid (PUFA) Content

The lipid composition of fish is distinctive for its high proportion of long-chain polyunsaturated fatty acids (PUFAs), notably EPA (20:5n-3) and DHA (22:6n-3). While these omega-3 fatty acids are responsible for the well-established health

benefits of fish consumption, the multiple double bonds in their carbon chains represent chemical vulnerabilities sites at which molecular oxygen preferentially initiates chain reactions of lipid peroxidation (Food Quality and Safety, Oxford Academic, 2024). Fatty fish species such as mackerel, herring, salmon, and tuna, with lipid contents exceeding 10–15% of wet weight, are consequently at substantially elevated risk of oxidative rancidity in addition to microbial and enzymatic deterioration.

2.3 Extrinsic Properties of Fish that Predispose it to Spoilage

While the intrinsic properties of fish establish its baseline spoilage susceptibility, extrinsic factors particularly temperature, handling practices, and initial microbial contamination determine the rate at which spoilage processes unfold in practice.

2.3.1 Temperature

Temperature is the single most critical determinant of post-harvest fish spoilage rate. The growth rates of psychrotrophic spoilage bacteria, the activities of autolytic enzymes, and the rates of oxidative reactions all increase exponentially with temperature, broadly following Arrhenius kinetics. For every 10°C increase in temperature, enzymatic reaction rates approximately double, and microbial generation times are dramatically shortened (Agriculture Institute, 2025). Fish held at ambient tropical temperatures of 20–25°C common in sub-Saharan Africa and much of tropical Asia can become organoleptically unacceptable within 8–12 hours of harvest, whereas fish maintained near 0°C with adequate icing may retain acceptability for 12–16 days (Agriculture Institute, 2025). High ambient temperatures above 20°C create particularly favourable conditions for lipid oxidation and accelerated microbial activity in small-scale fisheries (Fleming *et. al.*, 2020). This temperature sensitivity underscores the critical importance of rapid cooling and maintenance of cold chain integrity from the point of capture to the point of consumption.

2.3.2 Handling Practices and Hygiene

The initial microbial load on harvested fish is strongly influenced by hygiene conditions throughout the post-harvest value chain. Contamination from fishing gear, vessel surfaces, handling containers, processing equipment, and water used for washing constitutes a major source of spoilage microorganisms beyond those naturally present on the fish surface and in the gut. Poor handling practices including delays between capture and icing, rough handling that causes physical tissue damage and facilitates enzymatic and microbial access to

internal muscle, and cross-contamination from spoiled to fresh fish substantially accelerate quality deterioration. A comprehensive microbiome characterisation study of fish processing facilities found that *Pseudomonas* and *Psychrobacter* were the most prevalent bacterial genera across multiple processing environments, with additional SSO genera including *Aeromonas*, *Photobacterium*, and *Shewanella* distributed across processing rooms, cold storage, and delivery areas (PMC, 2024). The distribution of antibiotic resistance genes within these microbial communities was also documented, raising concerns about the role of processing environments as reservoirs of resistant spoilage and pathogenic organisms.

2.3.3 Aquatic Environment and Species-Specific Variability

The composition of spoilage microbiota on freshly harvested fish reflects the microbial ecology of the aquatic environment from which the fish was taken. Fish from cold marine waters carry predominantly psychrotrophic gram-negative bacteria adapted to low-temperature environments, while fish from tropical marine, estuarine, or freshwater environments carry different microbial assemblages that may include higher proportions of mesophilic organisms such as *Vibrio*, *Aeromonas*, and *Enterobacteriaceae*. Climate, geography, and environmental pollution further modulate this initial microbial community (Wu *et. al.*, 2025).

Species-specific differences in fat content, TMAO concentration, muscle structure, and glycogen reserves also create substantial variability in spoilage susceptibility and dominant spoilage pathways. Freshness and spoilage patterns have been shown to vary significantly among tropical fish species including barramundi, cobia, coral trout, giant trevally, and milkfish, with species from warmer waters showing markedly different shelf-life characteristics under equivalent storage conditions compared to temperate species (PMC, 2025).

2.4 Conventional Preservation and Processing Techniques

Traditional preservation methods remain the foundation of the global fish processing industry, particularly in regions where access to advanced technology is limited. Their mechanisms are generally well-understood, and many of them operate through synergistic "hurdle" principles.

2.4.1 Chilling and Refrigeration

Refrigeration at temperatures approaching 0°C, typically using flake ice or ice slurry, is the most universally employed post-harvest preservation strategy. Cold temperatures retard microbial growth, slow enzymatic reactions, and reduce

the rate of lipid oxidation. Super chilling; the storage of fish at temperatures between -1 and -4°C , just below the initial freezing point extends the benefits of chilling without the quality degradation associated with full freezing. Tavares *et. al.* (2021) demonstrated that super chilled storage significantly retards microbial proliferation and autolytic activity, and emerging evidence from Zhang *et. al.* (2025) confirms that super chilling at -1 to -4°C further retards biochemical reactions and microbial growth relative to standard refrigeration at 4°C . Nevertheless, refrigeration alone offers a shelf life of only five to seven days for most species and requires continuous cold-chain maintenance, which remains a significant logistical and economic challenge in low-income settings.

2.4.2 Freezing

Freezing below -18°C effectively arrests microbial growth and dramatically slows enzymatic and chemical deterioration, yielding a commercial shelf life of nine to twelve months or longer. However, freezing is not without quality costs: ice crystal formation causes physical rupture of muscle cell membranes, leading to protein denaturation, drip loss on thawing, and textural degradation. The rate of freezing critically determines crystal size; rapid freezing (blast freezing, cryogenic freezing with liquid nitrogen) produces smaller intracellular crystals and superior texture retention compared to slow freezing (Ali *et. al.*, 2022). The application of cryoprotectants such as sorbitol and sucrose are standard practice in the production of surimi to mitigate freeze-induced myofibrillar protein aggregation.

2.4.3 Salting

Salting is among the oldest known methods of fish preservation, practised for millennia across diverse food cultures. Salt acts by reducing water activity (a_w) through osmotic extraction of free water from the muscle tissue, thereby inhibiting the growth of the water-demanding spoilage bacteria and, at sufficient concentrations, halting all microbial activity. Two principal salting modalities are employed commercially: dry salting, in which fish are packed between layers of solid salt, and wet salting (brining), in which fish are immersed in a saturated or near-saturated salt solution (Kontominas *et. al.*, 2021). Cod, herring, and mackerel are the species most extensively processed by salting. The degree of preservation achieved is directly proportional to salt concentration and the duration of treatment. At water activity values below 0.75, virtually no microbial growth is possible, though halotolerant yeasts and moulds may persist at slightly higher a_w values. A recognised limitation of heavy salting is the substantial alteration of the sensory profile, excessive saltiness, firmness, and

reduced palatability that may make the product unacceptable to consumers accustomed to fresh-tasting fish.

2.4.4 Drying

Solar or hot-air drying reduces moisture content and water activity to levels incompatible with microbial growth or enzymatic activity. Dried fish products have been central to the food security of coastal and artisanal fishing communities in South and Southeast Asia, West Africa, and Latin America for centuries. Traditionally, fish are sun-dried on raised racks or on the ground; modern industrial processes employ controlled mechanical drying tunnels with precise regulation of temperature, humidity, and air velocity. At a water activity of approximately 0.60 or below, dried fish products exhibit shelf lives of several months without refrigeration. However, drying alone can produce hard, leathery textures and oxidative rancidity in fatty species; it is therefore most commonly combined with salting and/or smoking (Ali *et. al.*, 2022). Smoke drying; the primary method used in many artisanal fisheries in West Africa, including Nigeria integrates the preservative effects of desiccation, heat, and antimicrobial smoke constituents into a single operation.

2.4.5 Smoking

Smoking preserves fish through the simultaneous action of four interacting mechanisms: partial thermal denaturation of surface proteins and inactivation of microorganisms; surface drying, which reduces water activity; deposition of phenolic compounds (primarily guaiacol and syringol), aldehydes, organic acids, and creosote-derived antimicrobials from wood smoke; and, in hot smoking, deep heat penetration that cooks the fish (Agriculture Institute, 2025).

A distinction is drawn between cold smoking (conducted below 29–30°C), which focuses on flavour development and surface preservation without cooking, and hot smoking (60–80°C and above), which simultaneously cooks and preserves the fish. Prior brining is standard practice in commercial smoking to enhance flavour, promote protein solubilisation, and facilitate the formation of the surface pellicle; a partially dehydrated protein layer that improves smoke adhesion. Smoked fish products have gained considerable consumer acceptance in European, North American, and African markets.

A significant concern associated with traditional wood-smoke processing is the formation of polycyclic aromatic hydrocarbons (PAHs), particularly benzo[a]pyrene, which are classified as probable human carcinogens. The EU has established a maximum limit of 2 µg/kg for benzo[a]pyrene and 12 µg/kg for

the sum of four regulated PAHs (PAH4) in smoked fish products (Regulation (EU) No. 835/2011). Modernisation of smoking kilns, adoption of smoke condensate (liquid smoke) applications, and optimisation of wood type and combustion conditions are active areas of research aimed at PAH mitigation without compromising the sensory characteristics valued by consumers.

2.4.6 Fermentation

Fermentation is one of the most transformative of all fish processing operations. Under controlled or spontaneous microbial fermentation, complex biochemical changes proteolysis, lipolysis, glycolysis, and the generation of organic acids produce products of intense flavour and extended shelf life. Examples of fermented fish products include surströmming (Sweden), prahok (Cambodia), fermented fish paste (ngapi in Myanmar; shrimp paste in Southeast Asia), and various traditional fermented fish sauces throughout East and Southeast Asia. The low pH generated by lactic acid bacteria (LAB) during fermentation inhibits the growth of pathogens and putrefactive organisms. Fermented fish products can be shelf-stable at ambient temperature for months to years, making fermentation of exceptional value in low-income settings where cold-chain infrastructure is unreliable (Kontominas *et. al.*, 2021).

2.5 Emerging Non-Thermal Preservation Technologies

Consumer demand for minimally processed, additive-free products with extended shelf life has driven intensive investigation of non-thermal processing technologies, which offer the dual advantage of inactivating spoilage organisms and pathogens while preserving the sensory and nutritional attributes of fresh fish (Speranza *et. al.*, 2021).

2.5.1 High-Pressure Processing (HPP)

High-pressure processing applies isostatic pressures typically in the range of 100–600 MPa for durations of seconds to minutes at ambient or near-ambient temperatures. The technology acts on microorganisms through several mechanisms: disruption of cell membrane integrity, inactivation of pressure-sensitive enzymes, denaturation of vital structural proteins, and interference with DNA replication (Kontominas *et. al.*, 2021; Roobab *et. al.*, 2022). HPP is particularly effective against vegetative bacteria, yeasts, and moulds; bacterial spores, however, are considerably more resistant and may require combined pressure-thermal treatments for full inactivation.

Research on the application of HPP to fish has yielded encouraging results. Roobab *et. al.* (2022) conducted a comprehensive review concluding that HPP

helps seafood manufacturers maintain a balance between safety, processing efficiency, quality, and regulatory compliance, and that high pressure preserves organoleptic and functional properties for extended periods during refrigerated storage. Empirical studies on salmon and plaice fillets demonstrated that HPP treatment maintained the microbiological profile within acceptable limits for up to twelve days of storage, compared to approximately five to seven days for untreated controls (Castrica *et. al.*, 2021). In sardines, HPP at 400–600 MPa significantly reduced ketone compound levels, an indicator of lipid-derived off-flavour development, and showed measurable potential for extending shelf life in the sardine market (Ismail *et. al.*, 2025). Species-specific responses to pressure, however, are an important consideration: a comparative study on salmon, cod, and mackerel demonstrated that HPP at 500 MPa restrained bacterial flora in cod and mackerel to below spoilage levels, while salmon at the same pressure showed a different oxidative response, highlighting the need for species-specific optimisation of treatment parameters (Rode and Hovda, 2016). A practical limitation of HPP is the capital cost of the high-pressure vessels, which can exceed USD 1 million, confining the technology at present largely to large-scale processors in high-income markets. The technique cannot be applied to gas-containing products without causing physical damage, and some texture modification particularly in delicate species, has been reported at higher pressures.

2.5.2 Pulsed Electric Field (PEF) Technology

PEF delivers short, high-intensity electric field pulses (typically 10–80 kV/cm) through liquid or semi-liquid food products, causing irreversible electroporation of microbial cell membranes and achieving microbial inactivation without significant thermal effects. For fish preservation, PEF has demonstrated efficacy in reducing surface microbial loads and extending shelf life. Speranza *et. al.* (2021) reviewed PEF along with other emerging technologies, noting that it contributes to shelf-life extension while minimally affecting organoleptic properties. One challenge specific to fish products is the high ionic strength of fish muscle, which reduces the efficiency of electric field transmission through the tissue and may require higher energy inputs to achieve equivalent microbial kill levels. Research into optimised electrode configurations and pulse parameters for heterogeneous solid fish matrices is ongoing.

2.5.3 Ultrasound

Ultrasonic processing at frequencies above 20 kHz induces acoustic cavitation, the generation, growth, and violent collapse of micro-bubbles within liquids,

producing intense local mechanical forces, microstreaming, and hydroxyl radical generation that disrupt microbial cell walls and inactivate enzymes. In fish processing, ultrasound has found application not only as a preservation technology but also as a processing aid: accelerating salt diffusion during brining, improving the efficiency of thawing, enhancing the extraction of bioactive compounds from processing by-products, and improving the texture and water-holding capacity of fish products (Speranza *et. al.*, 2021; Ali *et. al.*, 2022). Combined ultrasound-thermal treatments have demonstrated synergistic antimicrobial activity while reducing the temperature and time required for equivalent inactivation, thereby limiting thermal quality damage.

2.5.4 Non-Thermal Atmospheric Plasma (NTAP)

NTAP, sometimes referred to as cold plasma, is generated by electrical discharge through atmospheric gases (air, nitrogen, helium, argon), producing a reactive cocktail of ions, electrons, ultraviolet photons, and reactive oxygen and nitrogen species (RONS) that exert potent antimicrobial and antiparasitic effects on food surfaces. Speranza *et. al.* (2021) identified NTAP as among the most promising of the emerging non-thermal technologies, noting its effectiveness against both Gram-positive and Gram-negative bacteria as well as biofilm-forming organisms. Unlike UV radiation, NTAP can penetrate irregularly shaped surfaces and partially inactivate micro-organisms in surface water films. Research into NTAP applied to fish fillets and whole fish has reported significant reductions in total viable counts and specific spoilage organisms without significant sensory impairment, though the penetration depth of NTAP remains limited to surface and near-surface tissues, and scale-up for continuous industrial processing presents engineering challenges.

2.5.5 Irradiation

Ionising radiation gamma rays (from cobalt-60 or caesium-137 sources), electron beams, or X-rays acts on microbial DNA through direct ionisation and indirect radical-mediated mechanisms, disrupting replication and causing cell death. At doses employed for fish decontamination (typically 1–3 kGy for extension of refrigerated shelf life; up to 10 kGy for frozen product), irradiation achieves substantial reductions in microbial load and extends shelf life by several days to weeks, depending on the initial load and storage conditions (Kontominas *et. al.*, 2021). The technology has received regulatory approval in numerous countries, including the United States, France, and the Netherlands, for specific fishery products. Consumer acceptance, however, remains a constraint in many markets, where the association of irradiation with nuclear

technology generates disproportionate concern despite overwhelming evidence of safety. Irradiation does not render food radioactive.

2.6 Packaging Technologies in Fish Preservation

2.6.1 Modified Atmosphere Packaging (MAP)

MAP replaces the air atmosphere within packaging with a tailored gas mixture, most commonly comprising carbon dioxide (CO₂), nitrogen (N₂), and oxygen (O₂) in species- and product-specific proportions. CO₂ is the active component: it dissolves in tissue moisture to form carbonic acid, lowering local pH and exerting direct bacteriostatic activity particularly against aerobic Gram-negative organisms such as *Pseudomonas* spp. and *Shewanella putrefaciens*, which are the principal SSOs of most temperate-water fish species (Kontou *et. al.*, 2023). Elevated CO₂ concentrations have been shown to shift the spoilage microbiota from aerobic proteolytic species towards lactic acid bacteria, which produce less intense sensory deterioration (Zhuang *et. al.*, 2023). N₂ serves primarily as an inert filler, preventing pack collapse caused by CO₂ absorption into tissue, while O₂ inclusion is sometimes required for red-fleshed species to maintain myoglobin in the oxymyoglobin form and preserve red colouration.

MAP combined with low storage temperatures (0–2°C) has been reported to extend the shelf life of many fish species from the typical five to seven days under simple refrigeration to ten to fifteen days or longer. Vacuum packaging the simplest form of modified atmosphere preservation, reducing O₂ to near zero can extend shelf life to up to thirteen days under cold temperature conditions (Zhuang *et. al.*, 2023). A critical food safety concern associated with MAP is the potential for outgrowth of psychrotrophic pathogenic bacteria, most notably *Clostridium botulinum* types B and E and *Listeria monocytogenes*, in the anaerobic or low-oxygen environments created by the packaging conditions that may suppress sensory spoilage indicators, masking danger (Sivertsvik *et. al.*, 2002, cited in Zhuang *et. al.*, 2023). This concern underscores the need for rigorous temperature control throughout the MAP cold chain.

2.6.2 Edible Coatings and Natural Antimicrobials

A rapidly growing body of research has examined the application of edible biopolymer-based coatings derived from chitosan, sodium alginate, carrageenan, gelatin, pectin, and starch to fish surfaces as vehicles for delivering antimicrobial and antioxidant active compounds (Antonino *et. al.*, 2024; Zhang *et. al.*, 2025). Edible coatings serve multiple functions simultaneously: they form a physical barrier against oxygen and moisture loss; they carry and allow

controlled release of bioactive agents; and, unlike synthetic packaging, they can be consumed with the food product, reducing packaging waste (Antonino *et. al.*, 2024).

Essential oils (EOs) derived from thyme, oregano, rosemary, clove, and cinnamon have attracted particular interest as natural antimicrobial additives for incorporation into coating matrices, owing to their GRAS (Generally Recognised as Safe) status and well-documented antimicrobial and antioxidant activities. Melarcode *et. al.* (2025) reviewed the application of EOs incorporated into biopolymer-based antimicrobial coatings for fish and seafood, identifying oregano, clove, and thyme EO-enriched coatings in chitosan, gelatin, and carrageenan matrices as showing efficacy in extending shelf life of rainbow trout, mackerel, and shrimp. Zhang *et. al.* (2025) confirmed that EOs classified as GRAS have become natural alternatives to synthetic preservatives by virtue of their antimicrobial and antioxidant properties. However, the same review noted that commercial feasibility depends on managing the strong sensory impact of EOs at functional concentrations, their cost, and limited stability under processing and storage conditions — challenges that nanoencapsulation strategies are increasingly being employed to address.

Chitosan, derived from the deacetylation of crustacean shell chitin, has emerged as the most widely investigated coating polymer for fish preservation. Its positive surface charge confers intrinsic antimicrobial activity through electrostatic interaction with negatively charged bacterial cell membranes, and it possesses film-forming properties that provide effective oxygen and moisture barriers (Ali *et. al.*, 2022). The incorporation of sea buckthorn oil into chitosan coatings for refrigerated fish fillets demonstrated shelf-life extension with preservation of physicochemical and sensory properties in a 2026 Scientific Reports study (Ates *et. al.*, 2026). Recent work has also explored the incorporation of plant polyphenols, bacteriocins, and nano-sized antimicrobial particles into biopolymer matrices to produce multifunctional active packaging systems.

2.7 Hurdle Technology

No single preservation strategy is universally effective against the full range of spoilage and safety hazards associated with fish products, and many individual technologies entail trade-offs between antimicrobial efficacy and quality preservation. Hurdle technology, originally conceptualised by Leistner (2000) and subsequently refined within the fish processing literature, frames

preservation as the simultaneous or sequential application of multiple sub-lethal preservation "hurdles" each insufficient alone to achieve the desired preservation outcome but collectively effective through the principle of metabolic exhaustion of microorganisms (Kontominas *et. al.*, 2021; Ali *et. al.*, 2022).

Classic hurdle combinations in fish preservation include: salting combined with drying (reduced water activity + low moisture); smoking combined with refrigeration (antimicrobial smoke constituents + cold temperatures); and MAP combined with low-temperature storage (reduced oxygen atmosphere + cold). More contemporary hurdle strategies integrate non-thermal technologies with natural antimicrobials: for example, the combination of plasma-activated water (PAW) pretreatment with high-CO₂ MAP during superchilling storage of half-smooth tongue sole (*Cynoglossus semilaevis*) demonstrated a synergistic antibacterial effect and delayed protein oxidation beyond what either treatment achieved alone (Qiu *et. al.*, 2026). Similarly, the combination of UV-C radiation with MAP for refrigerated tilapia fillets achieved significant reductions in biogenic amine accumulation and extended microbiological shelf life (Lázaro *et. al.*, 2020). The hurdle concept also underpins the design of active packaging systems, in which packaging materials are engineered to release or absorb substances antimicrobials, antioxidants, CO₂, moisture at defined rates throughout the storage period, functioning as a dynamic, continuously active preservation hurdle.

2.8 By-product Valorisation and Sustainability Considerations

Fish processing generates substantial quantities of by-products: heads, frames, skin, viscera, and trimmings that may comprise 30–50% of total raw material weight in commercial filleting operations. Traditional disposal of these streams as fishmeal or low-value fertiliser represents a significant economic and environmental inefficiency. A growing body of research, motivated both by circular economy principles and the high nutritional and functional value of fish-derived biomolecules, is exploring the extraction and valorisation of collagen, gelatin, fish oils, hydrolysates, chitin, and bioactive peptides from processing residues (Ali *et. al.*, 2022; Majumdar 2019). Many of these compounds; fish-derived gelatin, for example are themselves candidates for application as edible coating materials in fish preservation, creating closed-loop valorisation pathways within the fish processing industry.

2.9 Post-Harvest Losses and Food Security Implications

The convergence of the spoilage mechanisms described above with inadequate post-harvest infrastructure produces profound economic and food security consequences, particularly in the developing world. Post-harvest fish losses in developing nations are estimated to affect approximately 35% of the total harvest, with economic losses of particular severity in regions lacking reliable electricity, cold chain infrastructure, and access to appropriate preservation technologies (Siddiqui *et. al.*, 2024).

In sub-Saharan Africa, small-scale fisheries provide over 60% of the domestic fish supply and constitute a critical source of income, protein, and micronutrients for millions of households (Fleming *et. al.*, 2020). The small-scale fisheries of coastal Tanzania illustrate the typical challenges: high ambient temperatures, limited ice access, prolonged duration between capture and market, and dependence on traditional and often inappropriate handling vessels all compound to maximise post-harvest losses (Marine Policy, 2020). The economic consequences of these losses are borne disproportionately by the most vulnerable actors in the value chain, small-scale fishers and fish traders, frequently women, who lack the capital and infrastructure to implement effective preservation.

Addressing post-harvest fish losses requires not only technical solutions but also structural interventions including improved cold chain infrastructure, affordable icing and chilling technologies, training in hygienic handling, and the development of appropriate local preservation methods such as smoking, drying, and fermentation that are suited to the social and economic context of small-scale tropical fisheries.

3. RESEARCH AND CONTRIBUTION TO KNOWLEDGE

Mr. Vice-Chancellor sir, my first, second and third degrees were in these areas of research:

B. Agric. Tech. Fisheries and Wildlife (2000)

Research Topic: Harnessing of Shrimp head waste in Nigeria for low cost production of Tilapia, *Oreochromis niloticus* (L.).

M. Agric. Tech. Fisheries (2005)

Research Topic: Physical and Chemical Changes in Some Commercially Smoked Fish Species during Storage.

Ph.D., Fish Processing and Utilisation (2012)

Research Topic: Construction of a Model Fish Smoking Kiln using Agro-wastes as

Fuel and Quality Assessment of Smoked fish on Storage.

Furthermore, I have co-authored two books in Fisheries Technology; these are:

1. Sodamola, M.Y., Adeyemi, J.W. and **Daramola, J.A.** (2015). Fish Preservation and Processing. In: Approach to Aquaculture in West Africa.
2. Sodamola, M.Y. and **Daramola, J.A.** (2022). Fish: Processing Methods and Quality Assessments. In: Fish Aquaculture: Disease and Processing.

Sir, at the onset of my academic journey in Bells University of Technology from 2005, there was a big challenge of dearth of students to work with for research and by inference publication of papers. I was employed as a Lecturer of Fisheries and Aquaculture (and Marine Biology) in the Department of Biological Sciences, College of Natural and Applied Sciences (COLNAS); but there was no single student enrolment into the Fisheries programme! The only student that came after many years was advised to transfer to another institution as the University could not bear the cost of accreditation of the Fisheries and Aquaculture programme with a single student.

However, as the saying goes in academic parlance “**Publish or Perish**” but for me, I charged myself that: “**I will Publish to Prosper!**” Therefore, I had to collaborate across disciplines; mainly microbiology, biochemistry, food science, nutrition and engineering to survive. I must greatly appreciate collaborators, past and present staff of the University, particularly in the Department of Biological Sciences, who welcomed with open hands and accommodated me for collaborative research. Hence, it should not be surprising to note that the bulk of my publications are in the area of fish microbiology, health and food safety. At the acknowledgement section of this Inaugural Lecture, you shall be duly appreciated.

Sir, for clarity and simplicity of this Inaugural Lecture, my research contributions will be partitioned into works that have been done in the underlisted areas:

- A. Fish and Human Nutrition
- B. Aquaculture and Inland Fish Production
- C. Biochemical and Sensory Analyses of Fish
- D. Technology in Fishery
- E. Fish Microbiology
- F. Public Health and Fish

A. FISH AND HUMAN NUTRITION

A (i). Distinguished audience, my first research work, authored by Nwanna

and Daramola (2000) was titled **Harnessing of Shrimp Head Waste in Nigeria for Low Cost Production of Tilapia, *Oreochromis niloticus* (L).**

This paper highlighted waste to wealth: Shrimp head waste as a sustainable source of low-cost protein substitute in tilapia feed, a creative and circular solution to this problem.

Background: There is a very high cost and environmental footprint of fish feed, which accounts for over 60% of aquaculture production costs in Nigeria (Fagbenro, 1999). Meanwhile, if we cannot produce farmed fish affordably and sustainably, it will be difficult to meet the growing demand for animal protein. Shrimp head waste meal (SHWM) — a discarded by-product of the shrimp processing industry was used as a replacement for expensive fish meal in diets for Nile tilapia (*Oreochromis niloticus*). In Nigeria, an estimated 16,999 metric tonnes of shrimp head waste are generated annually from *Penaeus notialis* processing, yet most of this is discarded, causing environmental pollution (Balogun and Akegbejo-Samsons, 1992).

Therefore, Nwanna and Daramola (2000) formulated five isonitrogenous diets (30% crude protein) with SHWM replacing fish meal at 0%, 15%, 30%, 45%, and 60% inclusion levels. Over a 56-day feeding trial in a recirculating system, growth parameters (weight gain, specific growth rate SGR, food gain ratio FGR, protein efficiency ratio PER), nutrient digestibility (apparent digestibility coefficient ADC) and economic performance (profit index, incidence of costs) were measured. The results were remarkably positive. Apparent digestibility coefficients (ADC) were high across all diets, ranging from 88.1% to 97.9%, indicating that tilapia readily accepted and efficiently utilised the shrimp-head-based diets. Although fish fed the 0% SHWM (100% fish meal) as the control diet had slightly higher weight gain, there was no significant difference ($p > 0.05$) in FGR, SGR, or PER between the control and any of the SHWM diets — meaning the shrimp-head meal performed equivalently to fish meal in terms of feed conversion and protein utilisation. Most striking were the economic results: as SHWM inclusion increased, the cost of producing one kilogram of diet (incidence of cost) decreased progressively from US\$3.60 (0% SHWM) to US\$2.54 (60% SHWM). Projected production cost analysis showed that incorporating 60% SHWM reduced feed costs by US\$420 per tonne — a substantial saving for commercial fish farmers. The profit index remained similar across all diets, indicating that profitability was maintained while production costs dropped.

The paper concluded that shrimp head waste meal can replace up to 60% of fish meal in tilapia diets without compromising growth or nutrient utilisation, while simultaneously solving a major waste disposal problem and reducing feed costs. This novel research was followed up by Maribel et. al (2002), who worked on the feasibility of fishmeal replacement by shrimp head silage protein hydrolysate in Nile tilapia (*Oreochromis niloticus* L) diets. Similarly, Nwanna (2003) carried out research on the nutritional value and digestibility of fermented shrimp head waste meal by African catfish *Clarias gariepinus*.

Table 3: Nutrient utilisation *O. niloticus* fed graded diets of SHWM for 56 days.

Parameters	Diets/Treatments				
	1	2	3	4	5
Initial mean weight (g)	1.41	1.40	1.40	1.41	1.39
Final mean weight (g)	3.60	3.51	3.47	3.38	3.33
Mean weight gain (g)	2.19	2.11	2.07	1.97	1.94
Weight gain (%)	60.83	60.11	59.65	58.28	58.26
Total feed fed (g)	120.74	114.36	111.37	101.65	97.78
Feed gain ratio (FGR)	2.76±.07a	2.71±.06a	2.69±.05a	2.58±.05a	2.52±.06a
Specific growth rate (SGR)	1.67±.05a	1.64±.05a	1.62±.04a	1.56±.05a	1.56±.04a
Protein efficiency ratio (PER)	1.46±.07a	1.39±.07a	1.30±.06a	1.31±.07a	1.28±.07a

Means within the same row followed by the same letter are not significantly different (P>0.05)

A (ii). Gbadamosi, K. and **Daramola, J. (2007). Quantitative Requirements of Dietary Ascorbic acid Supplementation in the Diets of African Catfish *Clarias gariepinus* (Burchell 1822) fingerlings.**

Abstract: This study was undertaken to evaluate the quantitative requirement of dietary ascorbic acid supplementation in the diet of African catfish, *Clarias gariepinus*, using growth performance and nutrient utilization. *C. gariepinus* fingerlings weighing 6.02±0.4 g were randomly distributed into glass tanks of 60×45×45 cm³ dimension at 10 fish per tank in a triplicate treatment. Five isonitrogenous and isocaloric diets containing 40% crude protein were formulated. Ascorbic acid (AA) was supplemented in the diets as ascorbyl-2-polyphosphate. Each treatment had varying levels of ascorbic acid (AA) supplementation, 0 (control), 50, 100, 150 and 200 mg AA/kg in treatments I, II, III, IV and IV, respectively. Fish were fed practical diets twice daily at 09.00 and 16.00 h. Weekly weighing of fish was done, and the data collected were subjected to statistical analysis. Biological evaluation of the fish was based on growth performance and nutrient utilization efficiencies. At the end of week 4, the fish fed scorbutic diets (diets without AA supplementation) had significantly lower weight than fish fed AA-supplemented diets (p<0.05). The results showed that the productivity indices, mean body weight gain (BWG), specific growth

rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and feed efficiency ratio (FER) in all the treatments were significantly different from each other ($p < 0.05$). The best feed conversion ratio (FCR) was recorded in treatment IV (0.94 ± 0.08), and the worst FCR was obtained in treatment I (Control) fed scorbutic diet (1.77 ± 1.20). Considering all the parameters, treatment IV fed 150 mg AA/kg gave the best growth performance and nutrient utilization efficiencies, whereas treatment III fed 100 mg AA/kg showed the minimum dietary AA supplementation that prevented growth reduction in this study.

A (iii). Gbadamosi, O.K., **Daramola, J.A.** and Osungbemi, N.R. (2007). **Growth Performance and nutritional utilization efficiency of vitamin C in the diets of African catfish *Clarias gariepinus* (Burchell 1822) fingerlings.**

Abstract: This article investigated the Clinical changes observed in *Clarias gariepinus* (Burchell 1822) fed varying levels of ascorbic acid (AA) supplementation. Five isonitrogenous and isocaloric diets containing 40% crude protein were formulated. Ascorbic acid or vitamin C was supplemented in the diets as ascorbyl-2 polyphosphate (a mixture of phosphate esters of ascorbate) at different ratios and treatments. This is a great contribution to knowledge as many fish species lack the innate ability to synthesize ascorbic acid, which is essential for fish growth, reproduction and health; hence, must be supplied through feed. At the end of the research, the importance of AA in fish diets and the best ratio of AA supplementation that prevented growth reduction and clinical signs of AA deficiency was established.

A (iv). Adeparusi, E. O., **Daramola, J. A.** and Aina, E.A. (2009). **Histology of the Stomach and Intestine of African Mud Catfish (*Clarias gariepinus*) Fed Toasted African Yam Bean (*Sphenostylis stenocarpa*) Diets.**

Abstract: The African yam bean (AYB), *Sphenostylis stenocarpa* was evaluated as dietary protein source in the production of *Clarias gariepinus*. The effect of toasted AYB meal as a substitute for the widely used fish meal on the histology of the catfish was assessed. Toasting of the beans was done for 10, 15, and 20 minutes at 204°C . The toasted AYB meals were then used to replace fish meal in 40% crude protein formulated diets. Proximate analyses of the diets were carried out. Triplicate groups of 25 *Clarias gariepinus* fingerlings ($0.40 \pm 0.05\text{g}$) per treatment were fed one of the diets in 45-litre glass tanks for 8 weeks. Batch weighing was done weekly while water quality parameters were monitored. There was no significant ($P > 0.05$) difference in the weight of fish on T15 AYB diets and that of fish meal diet. Histological examination of the stomach and intestine revealed that fish fed with fish meal and T15 diets have normal

layer and arrangement. In fish fed diets T10 and T20, the mucous layer was highly stunted and fragmented. There was gross disintegration of the sub-mucosa and the muscularis was greatly eroded, although the serosa was intact.

A (v). Olutayo, K. O., **Daramola, J. A.** and Odukoya, O. F. (2023). **Organoleptic and Nutritional Value of Fish Roll made from Titus (*Scomber scombrus*) and Shawa (*Clupea harengus*)**

Background: Nigeria's dependence on the over-exploited *Scomber scombrus* for essential nutrients poses food security and sustainability challenges, emphasizing the need to promote abundant and nutritionally rich less expensive species like *Clupea harengus* to support SDG 2, SDG 3, and SDG 14 while diversifying the food system.

Abstract: This study compared the nutritional value and sensory properties of fish rolls made with two different species of fish, Titus (*Scomber scombrus*) and Shawa (*Clupea*) in Nigeria. The nutritional and sensory values determined using standard procedure. Descriptive statistics (mean and standard deviation) and one-way ANOVA were used to analyse the data. Fish rolls made with Shawa fish demonstrated significantly higher proximate, mineral, and vitamin content, whereas Titus fish roll was significantly preferred in sensory evaluation and exhibited a superior amino acid and fatty acid profiles. Titus (*Scomber scombrus*) and Shawa (*Clupea harengus*) fish rolls were both well-accepted in taste, making them interchangeable for consumers. However, Shawa fish rolls are richer in minerals and Vitamin B12, and D, while Titus fish rolls provide more Vitamin A and beneficial fatty acids like Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA). Additionally, Shawa fish roll has lower fat levels and contain essential Alpha-Linolenic Acid (ALA), making them a potentially healthier option. These fish rolls, more especially Shawa fish rolls are recommended for all age categories especially for infants, young children and adolescents. This is because it contains a desirable amount of poly unsaturated fatty acid for cognitive and behavioural development.

A (vi). Olutayo, K. O., **Daramola, J. A.** and Obidire, E. T. (2023). **Sensory Evaluation and Nutritional Value of Wheat Flour Enriched with Fish Flour in Bread Making**

Abstract: Bread is a staple food with low necessary nutrients and its enrichment with other supplements in bakery may cause sensory alteration and consumer rejection. This study assessed the sensory attribute and nutritional significance of the enriched bread made from wheat and fish flours. Enriched bread was produced from an Atlantic mackerel fish (*Scomber*

scombrus) and wheat flours for sensory, proximate, minerals, amino and fatty acid analysis using standard procedures for comparison with a plain wheat bread. Data was analysed with a Statistical Package for Social Sciences (SPSS version 16). There was no significant difference ($p < 0.05$) statistically in the sensory evaluation of the enriched and normal wheat breads. But, the enriched bread was significantly higher in proximate (crude protein: 13.32%, crude fat: 18.2%, total ash: 2.17%); minerals (calcium: 91.69mg/100g, magnesium: 71.29mg/100g, potassium: 57.16mg/100g, iron: 2.42mg/100g, iodine: 28.57 mg/100g); vitamins (vitamin A: 77.11mg/100g, B5: 5.14mg/100g, B12: 1.56mg/100g, E: 2.95mg/100g), amino acids (cysteine: 1.55mg/100g, methionine: 1.38mg/100g, lysine: 1.73mg/100g, alanine: 3.47mg/100g) and fatty acids (myristic acid: 26.87mg/100g, hexadecanoic acid: 430.65mg/100g, trans-palmitoleic acid: 56.23mg/100g) contents. While the enriched bread had higher nutritive values; both the enriched and normal bread were acceptable in sensory appraisal. A modest consumption of the bread is recommended for humans. Further studies are needed to evaluate its water activity, pH, microbial activity, and rancidity indicators.

A (vii). Anaemene, D. I., Daramola J. A. and Adejare O. A. (2023). Physico-Chemical and Sensory Evaluation of Maize-Pigeon Pea Based Complementary Foods Fortified with Milk and Fish powder.

Abstract: Undernutrition among young children during the complementary feeding is high. Quality cereal legume based complementary food fortified with fish or milk would contribute towards reduction of undernutrition in young children. There is need for information on the animal source food that confers the best nutritional value on cereal-legume based complementary foods. This study assessed the physico chemical and sensory characteristics of maize-pigeon pea based complementary foods fortified with either milk or fish. Two complementary foods fortified with milk (COMPIM) and fish (COMPIF), were formulated from germinated maize, fermented pigeon pea, carrot and date powder using NutriSurvey application. The formulated diets were evaluated for nutrients, anti-nutrients, functional and sensory properties using standard methods and compared with commercial complementary food (CCF) and maize gruel (HCF).

The study concluded that while the maize-pigeon pea complementary food fortified with fish was superior to the milk-fortified version in terms of beta-carotene, essential amino acids (lysine and methionine), functional properties, and lower anti-nutrient content, it was the least accepted by panelists.

Anaemene *et. al.* (2023) therefore recommended that further studies be carried out to improve the sensory properties of home-based complementary foods prepared with fish and pigeon pea, as quality complementary food can be produced from locally available ingredients—maize, pigeon pea, carrots, and dates—with either fish or milk.

A (viii). Anaemene, D.I., Oni, R.A., Akinwumi, **K. A. and Daramola, J. A.** (2023). **Linear Growth and Blood Characteristics of Wistar Rats Fed Either Milk or Fish Based Complementary Foods.**

Background: Information on the effect of different animal protein sources on linear growth is needed to inform specific complementary food recommendations.

Objective: This study evaluated the effect of milk (COMPIM1) and fish (COMPIM2) based complementary foods on linear growth and blood characteristics using Wistar rats.

Method: The study adopted completely randomised design involving feeding of COMPIM1, COMPIM2, COMPIM3 (control) and basal diets to weanling rats (8 per group) for 28 days. Length (cm) and weight (grams) measurements were taken once and twice weekly, respectively. Blood samples were subjected to haematological and biochemical analysis.

Conclusion: The study concluded that while the maize-pigeon pea complementary food fortified with fish was superior to the milk-fortified version in terms of beta-carotene, essential amino acids (lysine and methionine), functional properties, and lower anti-nutrient content, it was the least accepted by panelists. It was therefore recommended that further studies be carried out to improve the sensory properties of home-based complementary foods prepared with fish and pigeon pea, as quality complementary food can be produced from locally available ingredients—maize, pigeon pea, carrots, and dates—with either fish or milk, contributing to the reduction of undernutrition in young children across Nigeria.

B. AQUACULTURE AND INLAND FISH PRODUCTION

B (i). Technical Report: **Daramola, J. A.** (2000). **Cage Culture in Nigeria, Prospects and Problems.** Seminar Paper presented to the Fisheries and Wildlife Department, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure.

Background: Cage culture is a method of rearing organisms in a confined structure within a large pool of water or water bodies (Beveridge, 1996). Cage of

different shapes and sizes, depending on the purpose, fund available and species to be cultured. Their horizontal area varies within the range of 1 to 100m², according to the type of culture considered. Cages have average life span between 3-5 years. Cage culture is super-intensive. The cultured organisms depend wholly on fed food. Large and high valued fishes like salmon, groupers and car are culturable in cages. In Scotland, annual turnover of salmon reduced cage aquaculture is about 4 million pounds (Beveridge 1987). Cage culture can be practiced in fresh or marine water. However, due to the salt content of marine water, materials to be used must not be corrosible. According to Stewart and Beveridge 1997, cage aquaculture throughout Asia is increasing. In Nigeria, the available waters are mostly freshwater. Hence, freshwater species of commercial value like *Clarias* and *Tilapia* are culturable in cages.

Conclusion: The potential of cage culture augmenting fish production is great. However, its acceptance in Nigeria still falls below a reasonable level. Hence, there is much to be done in the extension and awareness aspect.

B. (ii). Daramola, J. A., Osofero S. A., Kester, C.T., and Gbadamosi, O.K. (2007). Overview of the Status of Aquaculture in Nigeria with Reference to Ekiti State.

Background: Fish supplies over 50% of the total animal protein consumed in developing countries including Nigeria, yet the annual fish demand in Nigeria is approximately 1.5 million tonnes while local production does not exceed 0.6 million tonnes, creating a deficit of 0.9 million tonnes that has made Nigeria the largest importer of frozen fish in Africa, with annual fish import bills exceeding N27 billion in the year 2000 alone (FOS, 1987; FAO, 1998; Daramola *et. al.*, 2007). This paper reviewed aquaculture in Ekiti State, a landlocked state in South-West Nigeria created in 1996, over an 8-year period (1996–2003). The study revealed that Ekiti State, with a population estimated at 1.75 million upon creation and a fish demand of approximately 26,325 metric tonnes per annum, had total annual fish production of only 249.17 metric tonnes (comprising 170.50 metric tonnes from artisanal fisheries and 78.67 metric tonnes from aquaculture), resulting in a staggering annual shortfall of 26,075.83 metric tonnes (EKDFS, 2001; Daramola *et. al.*, 2007). The state possesses 7 state-owned dams and reservoirs with a total surface area of 767 hectares, supporting 400 fishermen and producing an annual yield of 115,877.50 kg. Between 1996 and 2003, there was a progressive increase in aquaculture activities as evidenced by the growth in number of earthen ponds, with yearly increases of 6.20%, 18.58%, 23.89%, 48.67%, and 67.25% in the last three years (2000–2003) of the review period

(Daramola *et. al.*, 2007). Despite these increases, the state of aquaculture development in Ekiti State has not kept pace with the growing human population and fish demand, a situation reflective of broader challenges facing Nigerian aquaculture.

The study identified numerous problems militating against fish culture in Nigeria, including: untimely funding of fisheries projects and research; lack of reliable data for effective planning; scarcity and high cost of fishing inputs; ineffective extension officer services; misplaced priority with more emphasis on industrial and artisanal fisheries to the detriment of aquaculture; low level of budgetary allocation to agriculture and the fisheries sub-sector; lack of modern biotechnology, processing and storage techniques and equipment; lack of skilled fisheries personnel and trained experts; invalidity of fish seeds due to ineffective hatcheries; lack of fish feed industries; lack of finance and access to credits and loans for prospective fish farmers; lack of patronage and promotion of fish farmers; non-involvement of local governments in fisheries policy-making; problems of land ownership, communal crisis, waterweeds, pollution, pilfering, and management challenges (Daramola *et. al.*, 2007).

Furthermore, the paper noted with appropriate promotional strategies and if approximately 25% of the available 483,406 hectares of water suitable for fish farming were placed under cultivation, Nigeria has the capability to produce about 656,915 metric tonnes of fish annually from aquaculture, which would substantially bridge the supply-demand gap (Ita *et. al.*, 1985; Daramola *et. al.*, 2007).

To achieve self-sufficiency in fish production on a sustainable basis, Daramola *et. al.* (2007) recommended that production from the aquaculture sector must be re-engineered through strategies including: establishment of fish farms and estates by all tiers of government; support and strengthening of fisheries-related associations; adoption and innovation of biotechnological advances for rapid increase in fish production; promotion of fish feed industries and better utilisation of agro-industrial by-products through integrated fish farming systems; establishment of fish seed centres for fingerlings and broodstocks nationwide; promotion of private sector participation in aquaculture; encouraging, financing, and facilitating aquaculture research; promoting local exports rather than imports; creating avenues for credits and loans for fish farming; securing equitable percentage of annual budget *al* location to reflect the sub-sectoral importance of aquaculture; consolidating and improving

training programmes for capacity building and skilled manpower development; establishing up-to-date fisheries information network systems (data banks); and reducing or abolishing import duties on fishing inputs through subsidies or duty-free access.

The study concluded that while aquaculture in Nigeria can be described as fairly well developed, much remains to be done, and with better planning, incentives, and commitment, Nigeria can drastically reduce or eliminate fish importation and ensure that aquaculture takes its rightful place in the forefront of fish production to achieve national food security in the nearest future.



Figure 1: The Map of Ekiti State, Nigeria.

B (iii). Kester, C.T., Osofero, S.A., Daramola, J.A. (2007). **Assessment of the fisheries potential of Ero reservoir, Ekiti State, Nigeria.**

Abstract: This survey studied the catch composition of the reservoir, the Socio – economic impact of the fishing activities on the locality. The catch composition

of the reservoir showed three different species, *Oreochromis niloticus*, *Sarotherodon galilaeus*, and *Clarias* species with *O. niloticus* having the highest occurrence by number and weight of 83.6% and 69.2% respectively. The potential fish yield of the reservoir with a total surface area of 450ha was predicted to be 652.97 metric tones per annum, while the post calculated annual yield give a figure of 21.06 metric tones per annum. The assessment of socio – economic impact of the fishing activities of the reservoir on the fishing locality and the state at large revealed a number of operational constraints that contributed to the under – exploitation of the reservoir and fishing profession as unprofitable in the community. These constraints in conjunction with the seasonality of the catch of the more valuable *Clarias* spp. constituted to the factors responsible for the mass – drift of 55% of the fishermen population to other fishing villages in or outside the state and urban centres for more lucrative business. Suggestions were made towards the adoption of certain strategies of improving the income generated by the fishermen at every fishing effort to a sustainable level.

B (iv). Osofero, S.A, Otubusin S.O. and **Daramola J. A.** (2009). **Effect of stocking density on Tilapia (*Oreochromis niloticus*, Linnaeus 1757) growth and survival in bamboo-net cages trial.**

Abstract: The study was carried out to evaluate the effect of varying stocking densities on the growth, survival, and yield of tilapia (*Oreochromis niloticus* Linnaeus 1757) at the freshwater reservoir (average depth, 1.7 m) of the University of Agriculture Abeokuta, Nigeria, for a period of 3 months. Tilapia juvenile with a mean weight of 29 ± 4.81 g were randomly (Complete Randomized Design) stocked at 50, 100, 150 and 200 specimen per cage (1 m³) were fed with commercial feed (34.55% Crude Protein). 20% of stocked fish was sampled for growth every two weeks. Profit index of the fish harvested under each treatment was evaluated. Relevant physico-chemical parameters like pH, conductivity, temperature, water depth and dissolved oxygen were also monitored forth nightly. The experimental fish and fish carcass (before the experiment and at harvest) from each treatment were analysed in replicates for their proximate composition. There were no significant differences ($P > 0.05$) in daily weight gain, specific growth rate, final weight, relative growth rate, feed conversion ratio (FCR), survival, protein efficiency ratio for all the treatments. However, there were significant differences ($P < 0.05$) in fish production (harvest), profit index, crude protein, crude fat, and ash composition of the fish

carcass (at harvest). As stocking density increased, the crude protein content of the fish carcass decreased indicating an inverse relationship. The stocking density of 150 juvenile/cage with a final weight of 82.74 g per fish, feed conversion ratio of 2.15, survival of 99.35% and fish production of 24.79 kg/cage was considered best on the basis of the profit index of 2.01 compared with the range of 1.45 to 1.82 for the other three treatments.

B (v). Osofero, S. A., Otubusin S. O., **Daramola J. A., Obasa, S. O.** and Idowu, O. M. O. (2014). **Performance of Nile Tilapia *Oreochromis niloticus* (Linnaeus 1758) under two Polyculture Systems in Bamboo Cages in a Freshwater Reservoir.**

Abstract: Excessive breeding of Tilapia leading to stunted growth and harvest have been a major problem for its commercial culture in Nigeria. The objective of this study was to determine the performance of Nile Tilapia *Oreochromis niloticus* (Linnaeus 1758) in polyculture with prawn *Macrobrachium vollenhovenii* (Herklot 1857) and African Mud Catfish *Clarias gariepinus* (Burchell 1822) in cage system in the University of Agriculture, Abeokuta freshwater reservoir. The study investigated the effect of stocking ratio and species combination in cage production of Tilapia for a two-year period (2007 - 2008). The result from the experiment shows that tilapia in polyculture with catfish and prawn attained a significantly different ($P < 0.05$) final weight compared to tilapia in monoculture, a combination ratio of 1:2 (Tilapia: Prawn) and 6:1 (Tilapia: Catfish) was recommended at the end of this experiment.

C. BIOCHEMICAL AND SENSORY ANALYSES OF FISH

C (i) Adeparusi, E.O., **Daramola, J.A.** and Badejo, S.O. (2006). **Effect of Cold and Hot Smoking of *Clarias gariepinus* on Consumer Preference.**

The paper investigated the effects of cold smoking (temperature below 30 °C) and hot smoking (temperature above 100 °C) on African catfish (*Clarias gariepinus*) using two different drying methods: oven drying and traditional drum smoking kiln. Four smoked products: Hard Oven Dried (HOD), Soft Oven Dried (SOD), Hard Smoke Dried (HSD), and Soft Smoke Dried (SSD) were produced. These were subjected to proximate chemical analysis, mineral content analysis (including calcium, potassium, sodium, zinc, lead, iron, and phosphorus), and sensory evaluation by consumer panels for colour, odour, taste, texture, and overall acceptability.

The results of the proximate analysis showed no significant difference ($p > 0.05$) in protein, ash, and moisture content across all smoking methods, with protein

ranging from 66.00% to 67.52%, ash from 12.86% to 14.16%, and moisture from 7.82% to 8.24%. However, significant differences ($p < 0.05$) were observed in fat content, with Hard Smoke Dried (HSD) having the highest fat content (12.28%) and Soft Oven Dried (SOD) the lowest (9.83%).

Calcium, potassium, sodium, zinc, iron, and phosphorus all showed significant variation across treatments, with HSD recording the highest iron content (22.91 mg/100g) and SSD the highest phosphorus (452.60 mg/100g). Sodium and potassium levels were relatively high across all samples, which is expected given that salting often precedes smoking. Regarding consumer preference, sensory evaluation revealed no significant differences ($p > 0.05$) in colour and taste ratings across the four smoking methods. However, significant differences ($p < 0.05$) were observed in odour, texture, and overall acceptability. The highest overall acceptability ratings were for Hard Smoke Dried (HSD) and Hard Oven Dried (HOD), indicating that consumers preferred harder, more thoroughly dried products over softer ones, regardless of whether the heat source was smoke or an oven.

C (ii) Daramola, J.A., Fasakin, E.A. and Adeparusi, E.O. (2007). Changes in physicochemical and sensory characteristics of smoke-dried fish species stored at ambient temperature.

Background: Fish is a highly perishable commodity, and in tropical regions like Nigeria, the absence of robust cold-chain infrastructure necessitates affordable and effective preservation methods. The Nigerian fisheries sector remains significantly constrained by substantial post-harvest losses, often exceeding 40% annually (Ibrahim et. al. 2024 and Onyeka, 2025).

Abstract: This study assessed the comparative changes in the physical and chemical components of five different species of smoked freshwater fish: Bony tongue, *Heterotis niloticus*, African carp, *Labeo coubie*, Snake fish, *Parachanna obscura*, Nile Tilapia, *Oreochromis niloticus* and African mud catfish, *Clarias gariepinus* during storage. The fish were smoke-dried to average moisture content of $10.41 \pm 0.02\%$ and stored. Fish were packaged in black polythene bags and kept in perforated plastic containers. The fish were left in the plastic baskets for 56 days at ambient temperature (25-32°C).

Samples of fish were assessed weekly for physical attributes such as colour, fragmentation, odour, taste and texture. Proximate composition was assessed using changes in moisture content, crude protein, lipid and ash content.

Biochemical indexes carried out were: Total Volatile Nitrogen (TVN), pH, Peroxide Value (PV) and Free Fatty Acid (FFA) levels. There was a general decline in physical attributes i.e. colour, fragments or cracks, odour, taste and texture of fish during storage. Fluffy woolly mat of moulds were noticed on the *Clarias gariepinus* from the 5th week of storage. There was a significant ($P < 0.05$) colour change in most species as from the 6th week. During this study, the moisture content increased weekly in the five smoked fish species from the initial average of $10.41 \pm 0.02\%$. This could be attributed to the difference in the moisture of the smoked fish relative to the surroundings.

Oreochromis niloticus and *Heterotis niloticus* had the best taste value. Apart from *Parachanna obscura*, the other fatty species, *C. gariepinus* and *L. coubie* became less firm as the weeks progressed. There were significant changes ($P < 0.05$) in most of the physical and chemical characteristics except odour from the 6th week (42 days) of storage. There were also significant differences ($P < 0.05$) between the initial and final values of the proximate and chemical constituents of the different species of fish. The study showed that keeping quality of smoked fish under ambient conditions decreases with increase in length of storage.

Other research findings have corroborated this assertion where smoked *Clarias gariepinus* have shown consistent rise in TVN and PV levels during ambient storage while emphasising that these markers remain the industry standard for assessing the safety and quality of processed fish in West African markets (Adeyeye and Omoniyi, 2015; Famurewa *et. al.*, 2017).

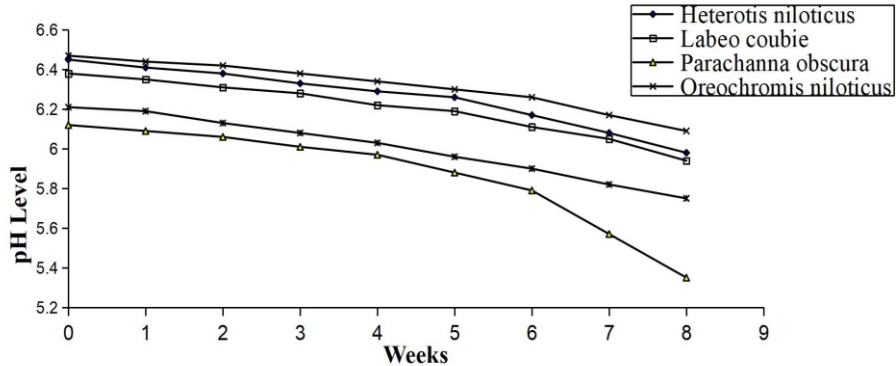
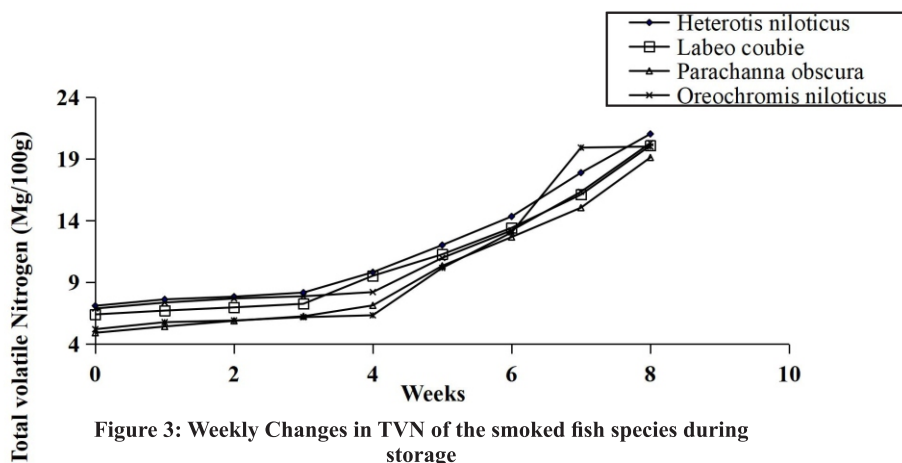


Figure 2: Weekly Changes in pH level of the smoked fish species during storage



C (iii) Akinwumi, Daramola et. al. (2015). Investigation of Heavy Metals and Oxidative Stress in *Sarotherodon melanotheron* Harvested at Abule-Ado Lagoon, Lagos, Nigeria.

Introduction: Contamination of aquatic life by heavy metals is common in petroleum polluted environment. Abule-Ado Lagoon (AAL) in Lagos State, Nigeria, houses a number of private petroleum depot and there is large scale oil spillage in the environment. Bioaccumulation of heavy metals in tissues of fish harvested in polluted areas may pose health risk to consumers

Purpose: Therefore, this study was designed to assess the bioaccumulation of heavy metals and oxidative stress in *Sarotherodon melanotheron* harvested at AAL and compared with the control, harvested at Iyana-Iba Lagoon, Lagos.

Methods: Ten female fishes each were harvested from test and control sites and the concentrations of Iron (Fe), Lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni) were determined in the gills, liver and flesh using atomic absorption spectroscopy. The toxicity and oxidative stress in the fishes were investigated by monitoring aspartate amino transferase (AST), alanine amino transferase (ALT), malondialdehyde (MDA), reduced glutathione (GSH) and super oxide dismutase (SOD) activities in the liver and gills.

Results: Fishes harvested from AAL showed marked ($P < 0.05$) increase in the tissue concentration of the metals as compared with control. The decreasing trend of metals in the tissues of harvested fish was $Fe > Pb > Cr > Ni > Cd$. Fishes collected at AAL showed a significant ($P < 0.05$) increase in GSH, MDA, SOD and AST activities in the gills and liver when compared with those taken at the

control site.

Significance: The results suggest that Abule-Ado Lagoon is polluted with heavy metal and fishes inhabiting the lagoon may be vulnerable to stress and diseases, which may make them unsafe and unhealthy for human consumption.

C (iv) Alamu, E. A., **Daramola J.A**, Effiok, M. I. (2018). **The Physico-Chemical and Antimicrobial Studies of Oleoresin Extracts from Selected Nigerian Pepper (*Capsicum frutescens*) on smoked fish.**

Abstract: The study was carried out to check the efficiency of using essential oils extracted from dried and fresh pepper samples for the preservation of food products, roasted fish as a case study. Red pepper fruits (*Capsicum frutescens*) popularly known as Shombo or Bawa and fish were obtained from Ota main market in Ogun state. The pepper was washed and the stem removed. The pod was blanched using hot water at 90°C for 3 min, cooled in cold water and drained on a perforated tray before drying. These pepper samples were later characterized with respect to their proximate properties. Microbial analysis (Mould/Yeast Count and Bacteria Count) were carried out on fish samples and were treated with extracted oils from pepper and were also characterized for their moisture content and water activity. The oils extracted from fresh pepper samples showed great resistivity to micro-organisms attacks on food product (fish) at concentration of 10^{-3} but could not preserve the fish more than six weeks. It is however cheaper to extract such oils from pepper using the extraction method engaged in this project and these oils are highly marketable, environmentally free and pocket friendly compared to other chemical based type of preservatives.

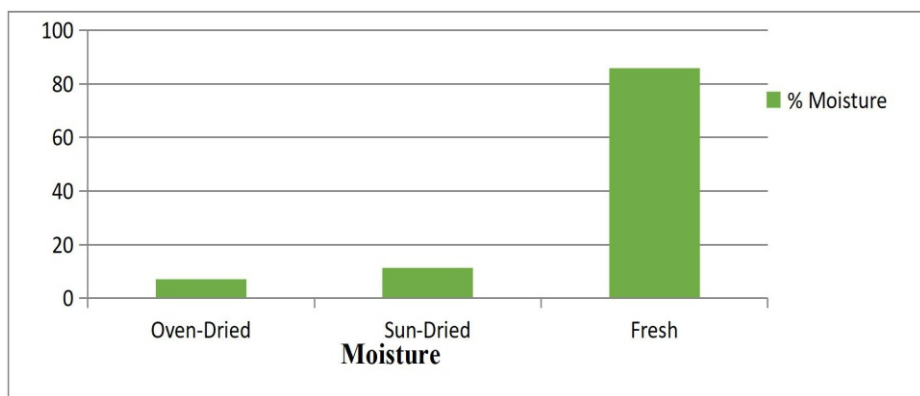


Figure 4: Chart of the percentage (%) moisture content of pepper samples

D. TECHNOLOGY IN FISHERY

D. (i) Fasakin, E.A., **Daramola, J.A.** and Famurewa, J.A.V. (2009). **Development of a Model Rotatory Fish Smoking Kiln using Agro-Wastes as Source of Fuel.**

Abstract: A model fish smoking kiln was designed and fabricated to use agro-wastes (sawdust, palm kernel shell and rice bran) as alternative to convectionally used charcoal (control) as fuel energy source for smoking fish. *Clarias gariepinus* was washed, brined and smoked in chunks or whole in the kiln. The smoking kiln has an estimated capacity of 40kg of fish/batch with six fish trays and 36 fish hooks. Heat transfer is by conduction and convection. The rotatory wheel and axle on which the fish drying trays are anchored ensured even distribution of heat. The kiln has 69.4% energy efficiency and drying period of 10 hours at an average temperature range of 60 – 120°C, depending on the type of agro-waste used as source of fuel energy. The fuel conversion ratio, drying rates and calorific values of the different agro-waste products were also determined. Calorific value of the four agro-wastes ranged between 16.2MJ/Kg in palm kernel to 30MJ/Kg in charcoal. The drying rates of sawdust and rice bran compare favourably with charcoal and they produced smoked fish similar in dryness and quality with fish smoked with charcoal. Palm kernel had the least drying rate of smoked fish (weight/hour) during the 10-hour smoking duration.

Conclusion: Agro-wastes such as sawdust and rice bran are good substitute to the convectionally used charcoal in terms of heat generation and cost effectiveness. Palm kernel shell is not recommended because of the drudgery associated with fanning and slow burning process. The FUTA model fish smoking kiln is recommended to fish processors and other government agencies because of the unique quality of the kiln, such as, capacity utilisation, heat and smoke regulation and quality of smoked fish products.

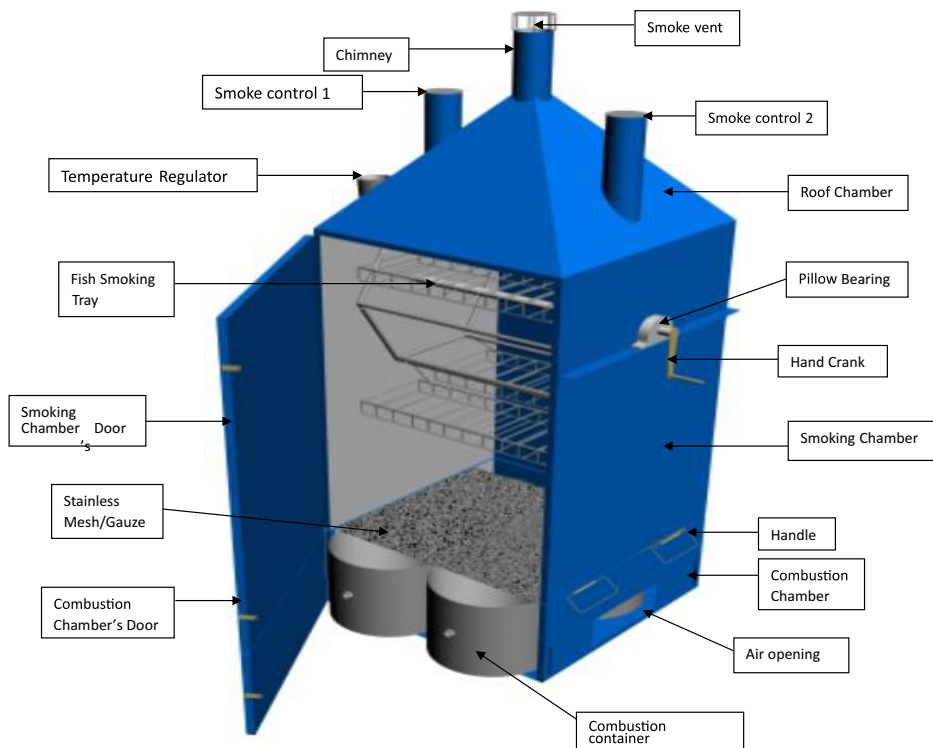


Figure 5: Details of the FUTA model fish smoking kiln

Table 4: Calorific Values of the Agro-Wastes

Agrowastes	Source	Calorific Value (MJ/kg)	Burning Temperature Range ($^{\circ}$ C)
Charcoal	Wood	30.0	90 – 120
Sawdust	Mixed wood	19.5	80 – 110
Rice bran	Rice	16.6	90 - 100
Palm kernel	Oil Palm	16.2	60 – 80

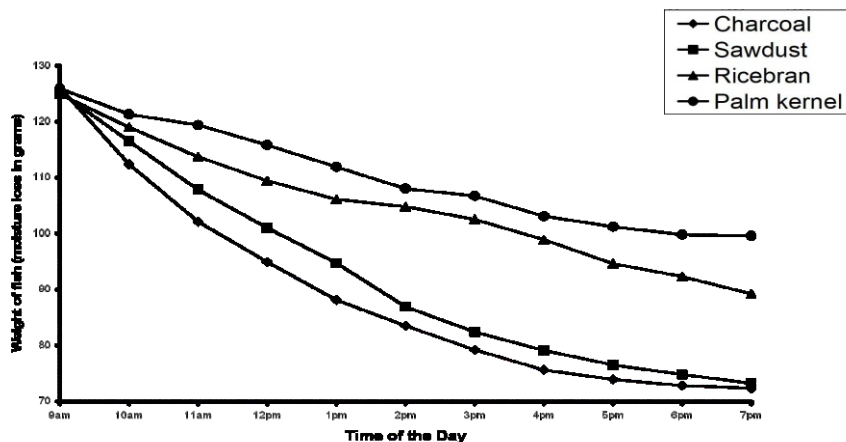


Figure 6: Drying Rate Curve of smoked *Clarias gariepinus*

D. (ii) Ezike J.O.J, Adeyiga J.A., Aderinko O. M., **Daramola J.A.**, Kester C, and Orhokomua E. E. (2013). **A Neural Network System for Determining the Optimal Profitability of Smoked Fish Business in Nigeria.**

Abstract: Small scale smoked fish business is a lucrative business venture in Nigeria as market fish sellers especially women living in riverside areas of the country earn a living from this business. However, these fish sellers may not know the combination of smoked fish type that will yield optimum profit. In this research, a neural network model was designed for achieving this purpose and was used to predict the profitability of smoked fish business based on the analysis from the sample survey of smoked fish sellers/retailers in selected markets in Ota, in Ogun State, Nigeria and its environs. This prediction results could help government and small-scale smoked fish retailers to fashion out best practices to help achieve maximum profitability in the smoked business.

Conclusion: After a critical look at the results of analysis, inferences and predicted outputs, the analysis of questionnaires shows that the factors such as, policies of government, location of business, willingness to expand business, family, combination of fish types, etc slightly affect the smoked fish business positively. Thus, business tends to yield moderate profit. This prediction corresponds to mean/average percentage analysis value of 60.4%, which shows moderate profitability using the prediction scales table. Therefore, when properly utilised, the system can definitely make the smoked fish business more profitable.

D. (iii) Fayomi, O. S., Musa, A. I. and **Daramola, J. A. (2022). Design and Fabrication of Hybrid Cabinet Dryer.**

Abstract: The fabrication of a cabinet dryer using both charcoal and gas as sources of energy is a cost-effective and efficient solution for drying various materials. The cabinet dryer is a type of dryer that uses hot air to dry the materials placed inside. The use of charcoal and gas as energy sources allows for flexibility in terms of cost and availability of fuel. The cabinet dryer is constructed using a combination of metal and wood. The cabinet dryer can be used to dry a wide range of materials including wood, fruits, vegetables, and grains. The drying process can be adjusted to suit the specific requirements of the materials being dried. With proper use and maintenance, this cabinet dryer is a reliable and efficient solution for drying materials.



Figure 7: Cabinet Dryer using Charcoal and Gas as source of energy

D. (iv) Sotonwa, K. A. **Daramola, J. A.** and Mbaja H. U. (2023). **Development of a Recurrent Neural Network to Analyse Computational Records of Smoked Fish Mongers.**

Background: Over the years, accurate data that can be relied upon for government interventions to the smoked fish mongers in Ota and Lagos markets are not available. In this study, Recurrent Neural Network-based Windows was developed from the survey to analyse data taken from questionnaires and display the influence of each element on the profitability of the fish-smoking business.

Research Approach: This research presents an approach to the development of a Computational Analysis System for Smoked Fish Mongers so as to bridge the spotted gaps in the previous works done by various researchers in this regard. The development of a computation analysis system for smoked fish mongers involves multiple steps which include:

- i. Analyse specific factors facing the smoked fish monger which includes: Age, Gender, Tribe, Profitability, and Species.
- ii. Design a questionnaire to capture relevant research data
- iii. Implementation of the model via the development of a windows system that applies the model in analysis
- iv. Take records of the performance metrics and analysis the performance metric.

Conclusion: In this study, a recurrent neural network was trained to predict the addition of sequences of numbers. Questionnaire responses from fishmongers were then collated and input as a sequence of numbers into the recurrent neural network model for analysis. Experimental result showed that Section 1(Profit Factor) and Section 4 (Financial Factor) highly affect the smoked fish business positively. While Section 2 (Location Factor), Section 3 (Government), and Section 5 (Family Involvement Factor) moderately affect the smoked fish business positively.

D. (v) Kester, C. T., Essien, E. R., Akinwumi, K. A., **Daramola, J. A.,** Iraye, P. U. (2024). **Microbiological Quality of *Gadus morhua* Treated with Silver Nanoparticles Synthesized Using *Launaea taraxacifolia* Leaves.**

Abstract: A number of shelf life-promoting strategies have been adopted for fish and fisheries products. The in vitro preservative effect of Ag-nanoparticles synthesized using *Launaea taraxacifolia* leaves on Atlantic cod fish (*Gadus morhua*) was investigated. The treated (TRD) fish samples were dipped in 25%

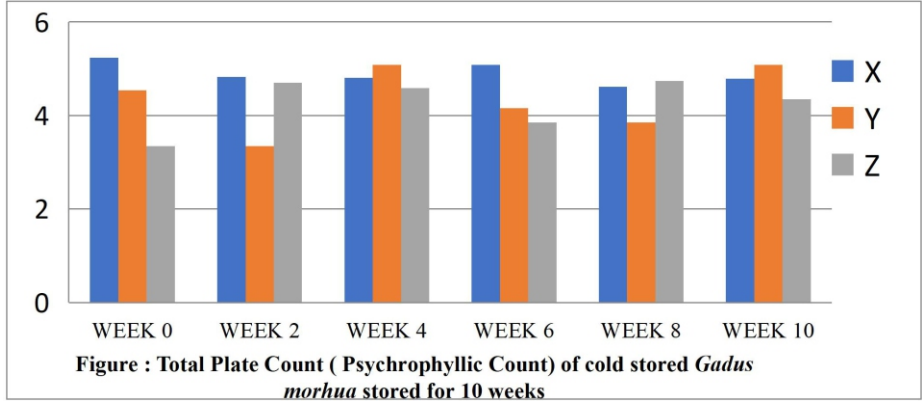
silver nanoparticles (AgNPs) preparation for 30 minutes and analyzed at four hours intervals for 24 hours. Samples were cut into Head (H), Trunk (TR), and Tail (TL) parts and evaluated for total heterotrophic bacterial counts (THBC) and total yeast counts (TYC) all expressed in log CFU/g. Untreated (UTD) served as control. The concentrations of silver in both treated and untreated fish samples were determined. Data were analysed using descriptive statistics and ANOVA at $\alpha 0.05$. The treated samples recorded lower THBC values than the untreated: head (6.18 ± 0.27 vs 6.55 ± 0.65); trunk (6.22 ± 0.11 vs 6.61 ± 0.41) and tail (6.40 ± 0.34 vs 6.57 ± 0.83). The treated samples had lower TYC values than the untreated: head (6.34 ± 0.58 vs 7.44 ± 0.38), trunk (6.59 ± 0.66 vs 7.05 ± 0.46) and tail (6.47 ± 0.30 vs 6.81 ± 0.95). Both the treated and the untreated samples were dominated by *Enterococcus* spp. (569 vs 957) and *Micrococcus* spp. (13 vs 18). *Bacillus* spp. (36) was isolated only in the untreated sample. The silver concentrations were highest in untreated and treated trunk samples respectively (1.12 and $2.13 \mu\text{g/g}$), followed by head samples (0.58 and $1.41 \mu\text{g/g}$) while the tail samples had the least (0.27 and $0.29 \mu\text{g/g}$). The Ag-nanoparticles synthesized from *Launaea taraxacifolia* leaves exhibited both antibacterial and antifungal activities and could be useful in preserving fish and fishery products.

E. FISH MICROBIOLOGY

E. (i) **Daramola J.A., Kester C.T., Ibironke, A. A. (2011). Evaluation of Some Microbiological and Biochemical Qualities of Atlantic Cod (*Gadus Morhua*) from selected Frozen Fish Depots in Sango-Ota.**

Abstract: The study was designed to investigate the effect of duration of frozen storage on the biochemical and microbiological qualities of Atlantic cod (*Gadus morhua*). Frozen fish samples from designated depots in Ota metropolis, Sango-Ota, Ogun state were used. The fish samples, coded X, Y and Z were subjected to ten weeks of frozen storage at -15°C to -19°C and analyzed bi-weekly. The Total plate count of sample X was the highest ($5.2 \times 10^3 \text{CFU/g}$) while sample Z had the lowest ($3.3 \times 10^3 \text{CFU/g}$), the Total coliform count of sample X was 25MPN/g, and sample Y was 10MPN/g; there was no coliform count in Sample Z. The occurrence of *Vibrio* spp. was relatively low in all samples; the count reduced inconsistently in sample X and sample Y and was not present at all in Sample Z. Total volatile nitrogen of the samples increased while the pH level and the crude protein content decreased in the bi-weekly analyses. At the end of the 10 weeks cold storage in the freezer, the fish samples were still fit for consumption, as there was no drastic degradation in their microbiological and biochemical characteristics. In terms of the assessed qualities, sample Z was the best. It was

concluded that freezing and storing procedures could not destroy the microorganisms totally but remain one of the best ways of preserving fish in its wholesome fresh state up to two and half months and more.



Key: Fish Depots: X (Jackdeb), Y (Progress) and Z (Edible)

E. (ii) Kester, C.T., Daramola, J.A., Oni, P.I., and Oshinaya, S.O. (2013). **Effect of Smoking. Duration on the Microbiological Quality of Cold-Smoked Atlantic Cod, *Gadus Morhua* (Linnaeus, 1758).**

Abstract: This study evaluated the effect of varying smoking durations of 6 hours, 65 hours, 7 hours and 7.5 hours on the microbiological quality of cold-smoked Atlantic cod fish, *Gadus morhua* (Linnaeus, 1758). The four batches of the cold-smoked samples stored in the metal baskets were kept on shelf at an average temperature of 30°C for 14 days and were analysed for Total Plate Count (TPC), *Staphylococcus aureus*, Mould count, Total Coliform Count (TCC), *Escherichia coli*, and % moisture content 7days starting from day 0 of the experiment. All the samples analysed tested negative for *Escherichia coli*. Significant variations ($p < 0.05$) were obtained for all the microbial counts between the four study samples. The best smoking duration was 7.5hours with most stable products that had the least microbial quality mean of TPC ranging from 2.55×10^4 cfu/g at day 0 to 4.40×10^5 cfu/g at day 4; *Staphylococcus aureus* count ranging from 3.50×10^4 cfu/g at day 0 to 1.10×10^5 cfu/g at day 12, Mould count ranging from 1.05×10^4 cfu/g at day 0 to 1.00×10^5 cfu/g at day 12, TCC ranged from 12MPN/g to 13MPN/g and % moisture content varied from 25.3% to 17.25%. *Escherichia coli* tested negative during the storage days of analysis.

E. (iii) **Daramola, J. A., Kester; C. T., Osofero; S. A. and Ojiakor, C. C. (2014). Microbiological and Proximate Assessments of Cold-smoked *Gadus morhua* in Traditional Fish Smoking Centers in Ota Metropolis.**

Abstract: This study evaluated the microbiological and proximate assessments of cold-smoked Atlantic cod, *Gadus morhua*. Fresh fish samples were purchased from cold room depots and were taken to five traditional fish smoking centres in Ota metropolis for cold smoking. The Atlantic cod were cold-smoked for a period of 1 hour and taken to the laboratory in baskets and stored on the shelf at room temperature ($\pm 27^{\circ}\text{C}$) for 4 weeks. Thereafter, the smoked fish samples were analysed for Total plate count, Staphylococcus count, Coliform count, mould count, moisture content, crude protein, ash content, lipid content and salt content. The microbiological analyses were carried out every three days while proximate analyses were weekly. From the analyses, microbiological parameters, moisture and ash contents of the smoked fish on storage increased while the percentage protein, lipid and salt contents of the fish sample decreased; from the second sampling day. TPC increased from 4.17 log₁₀ cfu/g to 5.78 log₁₀ cfu/g, Coliform from 5.03 log₁₀ cfu/g to 6.46 log₁₀ cfu/g and Moisture contents was between 11.15% and 25.80. The lipid content ranged between 12.56% and 15.64% while the protein contents ranged between 9.48% and 41.54%.

Conclusion: The increase in the microbial loads, moisture and ash contents as well as the decrease in lipid, protein and salt contents of the cold smoked *Gadus morhua* samples are factors which indicates the proliferation of spoilage organisms in the fish during storage. This automatically reduced the shelf life of the fish. Conversely, since cold-smoked *Gadus morhua* is widely acceptable by a good Nigerian populace and commonly available in Nigerian markets and does not have a long shelf life (less than 30 days) when stored under ambient temperature, it is better if they are supported with refrigeration storage since most micro-organisms are relatively inactive at such low temperatures.

E. (iv) **Daramola, J.A., Alao, F.O., Osofero, S. A. and Wemimo, O.O. (2014). Assessment of the Microbial and Sensory Qualities of Smoked African Catfish (*Clarias gariepinus*).**

Abstract: This study was carried out to assess the microbial and sensory qualities of smoked catfish (*Clarias gariepinus*) treated with sodium chloride during a 6-week storage at room temperature. Raw catfish steaks were subjected to the following salt treatments (5%, 7.5%, 10%, 12.5% and 15%) for 15 minutes prior to smoking. The non-treated (without salt) catfish served as the control. The fresh fish, control and the treated samples showed diverse microbial loads. After smoke treatment, the microbial loads were reduced and this was maintained

during the weeks of storage. The result from this study revealed that the smoked catfish are shelf stable for between three to five weeks under ambient storage condition, before the action and effects of spoilage microorganisms become significant. Smoked fish treated with 12.5% and 15% salt proved best in terms of reduced microbial loads but organoleptically, smoked fish treated at 5% salt was the most acceptable to the panelists.

E. (v) Opere, B. O., Daramola, B. E. and **Daramola, J. A.** (2018). **Assessment of Bacterial on some Cold-Smoked Fish in Five Markets in Ado-Odo LGA, Ogun State.**

Abstract: Cold-smoked *Scromber sp.*, *Trachurus sp.*, *Gadus sp.* and *Clupea sp.* were examined for the presence of pathogenic bacteria and fungi. Retailed samples of the cold-smoked fishes were obtained from five major Markets; Ota, Sango, Oju-ore, Atan and Lusaida. The samples were analysed for Total Plate Count (TPC) for bacteria and fungi; *Staphylococcus aureus*, *Escherichia coli*, *Salmonella sp.* and *Coliforms* count respectively. The variations in the microbial loads of the analysed smoked fishes were relatively significant. *Trachurus sp.* recorded a very high TPC bacteria in Atan market at 13.1×10^4 cfu/g. *Staphylococcus aureus* count of smoked fish samples was nil (0) in *Scromber sp.* (Ota), *Trachurus sp.* (Sango and Atan), *Gadus sp.* (Atan) and highest in *Trachurus sp.* (Ota) at 4.3×10^4 cfu/g. The *Escherichia sp.* count was highest in *Trachurus sp.* (Lusaida) and *Gadus sp.* (Oju-ore) at 5.3×10^1 cfu/g while *Salmonella sp.* count was nil (0) in *Scromber sp.* (Oju-ore), *Gadus sp.* (Ota, Sango and Lusaida) and *Clupea sp.* (Ota and Sango). *Coliforms* count was higher in *Trachurus sp.* (Ota) 5.9 MPN/g. However, by the recommended standards, all the analyses smoked fish in the study area were safe for human consumption.

E. (vi) **Daramola J.A.**, Kester C.T., Sodamola, M. Y. and Ben-Okoh, B. J. (2019). **Comparative Studies on the effect of Oven Drying and Traditional Smoking on the Microbial Shelf Life of Atlantic Herring (*Clupea harengus*).**

Abstract: The effect of Oven drying and Traditional Smoking on the Microbial Load of Atlantic Herring (*Clupea harengus*) was studied due to the unsatisfying knowledge about the microbial shelf life of Atlantic Herring in the area of Ogun state. This research work gave an insight about the effect of Oven drying and Traditional Smoking on the Microbial Load of Atlantic Herring. 10 Atlantic herrings were purchased for this research. 5 was oven-dried while 5 was hot smoked at 60-80°C at 5 different days (0, 1, 2, 3 and 4) respectively. The microscopic evaluation of the characteristics of bacterial and fungal colonies on agar plates revealed that *Shigella* and *E. coli* were present in both the oven dried and the wood smoked samples of *Clupea harengus*. Results showed that oven drying method of preservation had lesser Total Plate Count (TPC), Yeast Mold

Count (YMC), Total Empiric Bacteria Count (TEBC), Total Coliform Count (TCC), and Moisture Content (MC) as compared to the hot smoking method of preservation. Result showed that *Shigella flexneri*, *Escherichia coli*, *Salmonella arizonae*, are the microorganisms found to be associated with hot-smoked dried fishes sold in different market in Ota, Ogun state. It is therefore recommended that fish stores should be well screened and ventilated so as to avoid contamination of smoked fish products. The identified organisms are entirely preventable by practicing good sanitation and proper food handling techniques. Conclusion: This study revealed that oven dried and smoked-dried Herring locally known as Sawa in Ota markets, Ogun State are contaminated with micro-organisms. However, the microbial load still falls within the recommended microbial limit for ready-to-eat foods indicating that the fish sold in different markets within Ota metropolis is fit for human consumption. Oven drying method of preservation should be utilised as it will more likely increase the shelf life of the fish because of reduced microbial organisms. Notwithstanding, it is recommended that fish stores be well screened and ventilated to avoid contamination of smoked fish products.

E. (vii) **Daramola J.A., Kester C.T., Ayodele, D. O. (2019). Quality and Shelf Stability of Smoked Horse Mackerel Fish (*Trachurus trachurus*).**

Summary: In this study, smoked Horse mackerel fish (*Trachurus trachurus*) was stored under room temperature for 5 days and the results obtained showed that the values of microbial counts of salted and smoked Horse mackerel fish samples were observed to be significantly different ($P<0.05$) in their microbial loads measured as total plate count, *Staphylococcus* count, total mould count and total enterobacteriaceae count expressed as log CFU/g.

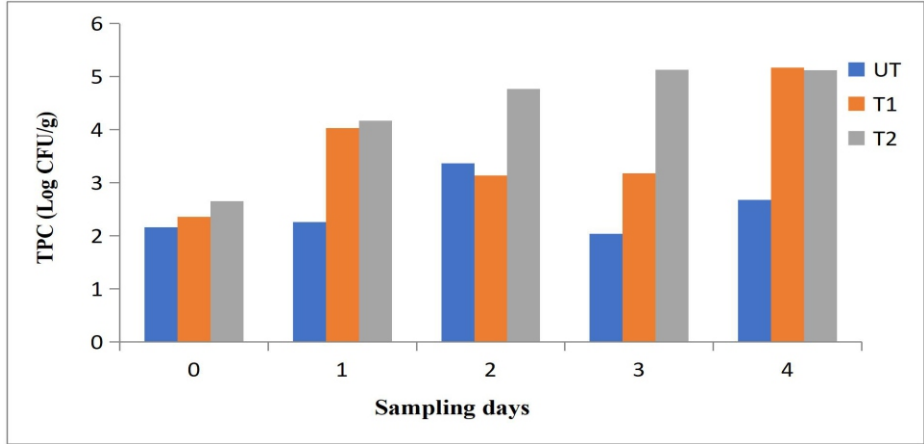


Figure 8: Total Plate Count of Smoked Mackerel Fish Samples

Key:

UT: Untreated

T1: Treated with 5% salt Concentration

T2: Treated with 10% salt Concentration

E. (viii) **Daramola, J. A. (2020). Pathogenic contaminants of fresh and processed fish: a review.**

Abstract: Fish is an essential and a major protein source in the diet of people in sub-Sahara Africa which supplies amino acids, poly-unsaturated fatty acids and other nutrients to the consumer. However, fish is a highly perishable food commodity and begins to spoil once dead. Researches have shown that the spoilage that starts immediately on dead fish can be due to autolytic breakdown of the nutrient components, contamination through handling and exposure to pathogenic organisms such as bacteria, fungi, virus and parasites in the air, soil and water. These spoilage organisms or contaminants are present on fresh and processed fish that are not hygienically handled and properly preserved. Contaminated fish and seafood are bad and has potential effect on the health of consumers and also cause economic loss to the farmers and traders. Therefore, the focus of this paper is to review some of these microorganisms and parasitic contaminants on fresh and processed fish with suggested procedures for ensuring safe fish and seafood products, among which is proper cooking before consumption.

E. (ix) **Daramola, J. A., Alao, F. O. and Adeniyi, A. E. (2020). Estimation of Bacteria and Fungi in Smoked Catfish (*Clarias gariepinus*) available in Ota markets.**

Abstract: This study was carried out to investigate the microbial quality of smoked *Clarias gariepinus* purchased from four different markets, namely Iyana-Iyesi (M1), Oju-Ore (M2), Oja-Ota (M3) and Sango-Ota (M4) in Ota metropolis. The samples from three retailers from the four markets were used for analyses for two weeks, making a total of 48 samples for the experiment. The microbiological procedure was carried out using Nutrient agar for bacteria load and Potato Dextrose agar for fungal load of the smoked catfish. The mean total plate count for bacteria ranged between 4.82×10^4 CFU/g for week 1 in Oju-Ore market and 4.92×10^4 CFU/g for week 2 and Iyana-Iyesi market while fungi ranged from 4.85×10^4 for week 1 in Sango-Ota market and 4.92×10^4 CFU/g for week 2 in Oja-Ota and Sango-Ota markets. *Vibrio cholerae*, *Staphylococcus aureus*, *Escherichia coli*, *Shigella spp* and *Salmonella typhi* were the bacteria isolated from the smoked catfish. The presence of these organisms confirms microbial contamination either from poor smoking of the fish, poor personal

hygiene of the processors or sellers, poor environmental conditions as well as packaging and storage of the fish. The adoption of good processing practice and the use of controlled temperature in processing and preserving of the smoked catfish are highly recommended.

E. (x) **Daramola, J. A., Kester, C. T., and Allo, O. O. (2020). Smoked African Catfish (*Clarias gariepinus*) Sampled from Two Markets and Occurrence of Microbes.**

Abstract: The study was carried out to assess some microbiological qualities of smoked African catfish, *Clarias gariepinus* retailed in Sango and Ota markets in Ogun state, Nigeria. Six smoked fish retailers were randomly selected from the markets and 36 fish samples were collected. The samples of smoked catfish were assessed weekly for a period of six weeks for microbiological parameters such as Total plate count (TPC), Total coliforms count (TCC), Staphylococcus count and mould count. In this study, the microbial load of the smoked *Clarias gariepinus* samples retailed in the two study sites increased weekly during the period of storage. TPC increased from $4.75 \pm 0.014 \log_{10}$ CFU/g for smoked samples from Ota market, retailer 1 (OMR1) in week 0 to $5.11 \pm 0.021 \log_{10}$ CFU/g for samples from Ota market, retailer 3 (OMR3) in week 5. TCC ranged from $1.47 \pm 0.001 \log_{10}$ CFU/g to $2.43 \pm 0.049 \log_{10}$ CFU/g; Staphylococcus from $2.15 \pm 0.070 \log_{10}$ (CFU/g) to $2.66 \pm 0.014 \log_{10}$ (CFU/g) and $1.82 \pm 0.070 \log_{10}$ CFU/g to $2.92 \pm 0.071 \log_{10}$ CFU/g for mould counts. The smoked *Clarias gariepinus* from the markets could not keep well till the 6th week. Hence, it can be inferred that smoked catfish with moisture content of about 10% or less will have a shelf life of about 4 - 5 weeks under ambient storage conditions before the effect of spoilage microorganisms.

E. (xi) **Daramola, J.A., Oladosu, T.O. and Ismail, K.S. (2020). Fermentation and Effect on the Microbial Loads of Atlantic Cod, *Gadus morhua*.**

Abstract: The study was carried out to evaluate the effect of fermentation on the microbial loads of Atlantic cod (*Gadus morhua*). Eviscerated samples of Atlantic cod were fermented in three media: sterile distilled water, 14% saline medium and 14% salt with potash for 24 hours. The fermented Atlantic cod samples were oven-dried at 60°C for one hour and thereafter, 100°C for three hours, cooled and stored in plastic baskets at ambient temperature for four weeks. Analyses of the dried fermented Atlantic cod was carried out weekly for Salmonella shigella, total bacterial, Staphylococcal, total fungal and total coliform counts. Results from the mean values indicated variations in the effects of the additives and processing treatments over the 24 hours fermentation period which were significant ($p < 0.05$). The dressed fish sample fermented with both salt and potash (DRSFP), recorded the least mean microbial counts during

the 4-week storage period, followed by the sample which was fermented with salt (DRSF) while the highest occurrence of microorganisms was recorded in the sample which was fermented with sterile distilled water (DRF). Hence, fermentation of fish with salt and potash is recommended. Meanwhile, in relation to the standard recommended microbial limits, the loads of microbes on the fermented Atlantic cod samples from the three treatments still fall within the safe and acceptable level.

E. (xii) **Daramola, J.A.,** Olumuyiwa, E.O., Omo-Emevor, P.O. (2020). **Spoilage organisms in smoked Atlantic cod (*Gadus morhua*) from different sources.**

Abstract: This study was designed to establish the microbiological safety and suitability for human consumption of the cold- smoked Atlantic cod, *Gadus morhua* retailed in Oju-Ore, Sango, Iyana-Iyesi and Oja-Oba markets in Ota, Ogun State, Nigeria. The fish samples were randomly purchased from the four markets and analysed for Total Viable Count (TVC), Total Coliform Count (TCC), Staphylococcal count and Fungi count using Nutrient agar, Plate count agar (PCA), MacConkey agar, Mannitol salt agar (MSA) and Potato Dextrose Agar. Samples were stored in wire baskets and examined for the presence of bacteria and fungi on day 1, 4, 8, 12 and 16. The highest mean values were TVC, 5.7×10^6 CFU/g; TCC, 6.4×10^4 CFU/g and Staphy. Count, 7.9×10^3 CFU/g in the smoked Cod from Oja- Oba market, on day 16 of storage at ambient conditions. There were no fungal counts in all the smoked *Gadus morhua* samples from the four markets on day 1. However, from the 4th day, there were traces of fungi from 0.4×10^2 CFU/g in samples from Oju-Ore to 4.6×10^2 CFU/g on day 12 in samples from Oja-Oba market. By the 16th day, moulds have completely covered the smoked fish and it was too numerous to count (TNC). Also, through biochemical characterization, some bacterial isolates from the smoked fish were identified. Generally, smoked Cod from Oju-Ore had the best quality and least mean values of the microbial parameters, followed by that of Sango, Iyana-Iyesi and the highest values were the smoked fish from Oja-Oba markets. It was, however, recommended that the application of the Hazard Analysis Critical Control Point (HACCP) principles be introduced to the local fish processors, putting their literacy level into consideration for them to be able to understand and imbibe the concept of the practice.

E. (xiii) **Daramola J.A.,** Kester C.T., Adebayo, O. A. (2020). **Studies on the Effect of Descaling and Evisceration on Bacteriological Quality of Smoked Tilapia (*Oreochromis niloticus*).**

Summary: This study was carried out to study the effect of scales and evisceration on microbiological stability of smoked tilapia (*Oreochromis*

niloticus). Twenty-eight samples of raw tilapia were used. Twenty-four samples of raw tilapia were treated and smoked for two days. The remaining four samples were not smoked but treated which served as control. The microbial analysis was carried out in 6 trials i.e., days 0, 3, 6, 9, 12 and 15. After the experiment, the following parameters were determined; Total plate count, Total *Staphylococcus* count, Total *Enterobacterial* count. In the study the quantity of microbes in raw Tilapia samples reduced significantly ($P < 0.05$) after smoking; irrespective of the treatment, with or without scales and evisceration.

E. (xiv) **Daramola JA, Sodamola MY, Kester CT (2023). Prawns and shrimps: review of the aquaculture, biology, microbes and preservation.**

Abstract: Food, fish and other aquatic product's insecurity in developing and underdeveloped countries has led to the evasion of some diseases attributable to the consumption of these products. Seafood however refers to all fresh or salt water organisms such as shellfishes, fin fishes, molluscs, crustaceans and all other forms of aquatic animal life. Shrimp continues to represent one of the safest forms of muscle protein consumed in the world. Actual reported illnesses or outbreaks are rare and usually involve mishandling or cross contamination in retail/food service settings or homes. Seafood products are generally safe for consumption although, the bacterial load is high especially at the time of harvest due to the harvest techniques adopted. Poor post-harvest handling which may have removed the slime or protective covering on these aquatic species, poor processing techniques of such products also lead to an increase in the microbial load on these products. Therefore, this review is aimed at evaluating the culture, biological characteristics, microbial contaminations and ways of preserving Prawns and Shrimps from our water bodies.

E. (xv) **Daramola, J.A.; Kester, C.T. and Laraiyetan, K. S. (2023). Studies on Mycoflora Associated with Storage in Selected Fish Feed Brands Retailed in Ota**

Abstract: This research investigated the mycoflora of some selected fish feed brands retailled in Ota, Ogun State. Six samples coded; Oju-ore Ala Aqua (OJAA), Iju Ala Aqua (IJAA), Oju-ore Blue Crown (OJBC), Iju Blue Crown (IJBC), Oju-ore Local Product (OJLP) and Iju Local Product (IJLP) were randomly purchased from two selected axis of Ota (Oju-ore and Iju) and were analyzed weekly for Total Fungal Count (TFC) using Potato Dextrose Agar (PDA) which was made selective by adding 1% of Chloramphenicol, following standard procedures. The fungi were identified morphologically, microscopically and detected at molecular platform using ITS primer for Fungi. The data were analyzed using ANOVA $\alpha 0.05$. The final result showed insignificant difference ($p > 0.05$) among the fungal load of the imported (Ala aqua, AA) and Nigerian (Blown Crown, BC)

products ranging from 2.66 ± 0.10 log CFU/g [Iju Ala Aqua (IJAA)] to 3.50 ± 0.48 log CFU/g [Iju Blue Crown (IIBC)]. The local feed recorded a slightly higher range of 2.75 ± 0.13 [Oju-ore Local Product (OJLP)] log CFU/g to 3.56 ± 0.35 log CFU/g [Iju Local Product (IJLP)]. The feeds were discovered to be contaminated with six fungi namely: *Fusarium spp.* (28%), *Alternaria spp.* (9%), *Aspergillus fumigatus* (6%), *Rhizopus spp.* (6%), *Aspergillus niger* (11%), and *Saccharomyces cerevisiae* (40%). All the isolated Fungi are mycotoxin producers except the *Saccharomyces cerevisiae*. This implies consumption of the feeds held at longer storage period could pose health threat to the safety of fish as the ultimate consumers. Proper storage and handling practices are recommended to minimise contamination.

E. (xvi) Kester, C. T., **Daramola, J. A.**, Alao, F.O. and Chukwu, C. B. (2024). **Listeria Species and Occurrence in retailed Smoked Fish Samples in selected Ota Markets.**

Abstract: This study investigated the prevalence of *Listeria spp.* in 72 samples of smoked species of codfish (*Gadus morhua*), herring (*Clupea harengus*), catfish (*Clarias gariepinus*) and mackerel (*Scomber scombrus*) sampled from Sango (SA), Oju-ore (OO), Oja-Oba, Iyana-Iyesi (II), Iju (IJ) and Atan (AT) markets, all in Ota, Ogun State, Nigeria. Adopting Oxoid *Listeria* Precip method, *Listeria spp.* were isolated and characterized morphologically and biochemically. Of the 72 samples, 8 (11.11%) tested positive. *Listeria ivanovii* (1.38%), *L. grayi* (2.78%), *L. monocytogenes* (2.78%) and *L. innocua* (4.16%) were identified in all the fish samples except *Clupea harengus*. Antibiotic sensitivity tests revealed all the isolates resisted Imipenem, Cefuroxime, Amoxillin and Cefexine but susceptible to Levofloxacin: 34mm (*L. grayi*) to 39mm (*L. ivanovii*), Ciprofloxacin: 25mm (*L. monocytogenes*) to 36mm (*L. grayi*) and Ofloxacin: 20mm (*L. ivanovii*) to 29mm (*L. innocua*). Occurrence of these bacteria could indict the safety of the smoked fish products for consumption. The low percentage occurrences coupled with the high antibiotic susceptibility may, however, relieve the potential consumers of the menace of the associated health risks the consumption of such fish products could pose. The required control measures to prevent the occurrence of especially *Listeria monocytogenes* and other species in the processing and distribution chains of these smoked fish products should be prioritised.

F. PUBLIC HEALTH AND FISH

F (i) **Daramola, J. A.**, Kester, C. T. and Adeleye, A. O. (2018). **Microflora Associated with Smoked Shrimps (*Farfantepenaeus Notalis*) in some markets in Ota Metropolis, Ogun State, Nigeria.**

Abstract: This research was aimed at assessing the micro-organisms associated

with smoked shrimps from three market locations in the Ota Metropolis Ogun State. The samples were collected from Iyana-iyesi, Oju-Ore and Sango areas of the town. Six samples of shrimp were purchased from the various market locations from two different retailers in each market per trial. The period of the research was three weeks. Microbial risk assessment of these ready-to-eat smoked shrimps was carried out in the Microbiology laboratory and the analyses were done using MacConkey agar, Nutrient agar, Mannitol salt agar and Eosin Methylene Blue agar to isolate the bacteria, while Potato Dextrose agar was used to isolate fungi. The total bacterial counts for all the samples ranged from 1.5×10^1 cfu/ml to 17.6×10^1 cfu/ml. The microorganisms isolated and identified in the various markets implied that the bacteria genera: *Staphylococcus aureus* and *Citrobacter* species dominated the samples while the fungi genera that occurred most frequently in the samples were *Aspergillus niger*. The isolated bacteria have been implicated in various health risks such as food poisoning, food spoilage and medical complications. The health implication to consumers and the public health significance was also highlighted.



Figure 9: Samples of smoked shrimp purchased from selected markets

Conclusion: Shrimp which serves as an alternative source of animal protein cannot be banned from consumption based on its nutritional values; hence efforts should be made by relevant organisations on the formulation and enforcement of laws which would promote proper post-harvest technologies and good hygiene practice of shrimp and other seafood products. Efforts should be geared towards awareness programs amongst food vendors about safe and hygienic practices and its importance to the health of man. Consumers also need to recognize that a healthy food means a healthy body, hence, shrimp and other foods purchased from open markets should be processed further through washing and heating.

F (ii) **Daramola, J. A., Olumuyiwa, E. O. and Obi, E. C. (2022). Incidence of Pathogenic Bacteria in Frozen Mackerel (*Scomber scombrus*) retailed in Ota Metropolis.**

Abstract: The study aimed to evaluate the hygienic quality and freshness of fish Mackerel (*Scomber scombrus*) through the investigation of the occurrence of bacteria which is an indicator for fish quality. Aquaculture products (fish and fish products) can harbour pathogenic bacteria, which are part of the natural microflora of the environment. Frozen mackerel fish (*S. scombrus*) retailed in Ota, Ogun state, Nigeria had no documented research report till date. Fish samples were randomly selected from three (3) different depot in Sango, Ota. From this, ten (10 g) samples were used for microbiological analysis. The bacterial loads of the samples were determined using the spread plate technique. Isolates were morphologically and biochemically identified and characterized according to the identification scheme of Bergey's Manual of Determinative Bacteriology. In-vitro assay showed three predominant bacterial contaminants as *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas* spp. occurring at 75, 14 and 11% respectively. The mean bacterial load of the isolates from this study was found to be markedly higher ($1.252 \pm 1.03 \times 10^6$ CFU g⁻¹) than the recommended official public health and safety standard value between 5.0×10^5 and 1.0×10^6 CFU g⁻¹. Consequently, microorganisms could contaminate fish and therefore a source of food poisoning. Harvesting, handling and cooking of frozen fish especially mackerel (*S. scombrus*) should be done properly so as to reduce the bacterial load. Hence, eating of frozen *S. scombrus* raw or half-boiled should be totally discouraged to eliminate zoonotic infections from fish especially in this environment.

Table 5: Biochemical reactions, gram-staining reaction

Isolates	Gram reaction	SUL	IND	MOT	GLU	OXI	COA	CAT
<i>S. aureus</i>	Positive cocci	-	-	-	+	-	+	+
<i>E. coli</i>	Negative bacilli	-	+	+	+	-	NA	+
<i>Pseudomonas</i> spp.	Negative bacilli	-	-	+	-	+	-	+

Keys: SUL= hydrogen sulphide test, IND= indole test, MOT= motility test, GLU=glucose test, COA= coagulase test, CAT= catalase test, NA=not available.

F (iii) **Daramola, J. A.; Sodamola, M. Y., Muhammad, A. M. and Oladosu, T. O. (2023). Implication of Processing and Handling Methods to the Microbial Quality of Stored Fried Atlantic Cod.**

Abstract: The microbiological keeping quality of Atlantic cod (*Gadus morhua*) fried and stored under ambient condition was investigated. Raw Atlantic cods were subjected to two treatments in the laboratory of wheat flour coated fried fish (LFS) and the other fried without wheat flour (LS) against the conventional flour fried fish in the open market samples (MS). Microbial analyses were conducted on the three different fried fish samples at the initial stage and subsequently on weekly basis. The result of the microbial analysis over the 4-week storage period revealed increase in the total fungal count, bacterial count, *Salmonella* spp and *Staphylococcus aureus*, an enteric gram-negative bacterium. *Escherichia coli* was not isolated in any of the fried fish samples. The flour fried fish samples obtained from the open market (MS) had no count in week 0, it recorded the highest total heterotrophic bacterial counts at 20.0×10^6 cfu/g in week 2; 22.2×10^6 cfu/g in week 3 and 24.0×10^6 cfu/g in week 4 respectively. Meanwhile, the fish samples which were fried without flour (LS) in the laboratory had the lowest count of total heterotrophic bacteria in week 2, week 3 and week 4 at 5.0×10^6 cfu/g, 8.2×10^6 cfu/g and 12.5×10^6 cfu/g respectively. Hence, based on the result of the microbial analyses of the fried Atlantic cod with or without flour, it is recommended that the fried fish under ambient conditions should be consumed within two weeks (14 days) of purchased or other preservation methods such as refrigeration or re-drying be applied.

F (iv) **Daramola, J. A; Kester, C. T; Adonkie, D. A. (2023). Antifungal Potential of Black Mangrove Leaf Extracts on Isolates of Smoked Bonga Fish Sampled from Oju-Ore and Iyana Markets.**

Abstract: The contamination of dried fishes by fungi poses serious threat to food safety and public health. This study was carried out on fungal contaminants found in smoked Bonga fish and to determine if there are any antifungal properties in the ethanol extract of Black Mangrove leaves. To achieve this, the study made use of six bonga fish samples purchased from two different markets, with six samples from three different retailers in each market, making a total of thirty-six samples. The antifungal properties of Black Mangrove (*Avicennia germinans*) were determined; the leaves were dried in the open air, followed by blending and extraction using absolute ethanol. Mycological examination of samples revealed the prevalence of seven types of fungi namely, *Aspergillus*

flavus, *Aspergillus niger*, *Aspergillus fumigatus*, *Rhizopus sp*, *Alternaria*, *Candida sp*, *Mucor sp*. Concentration of 1% and 0.1% was applied, using the agar well diffusion method. The 1% ethanol extract showed very small zone of inhibition on the fungal isolates. *Rhizopus*, *A. niger*, *A. flavus*, *A. Fumigatus*, *Alternaria sp*, *Candida sp*, *Mucor sp* showed zones of inhibition 2mm, 1mm, 0mm, 1mm, 0mm, 1mm, 2mm, respectively. The 0.1% ethanol extract showed no zone of inhibition. This showed that the extract had little or no antifungal effects on the isolates.

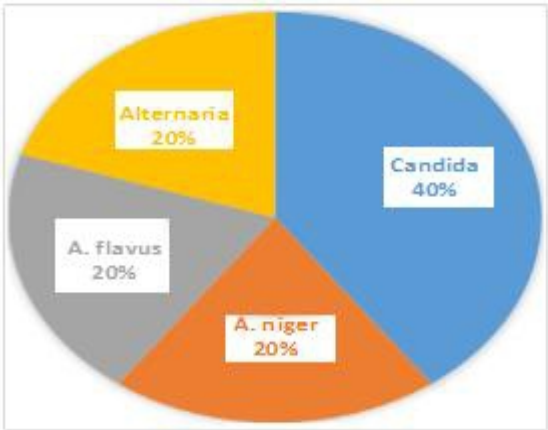


Figure 10: Percentage prevalence of isolated fungi from Oju-Ore market

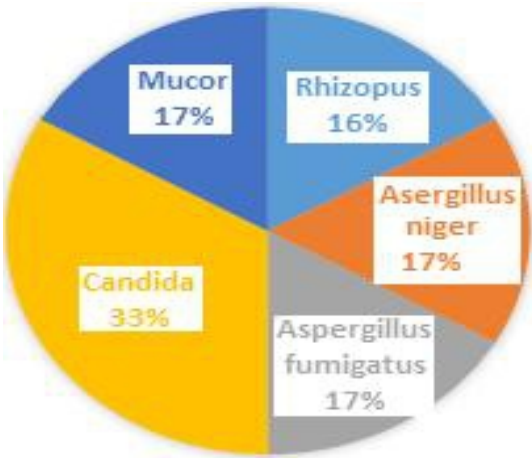


Figure 11: Percentage prevalence of isolated fungi from Iyana market

F (v) **Daramola, J. A., Alao, F. O. and Adesegun, R. A. (2023). Assay of the Bacterial flora in the Gut, Gill and Flesh of fresh Catfish (*Clarias gariepinus*).**

Abstract: This study was carried out to ascertain the bacterial flora in the gut, gill and flesh surfaces of fresh *Clarias gariepinus* purchased from four different markets located in Ota metropolis: Iyana-Iyesi, Oja-Ota, Oju-Ore and Sango-Ota. The fresh fish samples were randomly purchased from the markets and analysed using appropriate microbiological procedures. Bacterial isolates were identified based on colonial morphology, microscopy and biochemical tests. Analyses showed that the highest values of total bacteria counts (TBC) were 74.55×10^5 CFU/g in the gut, followed by that of the gill at 47.40×10^5 CFU/g and the flesh, 34.37×10^5 CFU/g; all from fresh *C. gariepinus* purchased from Oja-Ota market. There were five bacteria specie isolated from the gut, gill and flesh, namely Escherichia coli, Citrobacter spp., Salmonella spp., Shigella spp. and Proteus spp. The percentage occurrence of the bacteria species in the isolates indicated that Salmonella spp. had 36.4%, E. coli 27.3%, Citrobacter spp. 9.1%, Shigella spp. 18.1%, and Proteus spp. 9.1%. As a result of the presence of these pathogens in the fish; adoption of good fish culture standards, water quality and feeds, hygienic transportation and proper handling of fish by farmers and at the retail level by the vendors is highly recommended.

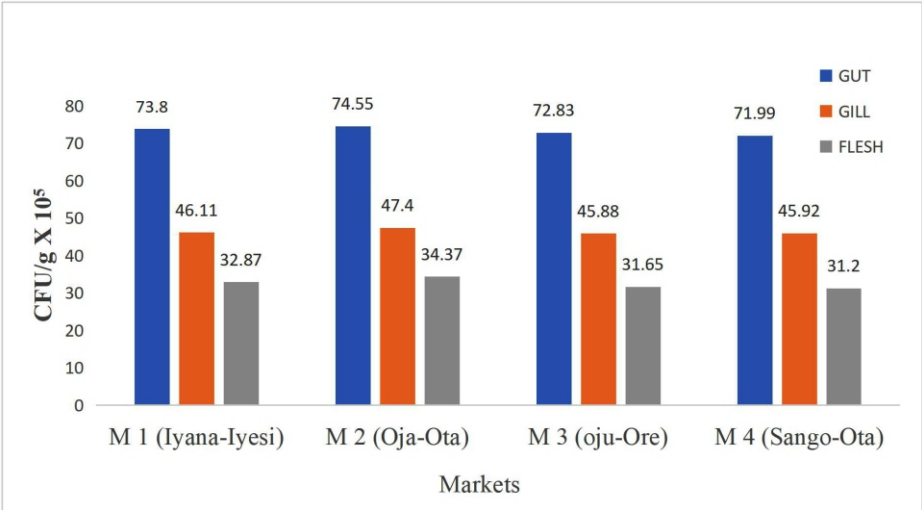


Figure 12: Mean Total Bacterial Counts (CFU/g) of the gut, gill and flesh of fresh *Clarias gariepinus*

Conclusion: This research showed that pathogenic organisms are present in different parts of fresh fish. The microbial loads of the gut, gills and flesh of catfish purchased from different markets showed that the gut had the highest microbial load, while the microbial loads of flesh was low when compared to the microbial loads of gills. The diversity of potential pathogens from the samples of fish is of concern particularly at a time when many in our communities are immunologically compromised as a result of various illnesses. The presence of this pathogens, though not at lethal levels showed there is the need for proper monitoring of the standards of fish and products in our markets. Fish ponds, rivers, lakes and different materials used for breeding catfish could be major source of contaminant. Fish feeds are known to contaminate fish pond-water which can contaminate the fish. To reduce such contamination, fish farmers should be educated more on the breeding and processing of catfish to ensure that fish pond water are properly treated and should be free of contaminants. Fish feed should be properly prepared and free of contaminants. All fish consumers should ensure that gills and gut are removed from the fish before cooking and proper washing of catfish flesh are done before cooking so as to reduce the microbial loads of fish. Also, proper and thorough cooking of catfish should be done before consuming fish.

F (vi) **Daramola J.A., Kester C.T., Abdullah M.A., Anaemene D.I. and Sodamola, M. Y. (2023). Evaluation of Bacteria of Public Health Importance in Fresh Lagoon Fish Retailed in Oyingbo Market, Lagos.**

Abstract: One of the common problems encountered by Lagoons in developing countries is that of microbiological contamination of the surface water generated by the on-shore activities. This necessitated investigating bacteria of public health importance associated with some selected fresh Lagoon fish retailled in Oyingbo market, Lagos. Catfish (*Clarias gariepinus*), Croaker (*Micropogonias undulates*) and Tilapia (*Oreochromis niloticus*) were purchased and held in cold box packed with ice for analysis. Using standard microbiological procedures, the fish samples were bacteriologically enumerated for Total Aerobic Bacterial Count (TABC), Total Staphylococcus count (TSC) and Total Coliform Count (TCC), all expressed in log CFU/g. Presence of Salmonella and Shigella was also determined and biochemically confirmed. Different culture media were used, isolation and identification were carried out using microscopy and biochemical tests. The prevalence of occurrence of the bacteria samples ranged from 3.28 ± 0.13 (*Oreochromis niloticus*) to 5.25 ± 0.22 (*Clarias gariepinus*) log CFU/g. *Staphylococcus aureus*, *Escherichia coli*, *Shigella spp*,

Salmonella spp and *Enterobacter aerogenes* were identified. The highest bacterial count recorded in the fresh fish samples are within the maximum limits recommended, implying their safe consumption. However, detection of *Escherichia coli* and *Salmonella sp.* is an object of public health concern which demands an improvement in the hygiene practices by the product handlers.

Table 6: Biochemical Characteristics used for Identification of Bacteria Isolated from the fish samples purchased from Oyingbo market Lagos State.

Gram Staining	CA	OX	GAS	CO	SL	IN	CIT	URE	H ₂ S	MO	Identified Organism
-	+	-	-	-	-	-	-	-	+	+	<i>Salmonella spp.</i>
-	-	-	+	-	-	+	-	-	-	-	<i>Shigella spp</i>
-	+	-	+	-	+	+	-	-	-	+	<i>Escherichia. coli</i>
+	+	-	-	+	-	-	-	+	-	-	<i>Staphylococcus aureus</i>
-	+	-	+	-	-	-	+	-	-	+	<i>Enterobacter spp</i>

Key: CA= catalase, OX= oxidase, CO = coagulase, SL = sulphide, IN = indole, CIT = citrate, URE = urease, MO = motility, H₂S = hydrogen sulphide, - = Negative, + = positive

Conclusion: Bacterial pathogens can contaminate seafood products anytime from post-harvest to the table. Effective methods should be adopted for control and prevention of bacterial hazards in fish industry. Other ways of preventing food-borne outbreaks due to consumption of fish is to enlighten sellers and the consumers about correct handling of food, proper preparation, and storage of fresh fish. Regular surveillance is important for assessing the effectiveness of current as well as future prevention strategies.

F (vii) **Daramola J. A., Kester C. T., Kehinde A. A. (2023). Bacterial Assessment of Retailed Smoked Edible Frog (*Hoplobatrachus occipitalis*).**

Abstract: This research work evaluated the bacteriological safety of smoked edible frog (*Hoplobatrachus occipitalis*) retailed in three selected markets in Ota metropolis, Ogun State, Nigeria. Three different markets namely Iju-Ota, Sango and Ijoko markets were visited and smoked edible frogs were procured. The study was conducted to determine if there is any potential risk of foodborne infection from consuming these smoked edible frogs by the populace. Microbiological analyses were carried out using nutrient Agar, mannitol salt agar, mac conkey agar, Salmonella shigella agar and eosin methylene blue agar

(EMBA) and conventional methods were used to identify the bacteria isolated. The results revealed that samples from Sango market had the highest heterotrophic bacterial counts and ranged from 2.57×10^7 cfu/g to 3.47×10^7 cfu/g among the three markets. Total coliform counts ranged from 1.23×10^5 cfu/g to 2.04×10^5 cfu/g, total enterobacteriaceae counts ranged from 8.91×10^2 cfu/g to 1.29×10^3 cfu/g, total staphylococcal counts ranged from 1.82×10^5 cfu/g to 2.63×10^5 cfu/g and that of *Salmonella shigella* counts ranged from 8.71×10^2 cfu/g to 1.15×10^3 cfu/g. The bacterial isolates in this study belong to six genera. Presence of these bacterial isolates is highly suggestive that these products were prepared and sold under condition that would permit the survival and multiplication of various microorganisms. Proper processing and cooking of the smoked edible frog meat will get rid of these pathogens, thereby preventing foodborne infections.



Figure 13: Smoked edible frog (*Hoplobatrachus occipitalis*)

Conclusion: The study has revealed the presence of some bacteria associated with smoked edible frogs (*Hoplobatrachus occipitalis*). The pathogens from this source of meat can be transmitted to man both actively and passively, since the smoked edible frog is veritable protein source.

F (viii) Kester, C.T., **Daramola, J.A.** and Shado, M.O. (2023). **Bacteriological Assessment of hawked ready-to-eat fried prawns retailed in selected locations of Lagos mainland.**

Abstract: Ready-to-eat (RTE) prawn product which characterizes many streets of Lagos Mainland undoubtedly exposes a large number of customers to bacteriological hazards of health risks but no ample report yet on the safety of this product in Lagos Mainland. This study examined the bacterial contaminants

of health importance in the hawked RTE prawns samples. Ten nylon-wrapped RTE prawns each were randomly selected from Oshodi (OS), Ebute-metta (EM) and Ketu (KT) vending areas of Lagos Mainland and bacteriologically enumerated for Total Aerobic Bacterial Count (TABC), Total Staphylococcus count (TSC) and Total Coliform Count (TCC), all expressed in log CFU/g. Presence of *Salmonella* and *Shigella* was also determined and biochemically confirmed. The bacterial counts differed insignificantly ($p < 0.05$) among the vending sites; lowest and highest mean TABC values (4.70 ± 0.15 , EM; 6.72 ± 0.18 , KT), TSC (4.46 ± 0.10 , KT; 5.86 ± 0.13 , OS), TCC (4.36 ± 0.13 (OS); 5.55 ± 0.06 , (OS) and TEBC (0, (EM); 5.48 ± 0.11 , OS). Biochemically identified *Staphylococcus aureus* dominated the prawn products. *Escherichia coli* were detected with traces of *Salmonella* spp. The highest bacterial counts recorded in the entire RTE fried prawn products of this study are within the maximum limits recommended, implying their safe consumption. However, detection of *Escherichia coli* and *Salmonella* sp. is an object of public health concern which demands an improvement in the hygiene practices of the product handlers.

FURTHER AREAS OF RESEARCH

Hitherto, I had thought that attaining the rank of Professor—the highest level of academic achievement—would be a position of rest. However, I have since discovered that this height is, in fact, the gateway to a chapter of unlimited work.

In light of the above, I express my profound gratitude to the one who has liberated this academic freedom and opened the doors to this new vista: Prof. J. O. Ojediran, Vice-Chancellor of Bells University of Technology, Ota. He established the Centre for Agricultural Technology and Entrepreneurial Studies (CATES), which in turn midwived the creation of the College of Food, Agricultural Science and Technology (COLFAST) and subsequently the Department of Agriculture and Agricultural Technology (AAT). I am privileged to have led the Centre, College and Department at different times through appointments by Prof. J. O. Ojediran.

By the creation of these Centre, College and Department; I have been well placed and no longer limited but opened to research collaborations across any field of study. Consequently, my focus moving forward is in the area of ensuring quality and safe fish for public health.

Specifically, this will involve research work in the areas such as:

- The effect of Phenols on Smoked Fish and the Consumer
- Investigating the consequence of microplastics and contaminants in Fish and Man
- Development of Rapid diagnostic Test for detection of Fish spoilage

Ongoing Research Works:

1. Effect of Smoke and Oven Drying Methods on the Quality and Stability of Dried Tilapia Fish (*Oreochromis niloticus*). Being supervised by **Daramola, J. A.** and Alamu, E. A.
2. Prevalence of Antibiotic Resistance Bacteria in fresh Catfish sold for Human Consumption in Ota. Being supervised by **Daramola, J. A.** and Umanu, G.

COMMUNITY AND PUBLIC ENGAGEMENTS

I. CATES - Bells Consult Pilot Fish Project

As the pioneer Director of the Centre for Agricultural Technology and Entrepreneurial Studies (CATES), my team partnered with Bells Consult Limited for the pilot fish project. Plastic tanks were purchased for fish rearing on campus for training, research and commercial purposes. Two cycles of fish culture and harvest have so far been concluded.



PROF. J. O. OJEDIRAN AT THE FISH TANKS

(ii) Newspaper Publications

VI **SUNDAY INDEPENDENT**
 December 9, 2012

Food & Beverages

Industry Watch

By **Marlene Caraballo**

Agro-waste is a by-product of agricultural processing that is often discarded or burned, contributing to environmental pollution. However, it can be transformed into a valuable resource through innovative technologies. One such technology is the agro-waste smoking machine, which is used to produce smoke for various applications, including food preservation and flavor enhancement. The machine is designed to efficiently process agro-waste, such as tobacco leaves, into high-quality smoke. This process involves the controlled burning of the waste material, which is then captured and filtered to produce a clean, consistent smoke. The resulting smoke can be used in a variety of ways, from curing meats and cheeses to infusing beverages with natural flavors. By utilizing agro-waste in this manner, the industry can reduce its environmental footprint while also creating new products and revenue streams. The agro-waste smoking machine represents a significant advancement in sustainable agricultural processing, offering a practical solution for managing waste while maximizing resource efficiency.

Gains from efficient agro-waste fish smoking machine

By **Marlene Caraballo**

Marlene Caraballo
 is a freelance writer and editor. She has written for various publications and is currently working on a book about sustainable agriculture.

The agro-waste smoking machine is a revolutionary piece of equipment that has transformed the way agro-waste is managed. It is a compact, efficient unit that can be used in a variety of settings, from small-scale operations to large industrial facilities. The machine is designed to handle a wide range of agro-waste materials, including tobacco leaves, coffee beans, and other agricultural by-products. By using the machine, users can significantly reduce the amount of waste they generate while also producing a valuable by-product. The machine's advanced features, such as its precise temperature control and efficient smoke capture system, ensure that the resulting smoke is of the highest quality. This makes it an ideal choice for anyone looking to improve their agro-waste management process while also creating new products and revenue streams.

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[illegible]

(iii) Media Stations, Lectures in Schools and Places

I have been privileged to share my academic experience as an ambassador of Bells University of Technology, Ota in the public space at different times. This I have done by delivering lectures at Primary and Secondary Schools to encourage the young minds in education and engaged with the media in dedicated interviews in the area of agriculture and agro-preneurship.

Media Outlets, Schools and Places:

Channels Television

Business Day

Daily Independent

Jordan FM

Oba FM

Little Saint Primary School, Ota

Bells Secondary School, Ota

Dalos Secondary School, Ota

Ark, Secondary School, Ota

FUTA Alumni, Ogun State



RECOMMENDATIONS

- Traditional techniques chilling, freezing, salting, smoking, drying, and fermentation remain the backbone of global fish processing. As global demand for fish continues to grow and pressure on natural fish stocks intensifies, reducing post-harvest losses through scientifically robust, economically accessible, and environmentally responsible

preservation technologies become an increasingly urgent priority.

- Future research should prioritise the translation of mechanistic understanding into practical, affordable, and culturally appropriate preservation strategies that can be deployed at scale in tropical developing-country contexts, where the burden of post-harvest fish loss is greatest and where food security stakes are highest.

ACKNOWLEDGEMENTS

I immensely thank God Almighty, who has brought me to the academic height of a Professor—the pinnacle of academic pursuit. This is a divine privilege, as the scripture declares: “For promotion cometh neither from the east, nor from the west, nor from the south. But God is the judge: He putteth down one, and setteth up another” (Psalm 75:6–7), and “A man can receive nothing, except it be given him from heaven” (John 3:27). He has been my strength and pillar; His grace, mercy, guidance, and protection have been sufficient for me. To God be the glory.

Importantly, I express my deep appreciation to my research collaborators: Dr. 'Yemi Gbadamosi (FUTA), Dr. Kehinde Sotonwa and Dr. Bolanle Opere (LASU), Dr. Dupe Sodamola, and the Bells team led by Dr. Titilayo Kester, Dr. Kazeem Akinwumi, Dr. Felix Alao, Dr. Emmanuel Olumuyiwa, Dr. Doris Anaemene, Dr. Joseph Ezike, and late Dr. Tolulope Oladosu (May his soul rest in peace).

Also, I am grateful to all who provided inputs and contributed to the review of this write-up: Dr. Felicia Yusuf, Prof. O. S. Fayomi, Prof. K. Ademola, Dr. Desmond Ighravwe, Dr. Olusegun Kasali, Dr. Olayemi Dudu, Miss Simi Enidunni, Olamide Daramola and Mrs. Bolanle Daramola.

Furthermore, I acknowledge with gratitude my teachers and friends from my early education at St. Joseph's Primary School and Anglican Grammar School, Igbara-Oke: Miss Akinola, Miss Akinmoju, Mrs. Ilori, Mr. Olowoyeye, Mr. Akodu, Ifeanyi, Emeka, Kunle, Majonagbe, and others.

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REFERENCES

- Adeparusi, E.O., **Daramola, J.A.** & Aina, E.A. (2009). Histology of the stomach and intestine of African mud catfish (*Clarias gariepinus*) fed toasted African yam bean (*Sphenostylis stenocarpa*) diets. In O. A. Fagbenro et al. (Eds.), *Conference book of abstracts of the 24th annual conference of Fisheries Society of Nigeria* (p. 49).
- Adeparusi, E.O., **Daramola, J.A.** & Badejo, S.O. (2006). Effect of cold and hot smoking of *Clarias gariepinus* on consumer preference. In Eni et al. (Eds.), *Proceedings of the 21st annual conference of Fisheries Society of Nigeria* (pp. 389–393).
- Adeyeye S.A.O., & Omoniyi S.A. (2015). Quality attributes, chemical and microbial safety of street-vended smoked West Africa Ilisha (*Ilisha africana*) from major markets in Ibadan, Oyo State, Nigeria. *International Journal of Aquaculture*, 5(32).
- Agriculture Institute. (2025). *Enzymes in autolysis: How they affect fish spoilage*. Agriculture Notes. Retrieved from <https://agriculture.institute/quality-assurance-dfpt/enzymes-autolysis-fish-spoilage/>
- Agriculture Institute. (2025). *Understanding the causes of fish spoilage*. Agriculture Notes. Retrieved from <https://agriculture.institute/fish-processing-packaging-value-addition/causes->
- Agriculture Institute. (n.d.). *Enzymes and autolysis in fish quality assurance*. <https://agriculture.institute/quality-assurance-dfpt/enzymes-autolysis-fish->
- Akinwumi, K., Osifeso, O., **Daramola, J.A.**, Onipede, O., Adedaja, A.W., Akinsola, D., & Aralamo, D. (2015). Investigation of heavy metals and oxidative stress in *Sarotherodon melanotheron* harvested at Abule-Ado Lagoon, Lagos, Nigeria. In *Book of abstracts of the International Association for Food Protection Conference* (pp. 135–203), United States.
- Alamu, E.A., **Daramola, J.A.**, & Effio, M. I. (2018). *The physico-chemical and antimicrobial studies of oleoresin extracts from selected Nigerian pepper (Capsicum frutescens) on smoked fish*. [Unpublished manuscript].
- Ali, A., Wei, S., Ali, A., Khan, I., Sun, Q., Xia, Q., & Liu, S. (2022). Research progress on nutritional value, preservation and processing of fish: A review. *Foods*, 11, 3669. <https://doi.org/10.3390/foods11223669>
- Anaemene, D. I., **Daramola, J. A.**, & Adejare, O. A. (2023). Physico-chemical and sensory evaluation of maize–pigeon pea based complementary foods fortified with milk and fish powder. *Dutse Journal of Pure and Applied*

Sciences, 9(2b), 76–85.

- Anaemene, D. I., Oni, R. A., Akinwumi, K. A., & **Daramola, J. A.** (2023). Linear growth and blood characteristics of Wistar rats fed either milk or fish-based complementary foods. *Mediterranean Journal of Nutrition and Metabolism*, 6(2), 123–137.
- Antonino, C., Difonzo, G., Faccia, M., & Caponio, F. (2024). Effect of edible coatings and films enriched with plant extracts and essential oils on the preservation of animal-derived foods. *Journal of Food Science*, 89(2), 748–772.
- Balogun, A. M., & Akegbejo-Samsons, Y. (1992). Waste yield, proximate and mineral composition of shrimp resources of Nigeria's coastal waters. *Bioresource Technology*, 40, 157–161.
- Beveridge, M. C. M. (1987). *Cage aquaculture*. Fishing News Books.
- Beveridge, M. C. M. (1996). *Cage aquaculture* (2nd ed.). Fishing News Books.
- Beveridge, M. C. M., & Stewart, J. A. (1997). Cage culture: Limitations in lakes and reservoirs.
- Biology Notes Online. (2024). *Microbial spoilage of fish and fish products and its preservation*. <https://biologynotesonline.com/preservation-and-spoilage-of-fish-and-other>
- Byrd, K. A., Fakoya, K., Akintola, S., Westlund, L., Isa, S., & Cohen, P. J. (2022). *The role of small-scale fisheries in Nigeria's food system*. WorldFish. <https://worldfishcenter.org/>
- Castrica, M., Pavlovic, R., Balzaretto, C. M., Curone, G., Brecchia, G., Copelotti, E., & Chiesa, L. M. (2021). Effect of high-pressure processing on physico-chemical, microbiological and sensory traits in fresh fish fillets (*Salmo salar* and *Pleuronectes platessa*). *Foods*, 10(8), 1775. <https://doi.org/10.3390/foods10081775>
- Cheng, L., Abraham, J., Trenberth, K. E., Boyer, T., Mann, M. E., Zhu, J., & Lu, Y. (2024). New record ocean temperatures and related climate indicators in 2023. *Advances in Atmospheric Sciences*, 41(6), 1068–1082.
- Cunnane, S. C., Plourde, M., Pifferi, F., Bégin, M., Féart, C., Barberger-Gateau, P. (2009). Fish, docosahexaenoic acid and Alzheimer's disease. Progress in lipid research. 48(5):239-256.
- Daramola, J. A.**, Kester C. T., & Kehinde A. A. (2023). Bacterial Assessment of Retailed Smoked Edible Frog (*Hoplobatrachus occipitalis*). *Dutse Journal of Pure and Applied Sciences*, 9 (2b), 50-57.
- Daramola, J.A.**, Kester C.T., Abdullah M.A., Anaemene D.I. & Sodamola, M.Y.

- (2023). Evaluation of Bacteria of Public Health Importance in Fresh Lagoon Fish Retailed in Oyingbo Market, Lagos. *Bells University Journal of Applied Sciences and Environment*, 4(1), 12-18.
- Daramola, J.A.;** Kester, C.T.& Laraiyetan, K.S. (2023). *Studies on Mycoflora Associated with Storage in Selected Fish Feed Brands Retailed in Ota*. [Unpublished Manuscript]
- Daramola, J.A.,** Kester C.T., Ayodele, D.O. (2019). *Quality and Shelf Stability of Smoked Horse Mackerel Fish (Trachurus trachurus)*. [Unpublished Manuscript]
- Daramola J.A.,** Kester C.T., & Ibironke, A.A. (2011). *Evaluation of Some Microbiological and Biochemical Qualities of Atlantic Cod (Gadus Morhua) from selected Frozen Fish Depots in Sango-Ota*. [Unpublished Manuscript]
- Daramola, J.A.,** Kester C.T., Sodamola, M.Y. & Ben-Okoh, B.J. (2019). *Comparative Studies on the effect of Oven Drying and Traditional Smoking on the Microbial Shelf Life of Atlantic Herring (Clupea harengus)*. [Unpublished Manuscript]
- Daramola, J.A.,** Sodamola, M.Y., & Kester, C.T. (2023). Prawns and shrimps: review of the aquaculture, biology, microbes and preservation. *International Journal of Multidisciplinary Research and Growth Evaluation*, 4(5), 510-516.
- Daramola, J. A,** Kester, C. T., & Allo, O. O. (2020). Smoked African Catfish (*Clarias gariepinus*) Sampled from Two Markets and Occurrence of Microbes. *European Journal of Agriculture and Food Sciences*, 2(2), 1-5.
- Daramola, J. A.** (2020). Pathogenic contaminants of fresh and processed fish: a review. *Acta SATECH*, 12(1), 52 – 65.
- Daramola, J. A.,** Alao, F. O. & Adeniyi, A. E. (2020). Estimation of Bacteria and Fungi in Smoked Catfish (*Clarias gariepinus*) available in Ota markets. *Journal of Research in Forestry, Wildlife and Environment*, 12(2), 65-73.
- Daramola, J. A.,** Alao, F. O. & Adesegun, R. A. (2023). Assay of the Bacterial flora in the Gut, Gill and Flesh of fresh Catfish (*Clarias gariepinus*). *Animal Research International*, 20(2), 4884–4891.
- Daramola, J. A.,** Fasakin, E. A., & Adeparusi, E. O. (2007). Physicochemical and sensory changes in smoke-dried fish (*Clarias gariepinus*) during ambient storage. *African Journal of Food, Agriculture, Nutrition and Development*, 7(6).
- Daramola, J. A.,** Kester, C. T. & Adeleye, A. O. (2018). Microflora Associated with Smoked Shrimps (*Farfantepenaeus Notalis*) in some markets in Ota

Metropolis, Ogun State, Nigeria. *Nigerian Journal of Fisheries*, 15(2), 1490-1496.

- Daramola, J. A.**, Kester; C. T., Osofero; S. A. & Ojiakor, C. C. (2014). Microbiological and Proximate Assessments of Cold-smoked *Gadus morhua* in Traditional Fish Smoking Centers in Ota Metropolis. *Pacific Journal of Science and Technology*. 15(1), 297-305.
- Daramola, J. A.**, Olumuyiwa, E. O. & Obi, E. C. (2022). Incidence of Pathogenic Bacteria in Frozen Mackerel (*Scomber scombrus*) retailed in Ota Metropolis. *Bells University Journal of Applied and Environment*, 3(1), 23-29.
- Daramola, J. A.**, Osofero S. A., Kester, C.T., & Gbadamosi, O.K. (2007). Overview of the Status of Aquaculture in Nigeria with Reference to Ekiti State. *Agricultural Journal*, 2(3), 447-452.
- Daramola, J. A.**, Osofero, S. A., Kester, C. T., & Gbadamosi, O. K. (2007). The state of aquaculture in Nigeria: A review with particular reference to Ekiti State, South-West Nigeria. *Agricultural Journal*, 2(5), 1–6.
- Daramola, J. A.**, Sodamola, M. Y., Muhammad, A. M. & Oladosu, T. O. (2023). Implication of Processing and Handling Methods to the Microbial Quality of Stored Fried Atlantic Cod. *Nigerian Agricultural Journal*, 54(1), 1-13.
- Daramola, J. A.**, Kester, C. T., & Adonkie, D. A. (2023). Antifungal Potential of Black Mangrove Leave Extracts on Isolates of Smoked Bonga Fish Sampled from Oju-Ore and Iyana Markets. *Journal of Applied Sciences and Environmental Management*, 27(4), 703-708.
- Daramola, J.A.**, Alao, F.O., Osofero, S.A. & Wemimo, O.O. (2014). Assessment of the Microbial and Sensory Qualities of Smoked African Catfish (*Clarias gariepinus*). *Journal of Agriculture and Environmental Sciences*, 3(1), 11–22.
- Daramola, J.A.**, Fasakin, E.A. & Adeparusi, E.O. (2007). Changes in physicochemical and sensory characteristics of smoke-dried fish species stored at ambient temperature. *African Journal of Food, Agriculture Nutrition and Development*, 7(6), 1-16.
- Daramola, J.A.**, Kester, C.T. & Allo, O.O. (2013). Biochemical Evaluation of Hot-Smoked African Catfish (*Clarias gariepinus*) Sampled from Sango and Ota Markets in Ogun State. *Pacific Journal of Science and Technology*, 14(1), 380-386.
- Daramola, J.A.**, Oladosu, T.O. & Ismail, K.S. (2020). Fermentation and Effect on the Microbial Loads of Atlantic Cod, *Gadus morhua*. *Journal of Applied Sciences and Environmental Management*, 24(3), 455-458.
- Daramola, J.A.**, Olumuyiwa, E.O., & Omo-Emevor, P.O. (2020). Spoilage

- organisms in smoked Atlantic cod (*Gadus morhua*) from different sources. *Sumerianz Journal of Agriculture and Veterinary*, 3(6), 80-84.
- Dietetics Academy. (2025). *Fish spoilage: Microbes, chemical changes, and storage tips*. <https://dietetics.academy/food-microbiology-safety/fish-spoilage-microbes-chemical->
- EAT-Lancet Commission 2.0. (2024). *Healthy diets from sustainable aquatic food systems*. EAT Forum.
- Ezike, J. O. J., Adeyiga, J. A., Aderinko, O. M., **Daramola, J. A.**, Kester, C., & Orhokomua, E. E. (2013). A neural network system for determining the optimal profitability of smoked fish business in Nigeria. *Computing, Information Systems, Development Informatics & Allied Research Journal*, 4(4), 39–46.
- Fagbenro, O. A. (1999). Comparative evaluation of heat-processed winged bean (*Psophocarpus tetragonolobus*) meals as partial replacement for fish meal in diets of the African catfish (*Clarias gariepinus*). *Aquaculture*, 170, 297–305.
- Famurewa, J. A. V., Akise, O. G., & Ogunbodede, T. (2017). Effect of storage methods on the nutritional qualities of African catfish (*Clarias gariepinus*). *African Journal of Food Science*, 11(7). <https://doi.org/10.5897/AJFS2016.1514>
- Food and Agriculture Organization of the United Nations. (2021). *The state of world fisheries and aquaculture: Sustainability in action*. FAO.
- Food and Agriculture Organization of the United Nations. (2022). *The state of world fisheries and aquaculture 2022*. <https://www.fao.org/publications/sofia>
- FAO/WHO Global Individual Food consumption data Tool. (2023). *Aquatic food composition database*. FAO. <https://www.fao.org/gift-food/>
- Fasakin, E. A., **Daramola, J. A.**, & Famurewa, J. A. V. (2009). Development of a model rotatory fish smoking kiln using agro-wastes as source of fuel. In Fagbenro et al. (Eds.), *Conference proceedings of the 24th Annual Conference of the Fisheries Society of Nigeria* (pp. 148–151). Akure, Nigeria.
- Fayomi, O. S., Musa, A. I., & **Daramola, J. A.** (2022). Design and fabrication of hybrid cabinet dryer. [Unpublished manuscript].
- Federal Office of Statistics. (1987). *Publication*.
- Fleming, A., Vanclay, F., Hiller, C., & Kelly-Moriarty, S. (2020). Minimizing negative impacts.
- Food and Agriculture Organization of the United Nations. (1998). *Fisheries*

statistics. FAO.

- Gbadamosi, K., & **Daramola, J. A.** (2007). Quantitative requirements of dietary ascorbic acid supplementation in the diets of African catfish (*Clarias gariepinus*) fingerlings. *Journal of Animal and Veterinary Advances*, 16(1), 90–93.
- Gbadamosi, O. K., **Daramola, J. A.**, & Osungbemi, N. R. (2007). Growth performance and nutritional utilization efficiency of vitamin C in the diets of African catfish (*Clarias gariepinus*) fingerlings. *Acta Zoologica Sinica*, 53(4), 763–766.
- Golden, C. D., Koehn, J. Z., Shepon, A., Passarelli, S., Free, C. M., Viana, D. F., & Thilsted, S. H. (2021). Aquatic foods to nourish nations. *Nature*, 598(7880), 315–320. <https://doi.org/10.1038/s41586-021-03917-1>
- Gram, L., & Dalgaard, P. (2002). Fish spoilage bacteria—problems and solutions. *Current Opinion in Biotechnology*, 13(3), 262–266. [https://doi.org/10.1016/S0958-1669\(02\)00309-9](https://doi.org/10.1016/S0958-1669(02)00309-9)
- Hussain, M. A., Sumon, T. A., Mazumder, S. K., Ali, M., Jang, W. J., Abualreesh, M. H., Ibrahim, M. A., Kamilu, M., & Maiyanga, I. E. (2024). The role of post-harvest technologies in the handling and preservation of fish and fish products in Nigeria: A mini-review. *Journal of Agricultural and Allied Applied Sciences*, 1(1).
- Ismail, L., Nartea, A., Fanesi, B., Lucci, P., Pacetti, D., Jaeger, H., & Schottroff, F. (2025). Effect of high-pressure processing on color, texture and volatile profile during sardine refrigeration. *Foods*, 14(2), 329. <https://doi.org/10.10339/foods14020329>
- Ita, E. O., Sado, E. K., Balogun, J. K., Pandogari, A., & Ibitoye, B. (1985). Inventory survey of Nigeria inland waters and their fisheries resources: A preliminary checklist of inland water bodies in Nigeria. *Kainji Lake Research Institute Technical Report Series*. New Bussa, Nigeria.
- Kester, C. T., **Daramola, J. A.**, Alao, F. O., & Chukwu, C. B. (2024). *Listeria* species and occurrence in retailed smoked fish samples in selected Ota markets. *Journal of Research in Forestry, Wildlife and Environment*, 16(3).
- Kester, C. T., Essien, E. R., Akinwumi, K. A., **Daramola, J. A.**, & Iraye, P. U. (2024). Microbiological quality of *Gadus morhua* treated with silver nanoparticles synthesized using *Launaea taraxacifolia* leaves. *Tropical Journal of Natural Product Research*, 8(4), 6989–6994.
- Kester, C. T., **Daramola, J. A.**, & Shado, M. O. (2023). Bacteriological assessment of hawked ready-to-eat fried prawns retailed in selected locations of Lagos

- Mainland. *Dutse Journal of Pure and Applied Sciences*, 9(2a), 290–300.
- Kester, C. T., **Daramola, J. A.**, Oni, P. I., & Oshinaya, S. O. (2013). Effect of smoking duration on the microbiological quality of cold-smoked Atlantic cod (*Gadus morhua* Linnaeus, 1758). *Journal of Fisheries and Aquatic Science*, 8(1), 196–201.
- Kester, C. T., Osofero, S. A., & **Daramola, J. A.**, (2007). Assessment of the fisheries potential of Ero Reservoir, Ekiti State, Nigeria. *European Journal of Scientific Research*, 16(1), 145–153.
- Kondejewski, L. H., Farmer, S. W., Wishart, D. S., Hancock, R. E. W., & Hodges, R. S. (1996). Gramicidin S is active against both Gram-positive and Gram-negative bacteria. *International Journal of Peptide and Protein Research*, 47(6), 460–466.
- Kontominas, M. G., Badeka, A. V., Kosma, I. S., & Nathanailides, C. I. (2021). Innovative seafood preservation technologies: Recent developments. *Animals*, 11(1), 92. <https://doi.org/10.3390/ani11010092>
- Kontou, A., Kourti, M., Iosifidis, E., Sarafidis, K., & Roilides, E. (2023). Use of newer and repurposed antibiotics against Gram-negative bacteria in neonates. *Antibiotics*, 12(6), 1072. <https://doi.org/10.3390/antibiotics12061072>
- Lázaro, C. A., Monteiro, M. L. G., & Conte-Junior, C. A. (2020). Combined effect of modified atmosphere packaging and UV-C radiation on pathogen reduction, biogenic amines, and shelf life of refrigerated tilapia (*Oreochromis niloticus*) fillets. *Molecules*, 25(14), 3222. <https://doi.org/10.3390/molecules25143222>
- Leistner, L. (2000). Basic aspects of food preservation by hurdle technology. *International Journal of Food Microbiology*, 55(1–3), 181–186. [https://doi.org/10.1016/S0168-1605\(00\)00161-6](https://doi.org/10.1016/S0168-1605(00)00161-6)
- Li, X., & Menchynska, A. A. (2025). World fish product raw material production base and market characteristics. *Scientific Bulletin*.
- Majumdar, R. K. (2019). Advances in fish processing technology. In *Technologies for value addition in food products and processes* (pp. 163–190). Apple Academic Press.
- Maribel, P., Miguel, A. O., José, L. A., George, M. H., & Keiko, S. (2002). Feasibility of fishmeal replacement by shrimp head silage protein hydrolysate in Nile tilapia (*Oreochromis niloticus* L.) diets. *Journal of the Science of Food and Agriculture*, 82.
- Marine Policy. (2020). Determinants of fish catch and post-harvest fish spoilage in small-scale marine fisheries in the Bagamoyo District, Tanzania. *Marine Policy*, 111, 103719. <https://doi.org/10.1016/j.marpol.2019.103719>

- Melarcodé, H. S., Ertugrul, O., Alzate Calderon, P. C., Kerry, J. P., & Morris, M. A. (2025). Advanced biodegradable antimicrobial coatings by combining biopolymers and natural antimicrobials for active packaging and extending the shelf-life of fish and other seafood products: A review. *International Journal of Food Science and Technology*, 60(2), vvaf168. <https://doi.org/10.1111/ijfs.16800>
- Science Publishing Group. (n.d.). Microbiological quality and safety of fish and fish products. <https://www.sciencepublishinggroup.com/>
- Mozaffarian, D., & Rimm, E. B. (2006). Fish intake, contaminants, and human health: Evaluating the risks and the benefits. *JAMA*, 296(15), 1885–1899. <https://doi.org/10.1001/jama.296.15.1885>
- Nie, X., Zhang, R., Cheng, L., Zhu, W., Li, S., & Chen, X. (2022). Mechanisms underlying the deterioration of fish quality after harvest and methods of preservation. *Food Control*, 135, 108805. <https://doi.org/10.1016/j.foodcont.2021.108805>
- Nwanna, L. C. (2003). Nutritional value and digestibility of fermented shrimp head waste meal by African catfish (*Clarias gariepinus*). *Pakistan Journal of Nutrition*, 2(6), 339–345.
- Nwanna, L. C., & Daramola, J. A. (2000). Harnessing shrimp head waste in Nigeria for low-cost production of tilapia (*Oreochromis niloticus* L.). In K. Fitzsimmons & J. C. Filho (Eds.), *Tilapia aquaculture in the 21st century: Proceedings of the 5th International Symposium on Tilapia in Aquaculture* (pp. 174–178). Rio de Janeiro, Brazil.
- Olutayo, K. O., Daramola, J. A., & Obidire, E. T. (2023). Sensory evaluation and nutritional value of wheat flour enriched with fish flour in bread making. [Unpublished manuscript].
- Olutayo, K. O., Daramola, J. A., & Odukoya, O. F. (2023). Organoleptic and nutritional value of fish roll made from different fish species. [Unpublished manuscript]..
- Onyeka, N. C. (2025). Advances in post-harvest fish processing: An appraisal of traditional and modern smoking techniques for improved quality and efficiency. *International Journal of Fisheries and Aquatic Studies*, 5(9).
- Opere, B. O., Daramola, B. E., & Daramola, J. A. (2018). Assessment of bacteria on some cold-smoked fish in five markets in Ado-Odo LGA, Ogun State. *Nigerian Journal of Fisheries*, 15(2), 1485–1489.
- Osofero, S. A., Otubusin, S. O., Daramola, J. A., Obasa, S. O., & Idowu, O. M. O. (2014). Performance of Nile tilapia (*Oreochromis niloticus*) under two

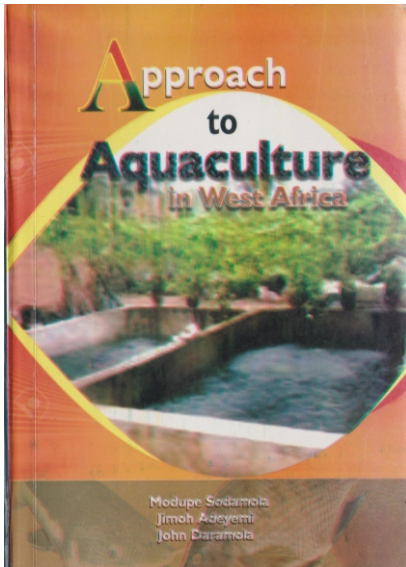
- polyculture systems in bamboo cages in a freshwater reservoir. *Journal of Agriculture and Biodiversity Research*, 3(2), 27–35.
- Osofero, S. A., Otubusin, S. O., & **Daramola, J. A.** (2009). Effect of stocking density on tilapia (*Oreochromis niloticus*, Linnaeus 1757) growth and survival in bamboo-net cage trials. *African Journal of Biotechnology*, 8(7), 1322–1325.
- PMC. (2024). *Effect of specific spoilage organisms on the degradation of ATP-related compounds*. <https://www.ncbi.nlm.nih.gov/pmc/>
- PMC. (2025). *Freshness and spoilage patterns of wild and farmed tropical fish species and preservation of fish and fishery products: A comprehensive review*. *Food Control*, 126, 108000. <https://doi.org/10.1016/j.foodcont.2021.108000>
- Qiu, X., Mei, J., & Xie, J. (2026). Effect of plasma-activated water pre-treatment combined with high-CO₂ modified atmosphere packaging on the quality and microbial profile of half-smooth tongue sole (*Cynoglossus semilaevis*) during superchilling storage. *Foods*, 15(3), 529. <https://doi.org/10.3390/foods15030529>
- Rode, T. M., & Hovda, M. B. (2016). High pressure processing extends the shelf life of fresh salmon, cod and mackerel. *Food Control*, 70, 242–248. <https://doi.org/10.1016/j.foodcont.2016.05.045>
- Roobab, U., Fidalgo, L. G., Arshad, R. N., Khan, A. W., Zeng, X. A., Bhat, Z. F., & Aadil, R. M. (2022). High-pressure processing of fish and shellfish products: Safety, quality, and research prospects. *Comprehensive Reviews in Food Science and Food Safety*, 21(4), 3297–3325. <https://doi.org/10.1111/1541-4337.12941>
- Shahidi, F., & Ambigaipalan, P. (2018). Omega-3 polyunsaturated fatty acids and their health benefits. *Annual Review of Food Science and Technology*, 9, 345–381. <https://doi.org/10.1146/annurev-food-111317-095850>
- Siddiqui, S. A., Abdullah, Bahmid, N. A., Khatkar, A., Bazkiaei, A., Awuchi, C. G., & Kumari, S. (2024). Applying innovative technological interventions in the preservation and packaging of fresh seafood products to minimize spoilage: A systematic review and meta-analysis. *Heliyon*, 10(8), e29066. <https://doi.org/10.1016/j.heliyon.2024.e29066>
- Sivertsvik, M., Jeksrud, W. K., & Rosnes, J. T. (2002). A review of modified atmosphere packaging of fish and fishery products—significance of microbial growth, activities and safety. *International Journal of Food Science and Technology*, 37(2), 107–127.

- Sotonwa, K. A., **Daramola, J. A.**, & Mbaja, H. U. (2023). Development of a recurrent neural network to analyse computational records of smoked fish mongers. [Unpublished manuscript].
- Speranza, B., Racioppo, A., Bevilacqua, A., Buzzo, V., Marigliano, P., Mocerino, E., & Sinigaglia, M. (2021). Innovative preservation methods improving the quality and safety of fish products: Beneficial effects and limits. *Foods*, 10(11), 2854. <https://doi.org/10.3390/foods10112854>
- Tavares, J., Martins, A., Fidalgo, L. G., Lima, V., Amaral, R. A., Pinto, C. A., & Saraiva, J. A. (2021). Fresh fish degradation and advances in preservation using physical emerging technologies. *Foods*, 10(4), 780. <https://doi.org/10.3390/foods10040780>
- U.S. Department of Agriculture & U.S. Department of Health and Human Services. (2020). *Dietary guidelines for Americans, 2020–2025* (9th ed.). <https://www.dietaryguidelines.gov/>
- U.S. Department of Agriculture, Agricultural Research Service. (2023). *FoodData Central*. <https://fdc.nal.usda.gov/>
- UN Nutrition. (2025). *Guidance on Aquatic Foods in National Dietary Guidelines*. Rome: UN Nutrition.
- UN Nutrition. (2021). *The role of aquatic foods in sustainable healthy diets*. <https://unnutrition.org/>
- U.S. Department of Agriculture, Agricultural Research Service. (2023). *FoodData Central*. <https://fdc.nal.usda.gov/>
- World Bank. (2019). *Fish to 2030: Prospects for fisheries and aquaculture* (Agriculture and Environmental Services Discussion Paper 03). <https://opneknowledge.worldbank.org/>
- World Bank. (2023). *The hidden harvest: The global contribution of capture fisheries*. <https://opneknowledge.worldbank.org/>
- WorldFish. (2024). *Annual report: Aquatic foods for zero hunger*. <https://worldfishcenter.org/>
- Wu, G., Ding, Z., Wang, J., & Xie, J. (2025). Frontier research on the risk of spoilage microorganisms in refrigerated marine fish: From regional to global perspectives. *International Journal of Food Microbiology*, 111465.
- Xi, Z., Chen, W., Guo, X., He, W., Ding, Y., Hong, B., & Gui, T. (2025). The rise and potential of large language model based agents: A survey. *Science China Information Sciences*, 68(2), 121101.
- Xia, T., Gong, C., & Zeng, J. (2023). Publication review of Food Quality and Safety during 2017–2022. *Food Quality and Safety*, 7, fyad062.

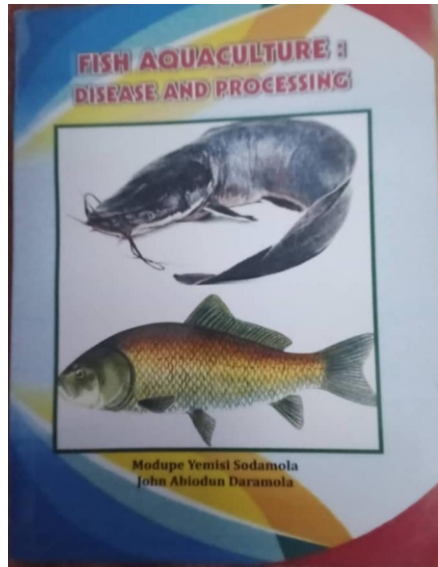
- Zhang, C., Bengio, S., Hardt, M., Recht, B., & Vinyals, O. (2021). Understanding deep learning (still) requires rethinking generalization. *Communications of the ACM*, 64(3), 107–115. <https://doi.org/10.1145/3446776>
- Zhang, P., You, X., Liu, R., & Xie, D. (2025). Advances in the application of edible antimicrobial coatings and films for fish preservation. *Journal of Food Science*, 90(12), e70729. <https://doi.org/10.1111/1750-3841.70729>
- Zhang, Z., Wu, R., Gui, M., Jiang, Z., & Li, P. (2021). Identification of the specific spoilage organism in farmed sturgeon (*Acipenser baerii*) fillets and its associated quality and flavour change during ice storage. *Foods*, 10(9), 2021. <https://doi.org/10.3390/foods10092021>
- Zheng, L., Reed, B. R., DeCarli, C., & Jagust, W. J. (2016). Association of serum docosahexaenoic acid with cerebral amyloidosis. *JAMA Neurology*, 73(10), 1208–1216. <https://doi.org/10.1001/jamaneurol.2016.2024>
- Zhong, V. W., Van Horn, L., Greenland, P., Carnethon, M. R., Ning, H., Wilkins, J. T., Lloyd-Jones, D. M., & Allen, N. B. (2020). Associations of processed meat, unprocessed red meat, poultry, or fish intake with incident cardiovascular disease and all-cause mortality. *JAMA Internal Medicine*, 180(4), 503–512. <https://doi.org/10.1001/jamainternmed.2019.6969>
- Zhuang, S., Liu, Y., Gao, S., Tan, Y., Hong, H., & Luo, Y. (2023). Mechanisms of fish protein degradation caused by grass carp spoilage bacteria: A bottom-up exploration from the molecular level, muscle microstructure level, to related quality changes. *Food Chemistry*, 404, 134309. <https://doi.org/10.1016/j.foodchem.2022.134309>

SELECTED PICTURES

1ST TEXTBOOK



2ND TEXTBOOK



Presenting the FUTA smoking Kiln at the FISON Conference in Akure, Ondo State



Presenting a Research Paper at International Conference (ABEMS-18), Slough, London, UK (2018)



Photograph with my father: Late (Engr.) J. I. Daramola after 1st degree in FUTA (2000)



Photograph with my mother: Dcns F. M. Daramola after 2nd degree in FUTA (2005)



Photograph with my nuclear family after the 3rd degree in FUTA

INAUGURAL LECTURE SERIES.

(June 25, 2015 - March 25, 2026)

1. The 1st Inaugural Lecture titled: "Food Product Development, Quality Assurance and Nutrition: Whither the Humane Senses?" by Professor Olugbenga A. Ben Ogunmoyela of the Department of Food Sciences and Technology. June 25, 2015.
2. The 2nd Inaugural Lecture titled: "Crisis in Forest Conservation in Nigeria: Threats to Livelihoods and Human Survival" by Professor Gbadebo Jonathan Osemeobo of the Department of Biological Sciences. January 13, 2016.
3. The 3rd Inaugural Lecture titled: "Minerals, Metals & Materials: The Hidden Wealth of A Nation" by Professor Gabriel Oladipo Oluwadare of the Department of Biomedical Engineering. May 18, 2016.
4. The 4th Inaugural Lecture titled: "Fungal Impact on Man: From Waste to Health" by Professor Olubukola Kuforiji of the Department of Biological Sciences. March 8, 2017.
5. The 5th Inaugural Lecture titled: "Chemistry is Reaction: Reaction is Chemistry" by Professor Violette Nkechi Atasie of the Department of Chemical and Food Sciences. March 7, 2018.
6. The 6th Inaugural Lecture titled: "Man and Materials: The indivisible Entities" by Professor Ojo Sunday Fayomi of the Department of Mechanical Engineering. March 14, 2025.
7. The 7th Inaugural Lecture titled: "My Nigeria Food Story: Scarcity in the Midst of Plenty" by Professor Ngozi Ugo Arisa, Department of Food Science and Technology. September 24, 2025.
8. The Eighth (8th) Inaugural Lecture titled: "Radiation and Human Well-being: A Doubled-Edged Sword in our World – Balancing the Benefits and Risks" by Augustine Kolapo Ademola Professor of Radiation and Health Physics, Deputy Dean, COLNAS. Wednesday, 8th October, 2025
9. The Ninth (9th) Inaugural Lecture titled: "At the Crossroads of Hunger and Sustainability: Environmental and Management Paradigms in Aquaculture and Artisanal Fisheries" by Augustine Omoike, Mfs, MANIFS, Professor of Aquaculture and Fisheries Management, Dean, College of Food, Agricultural Science & Technology. Wednesday, 25th March, 2026
10. The Tenth (10th) Inaugural Lecture titled: "From Water to the Table: Securing Safe and wholesome Fish for Public Health" by John Abiodun Daramola, Mfison, Mafs, Professor of Fish Post-Harvest Quality and Utilisation, HOD, Department of Agriculture and Agricultural Technology. Wednesday, 24th June, 2026

