www.theajfarm.com

Volume 6, Issue 2, 2021/22
ISSN: 2672-4197 (Print)
ISSN: 2627-4200 (Online)
Pages 48-70

Some Methods of Processing Fish: Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis in Nigeria.

AGBEJA, Y.E.

Department of Aquaculture and Fisheries Management, University of Ibadan, Ibadan, Nigeria
Corresponding author: eniolagbeja@yahoo.com

Abstract

Fish processing and preservation play a crucial role in reducing post-harvest losses and enhancing food security in Nigeria. This paper presents a comprehensive SWOT analysis of key fish processing methods, including freezing, heat-based curing, canning, extrusion cooking, coated/fried products and fermentation, with emphasis on their application in the Nigerian context. It highlights the strengths of these technologies in extending shelf-life, improving market value, and supporting aquaculture development. However, it also identifies significant weaknesses such as infrastructure deficits, high capital costs, and food safety concerns. Opportunities for innovation and market expansion, through improved technologies, value-added product development, and domestic industrialization are explored alongside threats including economic instability, environmental challenges, and shifting consumer preferences. By critically evaluating each method's viability, this study underscores the need for policy support, investment in infrastructure, and adoption of modern techniques to ensure sustainable fish consumption and production in Nigeria

Keywords: sustainable fish consumption, Fish processing, preservation Value addition, Post-harvest losses, Food security

INTRODUCTION

Fishes are nutritious, tasty, easily digestible, and they appeal to a broad cross-section of the world's population (FAO, 2012). According to FAO (2010) fisheries and aquaculture supply average animal protein intake of 20In the fishery system, adding value by processing represents a secondary industry and the trend in fish processing is generally driven by consumer demand and technological advances (Engle and Quagrainie, 2006). As fishes are highly perishable commodity because immediately after capture or harvest, several chemical and biological changes in the fish flesh cause spoilage which will lead to rejection for human consumption. Therefore, the shelf life of fishes are prolonged and nutritional properties conserved through processing. In addition, adding value supports fish producers in recovering part of the value of the product, that are usually generated further down the value chain. Nigeria is endowed with numerous marine and freshwater fish species (over 100 species) and a very promising aquaculture industry.

Production from the aquaculture sector of Nigeria will definitely increase in years to come, as the government is committed to increase capacity in the sector. The Nigerian government has established a policy that mandates all companies that are into fish and seafood importation to also practise aquaculture (USDA,2014).

There are a great variety of forms that fish

can be processed to provide product form which meets preferences of consumers. Fish can be distributed as live, fresh, chilled, frozen, heat-treated (thermal energy), fermented, dried, smoked, salted, pickled, boiled, fried, freeze-dried, minced, powdered or canned, or as a combination of two or more of these forms. These many options available to processing of fish accommodate a wide range of consumer tastes and presentation preferences, thereby making fish one of the most versatile food commodities (FAO, 2012).

However, notwithstanding technical changes and innovations, a country like Nigeria has challenges such as insufficient supply of electricity, potable water, availability of good roads, insufficient ice plants, cold rooms and refrigerated transport. These factors, combined with tropical weather temperatures, contribute to a high percentage of fish and seafood post-harvest losses and quality deterioration. Also, in Nigeria market facilities and infrastructures are quite limited and congested, increasing the difficulties of marketing perishable goods.

This paper highlights the strengths, weaknesses, opportunities, and threats (swot analysis) regarding some contemporary fish processing and preservation methods with a view to highlighting areas that can be further enhanced in the Nigerian food processing industry towards achieving sustainable consumption.

CONTEMPORARY FISH PROCESSING AND PRESERVATION METHODS.

FREEZING

Freezing is the most widespread method of fish preservation globally. As of 2016, freezing accounted for about 56% of all processed fish for human consumption and roughly 27% of total fish production (FAO, 2018). In absolute terms, over 88% of world fish production is now used directly for human food (rather than fishmeal or other uses), reflecting the importance of frozen and other processed forms in reaching consumers. Advances in refrigeration technology have greatly expanded the frozen fish trade, enabling fishing vessels to remain at sea longer and preserve large catches for broader markets. Frozen fish products (fillets, portions, etc.) are now available year-round worldwide, irrespective of season or location, making marine fish accessible even to populations far from coasts. This convenience and extended shelf-life (often over a year if properly stored) make freezing a cornerstone of the modern seafood industry. Nigeria's Frozen Fish Landscape: Nigeria relies heavily on frozen fish to meet its protein needs. With domestic fisheries and aquaculture supplying only about 30–40% of the national fish demand, the country is a net importer of frozen fish. In 2020 alone Nigeria spent over $876 million on frozen fish imports (excluding fillets), while exports were negligible (TrendEconomy, 2021). Imported frozen mackerel, herring, and other species make up roughly 40% of all fish consumed in Nigeria (Ojo, et.al. 2018). This reliance is driven by Nigeria's large and growing population and the affordability of frozen fish relative to fresh fish or meat. Studies indicate that aside from fresh fish, most Nigerian consumers prefer frozen fish over other processed forms like smoked or dried fish, due to its availability and ease of preparation (Famiodu and Agbeja, 2007). Frozen fish in Nigerian markets comes from four main sources: distant-water industrial fleets, inshore artisanal catches, direct imports, and more recently local aquaculture production (e.g. frozen catfish) (Agbeja, 2004, Subasinghe, et.al, 2021). The frozen fish and seafood enterprises are very lucrative businesses in Nigeria. A number of studies have been carried out on the economics of marketing frozen fish and seafood products in Nigeria and results from their studies reveal that the business is quite lucrative with profit margin up to 21%. (Agbeja, 2004; Agom et.al., 2012; Esiobu and Onubuogu, 2014). However, freezing operations in Nigeria face significant challenges. The foremost issue is infrastructure, partic-

ularly the high cost of cold storage due to an unreliable power supply. Many operators must invest in generators and expensive diesel fuel to maintain freezing facilities, driving up costs and risking product quality during outages. Market infrastructure is often congested and lacking sufficient cold chain capacity, leading to post-harvest losses in hot tropical conditions. Another challenge is policy inconsistency – the government has periodically imposed import restrictions on frozen fish to protect local producers (The FishSite, 2014). These sudden restrictions or tariff changes create uncertainty for importers and can lead to supply shortfalls or price spikes.

Freezing-SWOT Summary

Strengths

Freezing dramatically extends the shelf-life of fish while preserving nutritional value. Properly frozen seafood can be stored for many months (often well over a year), allowing surplus catches to be stockpiled and transported long distances. This ensures a stable, year-round supply of seafood even to inland areas (FAO, 2018). Frozen fish is also convenient for consumers – it is typically sold already gutted, filleted, or portioned, requiring minimal preparation. Nutritionally, frozen fish can be just as wholesome as fresh fish if handled correctly, retaining its proteins and healthy omega-3 fatty acids. Freezing effectively pauses microbial and enzymatic activity at the moment of processing, maintaining quality. For the industry, freezing enables economies of scale and global trade in fish commodities. It also helps stabilize prices by storing fish during high-catch periods and releasing inventory during off-seasons.

Weaknesses

The quality of frozen fish depends on strict temperature control; any break in the cold chain (partial thawing and refreezing) can cause texture damage, freezer burn, and loss of flavor. Without reliable electricity and infrastructure, maintaining sub-zero storage is challenging – a major weakness in countries like Nigeria. The high cost of generators and fuel for cold storage in Nigeria squeezes profit margins and can make frozen fish more expensive by the time it reaches consumers. Some Nigerian consumers perceive frozen fish as inferior to live or freshly caught fish – a cultural bias favoring "fresh" attributes – so frozen products must overcome that market perception. Additionally, Nigeria's heavy reliance on imported frozen fish makes supply and prices vulnerable to foreign exchange rates and global market fluctuations. If the naira weakens or international fish prices rise, frozen fish becomes less affordable locally. Lastly, freezing does not eliminate all food safety issues – while it halts bacterial growth, any contaminants or spoilage present before freezing (e.g. toxins or decay in the fish) will persist, so the input fish must be of good quality.

Opportunities

There is room for innovation in Nigeria's frozen fish market. Companies could develop ready-to-cook frozen fish meals (for example, pre-marinated fish steaks or microwavable seafood dishes) to attract busy urban consumers. Improved packaging, such as vacuum-sealed packs or individually quick-frozen (IQF) pieces, can make frozen fish more appealing and easier to use. The rise of e-commerce and online grocery delivery in Nigerian cities is another opportunity: sellers can use insulated packaging and cold-chain delivery to broaden distribution of frozen seafood, reaching customers in smaller towns and offering a wider variety of products. Health and nutrition trends can be leveraged by marketing frozen fish as a healthy protein source (rich in omega-3s and low in cholesterol) for diet-conscious consumers, which may help counter any negative perceptions about "freshness." Additionally, Nigeria's large population and growing middle class mean demand for protein will keep rising – this can justify investments in domestic freezing capacity. For instance, investing in modern freezer trawlers for Nigerian fisheries or building in-country processing plants to freeze locally farmed fish (catfish, tilapia) could create jobs and reduce import dependency. There is also scope for public–private partnerships to es-

tablish cold-chain infrastructure. Building cold storage hubs at major fishing ports or markets (possibly with government support) would improve the availability of high-quality frozen fish nationwide. Such investments would not only improve food security but could eventually enable Nigeria to export value-added frozen seafood to neighboring countries.

Threats

Frozen fish faces competition from multiple fronts. Fresh fish (when available) is often preferred by consumers, so if local fresh supply increases, demand for frozen imports may fall. Other protein sources like poultry or beef – sometimes cheaper or more culturally appropriate for certain meals – also compete with fish in the diet. Economic volatility is another threat: during recessions or periods of high inflation, consumers might cut back on pricier imported foods, and the government could impose currency controls that make it harder for importers to buy frozen fish abroad. Supply-side threats include environmental and regulatory pressures: if international fishing quotas tighten or exporting countries face bans (due to overfishing concerns), the frozen fish Nigeria imports (e.g. mackerel, herring) could become scarcer or more expensive. Food safety scares and public perception issues are also risks – for example, if media reports emerged about unsafe practices in imported frozen fish (such as use of harmful preservatives or selling fish that had thawed and been refrozen), consumer confidence could drop sharply. In Nigeria, any incident of people falling ill from poorly handled frozen fish could hurt the market. Finally, policy instability remains a looming threat. If the government suddenly bans imports or changes import duties without warning (as has happened in the past), it would disrupt supply chains and deter the private investment needed to expand cold-chain infrastructure. This unpredictability makes business planning difficult and could slow the growth of the frozen fish sector.

HEAT-BASED PROCESSING METHODS

Heat application is among the oldest and most reliable means of preserving fish. Broadly, these methods use thermal energy to inactivate spoilage microbes and enzymes. Traditional techniques like drying and smoking use moderate heat (often well below 100°C) to remove moisture and create acidic or smoky conditions that inhibit bacteria. More modern processes like canning involve high heat ($> 100\,^{\circ}\mathrm{C}$) to achieve commercial sterility, while emerging technologies like retort pouches combine heat with specialized packaging. In developing countries lacking cold-chain infrastructure, heat-based methods remain crucial – for instance, Africa has a higher share of cured (dried or smoked) fish in its production (14%) than the world average, as fish is often processed immediately after harvest to prevent spoilage (FAO, 2012). The following analysis covers several key heat-based fish preservation methods, highlighting global trends and the context specific to Nigeria.

Cured Fish (Drying and Smoking)

Curing refers to traditional methods that combine salting, drying, and often smoking to preserve fish. It is one of the oldest preservation techniques, historically enabling communities to store fish for months without refrigeration. Globally, cured fish (including dried, salted, and smoked products) have a long shelf life and a distinctive savory flavor that many cultures value. For example, dried or smoked fish is a staple in parts of Asia and Africa; smoked herring, dried cod (stockfish), salted anchovies, and fermented fish sauces are integral to diets from Northern Europe to Southeast Asia. In some regions, fermented or cured fish products are so ingrained that daily meals "would not be complete" without them (Mineva, 1992) Smoking in particular imparts a unique aroma and taste through wood smoke compounds, which is a selling point in many markets. Modern innovations have improved traditional curing – solar dryers and improved kilns

now produce more hygienic dried fish with less risk of contamination by dust or insects. Nonetheless, in many developing areas, open-air sun drying and rudimentary smoke pits are still common, yielding inconsistent quality. Globally, the demand for cured fish is modest compared to frozen or canned fish, but it persists due to cultural preferences and the rustic flavor profile that some consumers seek.

Cured Fish - Nigerian Context

In Nigeria, smoking is by far the most prominent curing method, given the country's tropical climate and limited refrigeration in rural areas. Artisanal fish processors (often women in fishing communities) smoke a large portion of the marine and freshwater catch to prevent spoilage soon after harvest. Traditional smoking ovens or kilns (such as clay or drum ovens) are widely used, but they have notable drawbacks: they often produce unevenly smoked fish and expose operators to thick wood smoke with no chimneys or ventilation. This leads to health risks for the processors and variable product quality. Moreover, these traditional methods are fuel-inefficient, consuming large amounts of firewood or charcoal (WorldBank, 2014). Despite these challenges, smoked fish is extremely popular in Nigerian diets for its flavor and shelf stability – it is common in local markets and is a key protein source especially in inland areas far from the coasts. Studies have shown that consumers often prefer smoked fish after fresh fish, more so than frozen or dried fish, due to the taste developed during smoking (sometimes described as "kilishi" when spiced and dried. Ipinjolu et.al., 2005). Notably, Nigerian smoked fish enterprises can be quite lucrative. Research in southwestern Nigeria found profit margins as high as 50–60% for small-scale smoked fish businesses, reflecting strong market demand and relatively low processing costs (since smoking uses inexpensive inputs) compared to selling fresh fish. There is growing interest in improving Nigeria's fish smoking techniques to address health and quality issues. Over the years, researchers and development projects have introduced improved smoking kilns. For example, the World Bank-supported Commercial Agriculture Development Project (CADP) trained fish processors in Lagos State on new smoking kiln technology that dramatically lowers the smoke residue on the fish (WorldBank, 2014). These modern kilns (such as the Chorkor oven or the FAO-Thiaroye technique) have chimneys and better heat control, producing more uniform smoked fish with reduced polycyclic aromatic hydrocarbons (PAHs). The impact is evident: a group of Lagos farmers using improved kilns under CADP were able to get their smoked catfish certified by the U.S. FDA for export, breaking into the international market (World Bank, 2014). This success story shows the potential for Nigeria to upgrade traditional curing methods and even generate export revenue from high-quality smoked fish. Domestically, smoked fish remains very popular – it is sold in open markets and by street vendors (e.g. smoked prawns as snacks) all over the country. However, Nigeria currently lacks specific regulatory standards for smoked fish safety. There are no enforced national limits on PAHs or other smoke-derived toxins in locally sold smoked foods. Studies have found that some traditionally smoked fish in Nigeria contain benzo(a)pyrene and other PAHs at levels above health guidelines (Tongo, et.al. 2017), due to incomplete combustion of wood and direct exposure of fish to smoke and flame. This poses a potential carcinogenic risk. As Nigerian consumers become more health-conscious and aware of food safety, there could be pressure on producers to adopt cleaner smoking methods or on regulators to set standards (Akintola and Fakoya, 2017). As Nigerian consumers become more health-conscious, there could be pressure to improve the safety of smoked products or risk losing consumer trust.

Cured Fish- SWOT Summary

Strengths

Cured fish (whether dried, smoked, salted, or fermented) achieves a very long shelf-life without the need for refrigeration – a

crucial advantage in regions with limited electricity. Properly dried or smoked fish can last for months, providing food security during off-seasons or lean periods. Curing also yields distinctive flavors that many consumers love. In Nigeria, smoked fish adds a deep, smoky savoriness to soups and stews that is hard to replicate with any seasoning or bouillon cube. This unique taste is a selling point and the reason smoked fish enjoys strong demand. Nutritionally, curing retains most of the fish's protein and mineral content. In some cases (e.g. smoked fatty fish), it even concentrates certain nutrients; for example, smoke-drying fish can preserve omega-3 fatty acids better than leaving fish to spoil. Another strength is that curing techniques are relatively low-cost and accessible – a small-scale fisher can smoke or sun-dry their catch with minimal equipment, thus adding value and extending the marketability of their fish. This makes curing an important income-generating activity, especially for women processors who can turn a day's fresh catch into a higher-priced product with just time and firewood. Cured fish products are also lightweight (once dried) and thus cheaper to transport inland than iced or fresh fish, aiding distribution to remote areas.

Weaknesses

Traditional curing methods have significant drawbacks in terms of efficiency, health, and consistency. Many local smoking ovens in Nigeria are inefficient and hazardous – lacking chimneys, they envelop the worker in smoke (leading to respiratory issues over time) and deposit tar and soot on the fish. The resulting smoked fish can contain very high levels of PAHs (cancer-causing compounds from wood smoke) if the process is not well-managed (Tongo, et. al. 2017). Sun-dried fish, on the other hand, if done in the open air, is prone to contamination by dust, insects, or spoilage when humidity is high. Quality control is a weakness; products may be over-smoked (turning bitter/charred) or under-dried (risking mold growth). The strong odor of most cured fish (especially fermented varieties) limits their appeal mostly to those already accustomed – many people find the smell off-putting. Cured fish are also often very high in salt (as salt is used to aid drying/fermentation), which is a health concern for consumers watching their sodium intake.

Opportunities

There are promising opportunities to modernize curing techniques in Nigeria and diversify the range of cured fish products. Adoption of improved smoke kilns (with filtration to remove smoke toxins) could be scaled up, possibly through government or NGO programs that subsidize these ovens for cooperatives. Such improvements would make smoked fish safer and potentially open doors to export markets, as seen with the CADP initiative where Nigerian smoked catfish entered the U.S. market (World Bank, 2014). There is also room to develop new products to appeal to a broader customer base – for example, lightly smoked and seasoned fish snacks in hygienic packaging, or different wood-smoke flavors, could attract urban youth who currently prefer imported snacks. Nigeria's large diaspora might be another opportunity: exporting premium-quality smoked fish (with proper packaging and compliance) to Nigerian communities abroad has proven lucrative in some cases (smoked fish is a sought-after ingredient for traditional soups overseas). Additionally, fermentation of fish into condiments (like fish sauce or protein-rich pastes) could be explored domestically to create value-added products for niche markets. Importantly, the of smoked fish is an incentive – with reported margins well above 50% in local markets, expanding cured fish production can boost rural incomes (Adebo and Toluwalase, 2014, Adedeji et.al., 2019). Support from government (in providing drying racks, solar dryers, or micro-credit for fish processors) would further capitalize on this opportunity.

Threats

Cured fish faces competition from both alternative proteins and changing consumer preferences. As Nigeria's economy develops, some consumers may shift towards fresh or frozen fish, chicken, and even plant-

based proteins, reducing demand for traditional smoked or dried fish (which might be seen as "old-fashioned" or less convenient). There are also health and safety threats; if incidents of foodborne illness (e.g. botulism from badly smoked fish or contamination in dried fish) occur, they could lead to stricter regulations or reduced consumer confidence in cured products. Environmental factors pose a threat as well – the wood used for smoking contributes to deforestation and carbon emissions, which is unsustainable in the long run; any future restrictions on wood fuel usage or emissions could impact fish smoking operations. Lastly, absent quality control in the cured fish sector leaves it vulnerable to reputational risks; reports of carcinogens or unsanitary production could prompt both domestic and international buyers to shy away from Nigerian smoked fish unless improvements are made.

Canning

Canning is a well-established industrial method for preserving fish and seafood. In the canning process, fish is sealed in airtight tins or cans and then heated to about 121°C (250°F) in a retort to achieve commercial sterility. This intense heat-kill step destroys all pathogenic and spoilage organisms, yielding a shelf-stable product that can last 12–24 months at room temperature (Featherstone, 2016). Globally, canning transformed the seafood market in the 19th and 20th centuries by making ocean fish available to inland populations. For instance, canned tuna, sardines, salmon, and mackerel became pantry staples around the world. By enabling marine fish to be consumed far from coasts, canning significantly expanded the reach of fisheries products (Dabeka et al. 1985). Even today, a large proportion of certain species (like tuna) is sold in canned form. Consumers value canned fish for its convenience (ready-to-eat or easy to use in recipes), long shelf life, and the fact that it often comes pre-cooked in edible oils or sauces which add flavor. Nutritionally, canned fish retains protein and minerals well, and in the case of canned sardines or salmon, the process softens the bones, providing a rich source of calcium when eaten. According to FAO in 2018, globally, about 12% of fish for human consumption is in prepared or preserved forms (which includes canned fish). While canning is a mature industry, innovations continue – such as improved can linings (BPA-free), easy-open lids, and a wider variety of value-added products (e.g., spicy canned mackerel, tuna in tomato sauce, etc.). Major fishing nations (Thailand, China, Spain, Morocco, etc.) have large canneries, often focused on export. One key global concern with canned fish is safety; proper canning eliminates bacterial risks, but failures can lead to botulism (a rare but serious risk if cans are under-processed or damaged). There are also consumer worries about contaminants – for example, mercury accumulation in large predatory fish (like tuna) has led to health advisories on how much canned tuna one should consume, and this has slightly affected demand in some markets.

Canning Fish- Nigerian Context

Surprisingly, Nigeria currently has no significant domestic fish canning industry. Despite being a major fish-consuming nation, Nigeria relies entirely on imports for canned fish products. Brands of canned tuna, sardines, and mackerel found in Nigerian shops are imported from Europe, Asia, or other African countries; local production is limited to pilot projects. Past assessments have noted that establishing a fish cannery in Nigeria would require substantial capital and technical know-how – estimates in the mid-2010s suggested a modern cannery could cost on the order of $7–15 million to set up (well beyond the reach of small-scale fishers or entrepreneurs). This high startup cost, along with the need for consistent electricity, skilled technicians, and a steady supply of suitable fish, has impeded the growth of canning in Nigeria. The Nigerian market, however, is favorable to canned fish consumption in principle. Canned sardines ("Geisha" brand and others) and mackerel in tomato sauce are popular among many households for their convenience and taste, although they are considered relatively expensive sources of protein. Consumer sur-

veys have indicated that the frequency of canned fish consumption in Nigeria is lower than fresh or smoked fish mainly due to the higher cost of canned products (being imports) and possibly a perception that canned foods are less natural ((Chukwujindu, et. al. 2009). If locally produced canned fish were available at lower prices, it's likely there would be a ready market, especially in urban areas and for institutional buyers (schools, military, etc.) looking for shelf-stable protein. Recognizing this, Nigerian researchers have been exploring canning of local species – for example, trials of canned catfish and tilapia have been conducted by the Nigerian Institute for Oceanography and Marine Research (NIOMR) and universities. These studies show promise that local freshwater fish can be successfully canned and accepted by consumers. The major hurdle remains the investment and scale: a cannery needs consistent throughput and market access. To address the capital barrier, one idea has been to develop community-based canning cooperatives, where groups of fishers jointly invest (possibly with government loans or grants) in small canning lines to process seasonal gluts of fish. Thus far, no such facility has become fully operational. On the policy side, the Nigerian government has generally encouraged domestic value addition in agriculture (including fish) through its import substitution policies (FMARD, 2016). While there is no explicit ban on imported canned fish, high import tariffs could be imposed in the future to protect any nascent local canning industry. In the meantime, all canned fish on Nigerian shelves; sardines, tuna, sardine-tomato sauces – are imported, meaning Nigeria is missing out on the value addition and jobs that a local canning industry could provide.

Canning- SWOT Summary

Strengths

Canned fish has an exceptionally long shelf life and does not require refrigeration, making it ideal for storage, transportation, and emergency food reserves. It enables distribution of fish to areas far from coasts or fresh fish sources, greatly expanding the availability of nutritious seafood to inland populations. Canned products are convenient – they are often ready to eat or need minimal preparation (e.g. sandwiches, salads), catering to modern lifestyles. Nutritionally, canned fish retains most of its value; in fact, canned oily fish, like sardines are one of the best dietary sources of calcium (due to the softened bones) and vitamin D. For Nigeria, an established canning industry could reduce post-harvest losses by processing seasonal fish surpluses (that might otherwise spoil) into stable products. Additionally, Nigerian consumers are already familiar with and accept canned fish, so the demand foundation is there. Should local production begin, it can tap into an existing market and potentially even export regionally (West Africa's landlocked countries could be customers).

Weaknesses

High startup and operating costs are a major weakness for canning in Nigeria. . The average cost of setting up a canning factory have been said to be between $7,000-15{,}000$ (NIOMAR, 2015). Building and running a cannery requires significant capital, reliable power, water sterilization systems, and a consistent supply chain of packaging (imported tin plates, cans, etc.) – all challenging in the Nigerian context. The lack of any current local production means expertise is limited; skilled personnel would need to be trained or hired from abroad. Another weakness is the limited variety of fish that are suitable for commercial canning – typically oily fish like sardine, mackerel, tuna are canned; Nigeria's prevalent species (catfish, tilapia) are less common in the global canned market and recipes/technologies for canning them need development. If these local species are canned, consumer acceptance is unproven. From a market perspective, canned fish in Nigeria is relatively expensive protein (due to import costs), so it's seen as a bit of a luxury or at least not the cheapest option for low-income families. This price sensitivity could make it hard for a new local product to compete unless efficiency is high. Finally, any canning operation must be extremely careful with quality control and safety – inadequate heat

processing can lead to botulism risk, which would be a critical failure. Maintaining rigorous standards might be difficult for new entrants and could be a weak point without strong regulatory oversight.

Opportunities

The opportunities for canning in Nigeria are significant if the challenges can be managed. For one, there is an import substitution opportunity; Nigeria imports hundreds of thousands of tonnes of fish; even capturing a fraction of that market with locally canned fish would save foreign exchange and create local jobs. There's potential to diversify product lines tailored to Nigerian tastes: for example, canned catfish in spicy pepper sauce, or small canned tilapia in palm oil with local spices – products that could appeal domestically and leverage Nigeria's culinary preferences. Canned fish could also serve institutional feeding programs (schools, NYSC camps, military rations) if produced affordably, thereby securing a steady demand. On the export front, high-quality canned fish from Nigeria (perhaps smoked fish in oil, or chili-seasoned variants) could find niche markets in the diaspora or regionally. Another opportunity lies in public-private partnerships: the government could incentivize foreign fish processing companies to set up canneries in Nigeria (through tax breaks or ensuring supply of raw fish), leveraging their expertise. With the African Continental Free Trade Agreement (AfCFTA) in effect, Nigeria could aim to become a hub for fish canning to supply West and Central Africa, given its large workforce and market (World Bank, 2020). Overall, as fish consumption grows with population, a home-grown canning industry has a ready growth trajectory if initial barriers are overcome.

Threats

Canned fish in Nigeria faces threats from market competition and health perceptions. On the market side, canned fish must compete with fresh, frozen, and smoked fish – if those are readily available or cheaper, many consumers will choose them over canned products. Additionally, other processed protein foods (like instant noodles with artificial chicken flavor, or canned meats) vie for the same convenience segment. Any economic downturn that reduces consumers' spending power will likely hit canned fish sales (seen as less essential and more expensive than buying fresh local fish). Another threat is the global health and safety concern around canned fish: cases of high mercury levels in tuna or warnings about excessive salt/oil in canned products can scare consumers. For example, awareness is rising that certain canned tuna can carry mercury, or that some imported canned fish had issues with contaminants; these perceptions could reduce demand or prompt stringent regulations. If Nigeria were to export canned fish, it would also face strict standards abroad – any failure (e.g., a batch with contamination) could close off export markets quickly. From an operational standpoint, a Nigerian cannery would be exposed to supply chain threats: if overfishing or climate change affects the availability of fish stocks (sardines/mackerel have boom-bust cycles), a factory could go idle. Also, inconsistency in government policy; such as suddenly lowering import tariffs on competing canned fish or removing incentives; could undercut a budding local industry. Lastly, consumer taste changes pose a long-term threat: if younger generations lean towards fresher or plant-based foods, the demand for canned fish might stagnate or decline over time, leaving any large investment stranded.

Retort Pouch packaging

Retort pouch processing is a relatively modern method (popularized in the last few decades) that combines the principles of canning with flexible packaging. A retort pouch is a heat-resistant laminated plastic and metal foil pouch in which food is sealed and then sterilized using high-temperature retort treatment, similar to cans. Globally, retort pouches have gained popularity for a variety of ready-to-eat foods – curries, soups, military rations, and also fish products like tuna or salmon in pouches. They offer the same shelf stability as cans but with some distinct advantages: lighter weight and less bulk (which reduces transportation costs), and often better preserva-

tion of texture and flavor due to the shorter heat penetration time. In fact, processing foods in pouches can significantly cut down the cooking/sterilization time. Studies have shown that retort pouches may require 40–60% less processing time than traditional cans to achieve sterilization, because the pouch's flat profile allows heat to penetrate faster (Gupta and Dudeja, 2017) This shorter cook time often means the food retains a higher quality – for example, fish in retort pouches can taste moister and fresher compared to canned fish that endures longer cooking. The global use of retort pouches has expanded dramatically. In the early 2000s, only a few billion units were used per year (with Japan and Europe being early adopters, especially for things like curry sauces and soups), but by the 2010s, tens of billions of retort pouches were being produced annually as more companies and countries switched to this packaging. Consumers appreciate the convenience (pouches are easy to open, sometimes even microwavable) and the fact that empty pouches are easier to dispose of than bulky cans. Tuna sold in pouches (instead of cans) is one notable success in Western markets. Additionally, retort pouches are suitable for "boil-in-bag" use – the sealed pouch can be dropped in hot water to warm its contents, a benefit for quick meal preparation. Despite these advantages, some challenges persist globally: pouches can be more prone to accidental puncture, they are not easily recyclable in many cases (raising environmental concerns), and consumers in some markets still associate canned foods with sturdier metal packaging and may be slower to trust pouches for long-term shelf storage. Nevertheless, the trend is toward more products – including high-quality seafood dishes – being offered in retort pouch form internationally.

Nigerian Context

In Nigeria, retort pouch technology is still at an early stage, especially for fish products. Nigerian food processing companies have begun to use retortable pouches for a few items – notably products like tomato paste, pepper puree, and some prepared local stews are now sold in flexible pouch packs. These items have been well accepted by consumers due to their ease of use and shelf stability. However, as of the latest information, no fish or seafood products in Nigerian markets are packaged in retort pouches yet. The absence is likely due to the high capital investment needed for retort processing equipment and the technical expertise required to ensure sterility and consistency. A fully operational retort line involves specialized autoclaves, sealing machines, and rigorous process controls – which few local fish processors can afford. Nevertheless, the potential for retort pouch fish products in Nigeria looks promising. If local companies or investors introduce this technology, Nigerians could soon see ready-to-eat fish meals (e.g. spiced fish fillets in sauce, or Nigerian-style fish stew) in pouch packs on supermarket shelves. The appeal would be significant to urban consumers: imagine a pouch of suya-spiced fish or "pepper soup" fish that can be quickly heated and served – this aligns with the convenience trend among busy professionals and families. From a policy perspective, the Nigerian government's push for value addition means it would likely support pilot projects or investors in this area. The fact that Nigerian firms have mastered retort packaging for other foods implies that extending it to fish is a logical next step. Researchers in Nigeria have indeed been studying retort processing for local fish species, and some have noted that using retort pouches for fish could dramatically improve product quality and cost-efficiency. Because the pouches require less processing time, the fish is not overcooked – preserving a more natural taste which could win over consumers who might be lukewarm about traditionally canned fish. Economically, since pouches are lighter than cans, producing fish in retort pouches domestically could make distribution cheaper across Nigeria's vast distances (important given fuel costs for transport). One challenge specific to Nigeria will be consumer education and trust. The average Nigerian is used to either fresh, frozen, or smoked fish – and to the extent they consume shelf-stable

fish, it's from a can. Convincing consumers that a soft pouch can safely contain fish without refrigeration might require some marketing and time. Also, any high-profile failure (like a spoiled pouch) could set back adoption severely, so producers will need to adhere to international standards from the start. On the whole, Nigeria stands to benefit from introducing retort pouch fish products: it aligns with the modern retail growth (supermarkets and convenience stores) and could also create a new avenue for exporting Nigerian culinary-style fish dishes abroad in shelf-stable form. The main barrier is the initial investment and technical know-how – issues that could be mitigated by partnerships with experienced foreign processors or by government incentives (such as technology acquisition grants). Given that Nigeria has already embraced retort packaging for things like tomato paste, it may not be long before entrepreneurial businesses apply the same to the fish processing sector.

Retort Packaging – SWOT Summary
Strengths
Retort pouch processing offers the same safety and shelf-stability as traditional canning but in a lightweight, flexible format. Products in retort pouches can last 12 months or more on the shelf without refrigeration, yet often taste closer to freshly cooked food than canned equivalents due to gentler processing. The reduced heat exposure (thanks to faster sterilization times) helps preserve the fish's moisture, texture, and nutrients – consumers get a product that isn't mushy or overly dry. From a logistical standpoint, pouches are a clear strength: they weigh far less than metal cans and occupy less space (a flat pouch vs. a bulky can), which means transporting them is cheaper and warehousing is more efficient (Robertson, 2019). This can significantly cut distribution costs in a country like Nigeria, where fuel prices are high and road transport can be inefficient. For consumers, retort pouches are easy to open (no can opener needed, just tear or cut), and they eliminate concerns about sharp can edges or metal lid injuries. Many pouches are designed to be stand-up for display and can sometimes be heated directly (some are microwave-safe or boil-safe). Portioning is flexible too – companies can offer single-serving pouches which are great for on-the-go meals or larger family-size pouches for quick dinner prep. Another strength is that the packaging doesn't rust or dent, removing issues that cans sometimes have. If widely adopted, retort pouches could also encourage more innovative fish products (e.g., fish combined with sauces or side dishes) because the form factor allows whole meals to be packaged (not just plain fish). Environmentally, while multi-layer pouches are not as recyclable as metal, their lighter weight means the carbon footprint for transport is lower, which can be a sustainability plus when considering the full product life cycle.
weeaknesses
The introduction of retort pouch processing in Nigeria faces several weaknesses. First, the high initial investment and technical know-how required are barriers. The machinery for retort packaging (specialized autoclaves, sealing equipment, etc.) is expensive and likely not produced locally, meaning a high upfront cost and reliance on foreign suppliers for parts and maintenance. Along with machinery, developing a workforce skilled in retort operations and in the microbiological quality control needed is a challenge; there would be a learning curve and potential risk of errors in early stages. Another weakness is the packaging material supply – since Nigeria doesn't manufacture the complex laminate films and foil needed for retort pouches, producers would have to import these materials continuously, exposing them to forex and import logistics issues. Another weakness is consumer perception: many Nigerian consumers are not yet familiar with retort pouch fish products; some may question the integrity of a soft pouch and fear leakage or spoilage. It will take time and marketing to build trust that a pouch can preserve fish as well as a can. In addition, the variety of fish that have been tested in retort locally is limited; common global retort products use tuna, salmon, mackerel, etc., but if Nigeria wants to pouch local species or traditional recipes, signifi-

cant RD is needed to get the right taste and texture. Lastly, while cheaper per unit in theory, in practice retort packaging material (the pouch itself) can be more expensive than a simple tin can if not procured at very high volumes, which could initially make the products pricier until economies of scale are achieved. Recycling and waste disposal is another weakness in an environment already grappling with plastic waste – adding multi-layer pouches could exacerbate waste management issues since they are not biodegradable and currently not recyclable in Nigeria's facilities.

Opportunities

The opportunities for retort pouch fish products in Nigeria are quite exciting. One big opportunity is to create new value-added products that modern consumers want. For example, ready-to-eat Nigerian fish dishes (like a catfish pepper soup or a fish curry with local spices) could be packaged and sold in supermarkets, catering to busy families and young professionals who want quick meal options. This taps into the convenience food market, which is growing in Nigeria alongside urbanization. Another opportunity is for e-commerce and delivery: with the expansion of online grocery services in cities like Lagos and Abuja, companies could sell retort pouched meals directly to consumers, delivering them without heavy refrigeration needs. The durability of pouches also means they could be included in food aid programs or military rations domestically – improving Nigeria's disaster preparedness and troop provisioning with locally made goods instead of relying on imported canned rations. On the export front, Nigeria could leverage retort packaging to export its cuisine: such as exporting pouched "Nigerian spicy fish stew" to specialty African food stores in Europe or North America – the diaspora and even adventurous foodies could be a market, similar to how Indian curries in pouches are sold internationally. Retort pouches also align with trends like healthy, preservative-free foods; since retort doesn't require chemical preservatives (the heat sterilization does the job), products can be marketed as natural and free of additives aside from spices. Additionally, if Nigeria develops competence in retort processing, it might extend it beyond fish to other sectors (meat, beans, ready meals), effectively opening a new segment of the food processing industry. This means more jobs, skills, and potentially an export niche in West Africa for ready-to-eat meals. With support from research institutes or partnerships (for example, collaborating with countries that have retort tech experience like Thailand, or seeking grants to pilot retort facilities), Nigeria could leapfrog into modern food processing. Early movers in this space could establish strong brands and capture market share in a relatively untapped segment domestically. Government support is likely, as such initiatives tick boxes for reducing post-harvest losses and increasing value addition. There's also an opportunity to integrate local agriculture: retort meals might include other Nigerian ingredients (yam, plantain, vegetables) along with fish, which boosts demand for those crops and diversifies farmer income.

Threats

A notable threat to the adoption of retort pouch fish products is competition from established products and consumer habits. Canned fish (though imported) is entrenched, and fresh/frozen fish are the default; retort pouches will have to carve out market share, potentially against skeptical consumers. If not executed well, an incident like a spoilage outbreak or packaging failure could severely damage trust in retort products. Additionally, retort pouch businesses would face competition from other convenience foods – for example, frozen ready-meals or fast-food delivery might compete for the same consumer expenditure that retort fish meals target. Economic instability (inflation or currency devaluation) poses another threat: the pouches and machinery are imported, so a weak naira could make producing retort packs very expensive and price the products out of reach for many consumers. From a regulatory angle, if export is planned, international standards (FDA, EU regulations) are very strict for retort pouch sterilization; any failure to meet

those could shut out Nigerian products from lucrative markets. Environmental concerns could also become a threat in the long run – as the world focuses on plastic waste, multi-layer retort pouches (which are not easily recyclable) might face backlash or additional costs (for waste management), unless more eco-friendly pouch materials emerge. In summary, while retort pouches have great promise, careful management is needed to avoid pitfalls that could threaten their success in Nigeria.

Extrusion Cooking (Fish Feed Pelleting)

Extrusion cooking is a process used widely in the food and feed industry, where a mixture of ingredients is cooked under high heat and pressure and forced through a die to create a shaped product. In the context of fisheries, extrusion technology is predominantly used to produce pelleted feeds for aquaculture. Globally, as aquaculture has boomed, the demand for formulated fish feeds – often in the form of floating or sinking pellets – has likewise grown exponentially. Extruders allow feed manufacturers to cook starches (from grains like corn, wheat) and proteins (from fish meal, soy meal, etc.) together, sterilizing the mix and improving digestibility, then cut the extruded strands into pellets of uniform size. The advantages of extruded fish feeds are well-documented: the heat and pressure gelatinize starches and denature antinutritional factors, making nutrients more bioavailable to fish (Harper, 1981). The pellets can be engineered to have desirable properties – for example, floating pellets (important for surface-feeding fish and for farmers to monitor feed intake) or slow-sinking pellets for other species. Globally, extruded aquafeed has enabled intensive fish farming by providing balanced nutrition in stable pellet form. The heat and pressure of extrusion have several advantages: it gelatinizes starches (improving digestibility), inactivates many anti-nutritional factors and pathogens (making the feed safer and more digestible), and allows fat to be effectively embedded or coated onto pellets. The result is a water-stable pellet that won't immediately disintegrate in water – crucial to prevent nutrient loss and water pollution in fish ponds (Singh et al., 2007). Beyond feed, extrusion is also used to create value-added human foods from fish – such as surimi-based analogues, or texturized fish protein products – though these are less common than feed use (Tumuluru, 2013). Many countries, especially in Asia and the Americas, have large factories dedicated to extruded aquafeeds. The equipment and process require significant energy and capital, but the output is high volumes of consistent product. One global trend is the push to reduce fishmeal content in extruded feeds (due to sustainability and cost), replacing it with plant or insect proteins – extrusion can accommodate these new ingredients if formulated correctly. Another trend is extruding fish waste or underutilized fish into feeds or pet foods, improving resource use. Overall, extrusion has become indispensable for modern aquaculture, enabling the sector's growth by providing efficient feeds that convert into fish biomass with minimal waste.

Nigerian Context

In Nigeria, extrusion cooking is most relevant through its application in producing fish feed for the burgeoning aquaculture industry. Nigeria is the largest aquaculture producer in sub-Saharan Africa (with catfish farming being especially prominent). However, for many years, Nigerian fish farmers depended heavily on imported extruded feeds – brands from Europe, Asia, or other countries – because local feed manufacturing was not keeping up countries (Miller and Atanda, 2011). These imported feeds (often in 15kg or 20kg bags) are high-quality but very expensive, and feed cost has been identified as one of the biggest constraints for Nigerian fish farmers. In fact, feed can account for up to 70% of the operating cost in intensive fish farming (Agbeja, 2008, Adewuyi et al, 2010). This has spurred efforts to develop local extrusion capacity. Over the past decade, Nigeria has seen some investment in fish feed mills. Notably, in 2017, Olam International (a global agri-business firm) opened a large integrated animal feed mill in Kwara State, which in-

cludes an advanced fish feed manufacturing facility. This mill alone has an initial capacity of 75,000 tonnes per year of extruded fish feed, with room to expand (Feedlink, 2017). The entry of such large players has started to reduce Nigeria's reliance on imported feed and made fish feed more accessible to farmers (as well as created jobs and utilized local crops like maize and soy). There are also a number of smaller indigenous companies and even on-farm feed extruders that have sprung up, though quality varies. The availability of locally produced floating catfish feed at a lower price is gradually improving profit margins for fish farmers and could encourage more people to enter aquaculture. Nigeria has abundant raw materials (maize, cassava, soybean, groundnut, fish trimmings, etc.) to use in fish feed, and using extrusion to turn these into pellets is a huge opportunity for import substitution. In terms of research, institutions like NIOMR and universities have experimented with formulating feeds using local ingredients – for example, replacing expensive fishmeal with alternatives like soybean meal, poultry by-products, or even fermented fish waste. Some findings indicate that using fermented fish silage or other waste products in the feed can cut costs significantly (A study by Magdy, et. al., 2017, found replacing 50% of fishmeal with fermented fish waste reduced feed costs by over 16% while maintaining fish growth). This is extremely relevant in Nigeria's context where cost reduction can make aquaculture more competitive. From a policy perspective, the government has recognized the importance of fish feed and has taken steps such as reducing import duties on feed mill equipment, and even considering incentives for local feed production. In 2021, there were reports of government initiatives to establish feed mills in different zones of the country to boost local supply (seafoodsource, 2021) The impact of reliable local feed is massive: it not only lowers costs but also ensures farmers have consistent supply (previously, farmers sometimes faced shortages or delays waiting for imported feed shipments). Moreover, a thriving feed industry creates a value chain that benefits crop farmers (for soy, maize) and reduces post-harvest waste by utilizing agro-industrial byproducts in feed. Even so, challenges remain. Some locally made feeds have been of inconsistent quality (e.g., pellets that disintegrate, or formulations that don't promote good fish growth), leading some farmers to still prefer expensive imported brands. This highlights the need for knowledge transfer and quality control in the local feed industry. Additionally, not all fish farmers can afford extruders for on-farm production (and small extruders may not produce true floating feed, instead producing sinking pellets which are less ideal for some operations). As such, ensuring that even small-scale farmers can access affordable extruded feed (perhaps via cooperatives or feed distribution networks) is important to fully realize Nigeria's aquaculture potential.

Extrusion – SWOT Summary

Strengths

The use of extrusion technology for fish feed in Nigeria brings clear strengths. It enables production of high-quality floating pellets that greatly improve feed efficiency – fish can eat them at the surface with minimal waste, and farmers can monitor consumption. Locally extruded feeds mean more control over feed formulation, allowing incorporation of local ingredients and adaptation to the nutritional needs of local fish species (like African catfish) for optimal growth. By producing feed domestically, Nigeria can save foreign exchange that would otherwise be spent on imports and reduce vulnerability to global feed price fluctuations. Another strength is the potential to reduce waste: extrusion can turn fish processing byproducts or invasive low-value species into useful feed, contributing to a circular economy. The extruded pellets also typically have a long shelf life if properly stored, which is vital for farmers who need to stock feed. For the broader economy, expanding fish feed extrusion creates downstream benefits – demand for maize, soy, etc., boosting agriculture. It also fosters technical skill development in machinery operation and feed formulation. In

summary, extrusion technology provides the backbone for a sustainable aquaculture industry, improving productivity and yield in fish farming.

Weaknesses

The main weaknesses related to extrusion in Nigeria are tied to cost and scale. Setting up and running an extrusion line is capital-intensive – equipment is costly, and running extruders requires steady power and technical expertise. Thus, only a few large companies can do it viably, which might limit competition and keep feed prices high. Small-scale farmers who try on-farm extrusion with mini-machines often produce subpar pellets (that may not float or have inconsistent size), so quality control is an issue outside the big mills. There is also a learning curve in formulation – if not done right, extruded feeds can have stability issues or nutrient deficiencies, affecting fish performance. Another weakness is that extruders, by cooking at high temperature, could potentially reduce certain heat-sensitive nutrients (like some vitamins or amino acids) if the process isn't carefully optimized, though this is usually mitigated by coating pellets with vitamins after cooking. Logistically, distributing heavy feed bags across Nigeria's poor road networks can be a weakness – feed is bulky, and if local production is centralized, getting feed to far-flung farms can be slow or costly (though still better than importing). Finally, reliance on extrusion means reliance on consistent ingredient supply: if local crops fail or prices spike (e.g., a bad maize harvest driving up corn prices), feed producers may struggle to maintain output and price stability.

Opportunities

There are substantial opportunities to expand and innovate in extruded fish feeds in Nigeria. One is to develop specialized feed formulations for different species and life stages – for instance, juvenile tilapia feed, floating shrimp pellets, or formulated feed for ornamentals – none of which are widely produced now. As Nigeria diversifies aquaculture (beyond catfish to tilapia, carp, etc.), the feed industry can grow in tandem. Another opportunity is export of fish feed to neighboring countries; Nigeria could become a feed production hub for West Africa given its resource base and large market (similar to how it's a cement or flour hub in the region). On the innovation front, Nigeria can explore incorporating unconventional ingredients (insect meal from maggots or soldier fly larvae, which can be locally produced; agricultural by-products like brewers' grains, etc.) into extruded feeds to further reduce costs – this aligns with global trends in sustainable feeds. There is also room for value-added products via extrusion: for example, producing fish pellets medicated with vitamins or probiotics to improve fish health, or even extruded snacks for human consumption made from fish (fish crackers, etc.) for domestic markets. Government and private investors have the opportunity to collaborate on establishing feed mills in major farming clusters, possibly through public-private partnerships, to ensure every region has access to fresh feed. Given Nigeria's unemployment issues, an expanding feed manufacturing sector can create jobs in manufacturing, sales, and research. Moreover, successful development of low-cost feeds could drastically lower the price of farmed fish, making protein more affordable to the population – an opportunity to improve nutrition nationally.

Threats

The extrusion-based feed sector faces a few threats in Nigeria. One major threat is raw material volatility – if key ingredients like fish meal or soybean meal become scarce or expensive (due to global market changes or local supply issues), feed production could suffer, and costs would rise. For instance, Nigeria still imports fish meal and a good portion of soybean meal; global price hikes for these will directly impact feed prices and thus fish farming profitability. Another threat comes from potential regulatory or safety issues: poor quality control could lead to contamination (e.g., aflatoxin in poorly stored feed ingredients is a known threat in tropical countries). If farmers encounter fish losses due to bad feed, it could hurt the credibility of local feed produc-

ers. Additionally, competition from imports isn't gone – if foreign feed becomes cheaper (say, through dumping or subsidies elsewhere), it could threaten local manufacturers unless tariffs or standards protect them. A broader threat is the energy situation: extrusion is energy-intensive, and Nigeria's power supply is unreliable. Operating large extruders on generator power is very costly; persistent energy crises could limit the growth or push up prices of local feed. Finally, the success of extruded feed is tied to the fortunes of the aquaculture sector itself – disease outbreaks in farms or market gluts of fish (driving prices down) could reduce demand for feed, creating an unstable market for feed companies. Essentially, anything that significantly undermines fish farming (like environmental issues, policy neglect, or crashing fish prices) will feed back into reduced feed demand, threatening the investments in extrusion. Maintaining a balance – where feed producers and fish farmers both thrive – will be key to mitigating these threats.

Coated and fried products

Battered, breaded, and fried fish products (like fish fingers, fish nuggets, tempura seafood, etc.) represent a significant segment of the global seafood market, especially in developed economies (FAO, 2012). These products typically involve coating pieces of fish in a batter or breading and pre-frying them, then freezing for distribution. They cater to consumer demand for convenient, ready-to-cook or ready-to-eat foods. Globally, items like fish sticks (fish fingers) have been popular since the mid-20th century – they provide a child-friendly, mild-tasting way to eat fish and have been widely adopted in North America, Europe, and beyond. Fast-food chains and restaurants also serve a variety of breaded fish (such as crispy fish fillets in sandwiches, fried shrimp, etc.), underscoring the universal appeal of fried seafood. The technology behind these products is quite advanced in large-scale operations; continuous battering and breading machines, flash fryers, and quick freezers are used to produce uniform products by the ton. The advantage is that final consumers or foodservice outlets can just bake or briefly fry the product to reheat, rather than handling raw fish. Globally, the growth of the frozen ready-meal market has driven innovation, with products like beer-battered cod fillets, coconut-breaded shrimp, or even gluten-free breaded fish appearing. However, these products are often high in calories, fats, and sodium, which has drawn some criticism from health experts, similar to other fried foods. There's also an increasing trend to improve the health profile – e.g., using whole-grain breading, air-frying techniques, or adding omega-3 fortification to make them a bit more nutritious. Nonetheless, the fundamental demand for crispy, savory fried fish as a convenient food remains strong worldwide.

Nigerian Context In Nigeria, coated and fried fish products have long existed in more informal forms. Street food vendors commonly sell fried fish snacks – for instance, crispy fried prawns on skewers, or "fish rolls" (a pastry with fish filling, which is slightly different but related in concept of convenience seafood). In many towns especially at bus stations, one can find hawkers with baskets of fried shrimp or small fish which are battered with spiced flour and deep-fried, often sold to travelers and locals as a quick snack. These products are loved for their taste and convenience; however, they are usually prepared by small-scale fryers and lack standardization or branding. In the formal market (supermarkets and grocery stores), the presence of ready-to-cook breaded fish is very limited. One might occasionally find imported breaded fish fillets in the frozen section of upscale stores, but local production is minimal. The concept of fish fingers or fish burgers is only just catching on among Nigeria's urban middle class, partly via fast-food restaurants that have introduced fish sandwiches. However, a critical challenge to address is food safety and quality control. The current street-vended fried fish is produced without any oversight – frying oil may be reused excessively, hygiene may be poor, and there are no standards, which means quality varies and there could be health risks. Any formal sector

producer of coated fish products would need to implement strong quality and safety measures (HAACP protocols, fresh oil, proper freezing) to gain consumer trust. There's also the challenge of cold-chain distribution: these products must remain frozen until they reach the consumer's kitchen, which requires reliable freezers in stores and at home. As Nigeria's electricity supply can be erratic, maintaining product integrity could be an issue if not carefully managed. On the positive side, the ingredients for coated products (flour, spices, bread crumbs) are readily available and relatively inexpensive in Nigeria, and labor costs are moderate, which could make local production cost-competitive. There's also a growing culture of small startup food processors in Nigeria who might venture into this area if they see a market niche. Government initiatives to encourage food processing could extend here too – for instance, training programs or grants under small and medium enterprise schemes could help entrepreneurs invest in equipment like industrial fryers or blast freezers.

Coated/Fried Products – SWOT Summary

Strengths

These products offer exceptional convenience and appeal to a broad range of consumers, especially children and young adults who are drawn to their crispy texture and mild flavor. The concept aligns naturally with Nigeria's fondness for fried, spicy foods. They are also versatile—different fish species and spice blends can be used to create varied flavor profiles. From a production standpoint, coated products can utilize low-value fish cuts or trimmings, boosting profitability while minimizing waste. Their frozen format ensures good shelf life, and with scale, these products could support Nigeria's aquaculture sector by turning fresh catfish or tilapia into value-added goods, thus reducing post-harvest losses.

Weaknesses

Despite their appeal, coated fish products have a less favorable health profile, being high in fats, calories, and sodium. This may deter health-conscious consumers. Quality control is another issue—without a stable cold chain, the coating may lose its texture, and the risk of spoilage increases. In Nigeria, the informal nature of most current production means inconsistency and lack of branding. For small businesses seeking to formalize, the upfront investment in equipment and compliance systems can be prohibitive. Additionally, while fried foods are popular, convincing consumers to adopt frozen, packaged versions may require a shift in perception. The need for relatively boneless fish also poses a constraint, as many local species are bony and require labor-intensive processing.

Opportunities

Nigeria's expanding urban middle class, growth of supermarkets, and increasingly fast-paced lifestyles offer strong potential for ready-to-cook seafood. Domestic producers can develop local brands of fish fingers, shrimp bites, or fish cakes, possibly targeting regional exports as well. Products tailored to Nigerian palates—featuring flavors like suya spice, chili, or ginger—can offer unique differentiation from foreign brands. The rise of e-commerce and home grocery delivery presents an opportunity to distribute frozen fish snacks using insulated packaging, bypassing some cold-chain issues. On a national scale, breaded fish could be incorporated into school feeding programs or workplace cafeterias to improve nutrition and support local aquaculture. Small-scale processors, too, could supply restaurants or hotels with semi-prepared breaded fillets, saving prep time and ensuring consistency. Overall, a well-positioned product—especially using popular fish like catfish or croaker—has significant market potential, particularly as refrigeration access and modern retail infrastructure continue to improve.

Threats

Competition from imports poses a major threat. Without adequate support for local production, cheaper foreign brands could dominate the market. Coated fish also competes with entrenched snack options like meat pies or sausage rolls, and will need aggressive marketing to secure a foothold.

Power outages that interrupt freezing can cause spoilage, with serious food safety risks and potential reputational damage. Reports of contamination or poor handling could easily erode trust in new brands. Economic instability and inflation may increase input costs, reducing profit margins and consumer affordability. Moreover, without strict regulation, there is a risk of unscrupulous practices—such as using degraded oil or extending shelf life improperly—that could damage the category's image. Globally, the push toward healthier eating could pose a long-term threat, though this trend is not yet widespread in Nigeria. To succeed, this sector will require sustained attention to quality, education, and market development to overcome these threats and realize its potential.

Fermentation

Fermentation is an ancient method of preserving food, including fish, by exploiting the growth of beneficial microorganisms to produce acids or other preservative compounds. Around the world, fermented fish products are common in many traditional cuisines. In East and Southeast Asia especially, fermented fish or seafood is highly prized: examples include fish sauce (ubiquitous in Thai and Vietnamese cooking), fermented fish paste (like bagoong in the Philippines or shrimp paste in Malaysia), and other delicacies where fish is salted and allowed to ferment for a strong umami flavor. In some cultures, daily meals historically weren't "complete" without a bit of fermented fish seasoning or side dish (Minerva, 1992, Olympia, 1992). Fermentation allows fish to be preserved at a low pH (usually below 4.5), where harmful bacteria cannot thrive (Bhujel, 2014). Lactic acid bacteria or added acids break down the fish, sometimes creating a very pungent product (notorious examples include the Scandinavian surstromming, a very strongly smelling fermented herring). Globally, fermented fish often has a niche but devoted consumer base, appreciated for its intense flavor. Nutritionally, fermented fish can be beneficial; the process may increase certain B-vitamins and removes some anti-nutritional factors, and fermented fish products are protein-rich condiments that can enhance otherwise bland staple foods. However, they often carry a strong odor and are extremely salty, limiting their appeal to those unaccustomed. In terms of safety, traditional fermentation can sometimes be risky if not done properly – outbreaks of botulism have been associated (though rarely) with homemade fermented seafood in a few cases, so some countries have regulations around their production. Overall, globally the market for fermented fish products is relatively small compared to frozen, canned, or fresh fish, but they remain culturally important. There's also growing scientific interest in fermentation for waste reduction – converting fish waste into silage or fermented feed, as an eco-friendly solution.

Nigeria's Fermented Fish Landscape Fermented fish products are not widespread in most of Nigeria, especially compared to smoking or drying. The Nigerian palate and foodways have a variety of fermented foods (for example, iru – fermented locust beans, or fermented cassava products like garri and fufu), but fermented fish is relatively uncommon. There are a few notable traditional examples in certain regions: in the Lake Chad area of northeastern Nigeria, some communities historically made fermented dried fish, known locally and traded in markets. In southeastern Nigeria (e.g., among the Ndokwa people of Delta State), a fish called Heterotis niloticus ("Aku") is often not eaten fresh but is fermented into a sort of condiment or seasoning which is then used to flavor soups (Ayeloja and Jimoh, 2022). These practices are highly localized, with fermented fish used in small amounts as a strong-flavored seasoning rather than a mainstream ingredient. Beyond direct human consumption, there is an area Nigeria could explore more; fermentation of fish waste or low-value catch into fish silage or meal. This involves using acids or lactic fermentation to liquefy fish by-products, which can then be dried into fish meal or used wet in animal feeds. It's a way of

preserving nutrients from fish heads, offal, etc., that would otherwise rot. As mentioned earlier, studies elsewhere have shown that replacing expensive fishmeal with fermented fish waste in fish feed can significantly cut costs (Soltan et.al. 2017). For Nigeria, where feed cost is a big issue, fermenting fish waste from processing plants or even by-catch from the sea into a protein ingredient for poultry or aquaculture feed is a promising avenue. There have been some small-scale experiments and projects on this, though it's not yet a common industry practice. In terms of consumer market for fermented fish, Nigeria could potentially see a niche market develop among adventurous foodies or in high-end restaurants exploring local food heritage. For example, just as iru (fermented locust beans) went from a village seasoning to being sold in urban supermarkets (dried or in bottled form), one could imagine a product like fermented fish flavoring being packaged and sold, if demand and production standards allow. Also, with international cuisine gaining interest in Nigeria, exposure to Asian fish sauces or soy-fermented products might indirectly spur curiosity about local equivalents. However, significant barriers exist. The strong odor of fermented fish is a major turn-off for many Nigerians who are not used to it – even in communities that make it, it's often something that outsiders find unappealing. Also, there is virtually no established supply chain or commercial production for such products currently; any expansion would require training and maintaining consistent quality (to avoid harmful microbial growth). Food safety regulation might also come into play if someone tries to sell fermented fish commercially – agencies like National Agency for Food and Drug Administration and Control (NAFDAC) would likely need to set standards to ensure these products are safe (proper salt content, fermentation time, etc.). Right now, these products are mostly informal and for local consumption.

Fermentation – SWOT Summary
Strengths
Fermentation allows fish to be preserved for very long periods without refrigeration, similar to drying or smoking. Properly fermented fish can last months and thus provides a food reserve, especially useful in areas with seasonal fishing or erratic supply. Fermentation also can enhance certain nutritional aspects – fermented fish products can be rich in amino acids and may develop probiotics or enzymes that aid digestion. They certainly provide a strong flavor, so a small amount can season a large pot of food (efficient use as a condiment). Culturally, fermented fish has a uniqueness and authenticity that can be celebrated; it ties into heritage and traditional recipes, which is a strength for tourism or specialty markets. In Nigeria's context, using fermentation for fish waste is a strong environmental and economic advantage; it can convert what would be pollution (discarded fish parts) into valuable feed ingredients, addressing waste management and lowering feed costs simultaneously. The process of making fermented silage is relatively simple (just needs drums, acids or inoculants, and time), which can be a low-tech solution adaptable even for small fishing communities to preserve excess catch that can't be sold fresh.
Weaknesses
Fermented fish products have a very limited appeal in the general market due to their often-pungent smell and acquired taste. In Nigeria, the majority of consumers are not accustomed to the strong odor, so demand is confined to small traditional circles. The odor can also be a logistical weakness – it's hard to store or sell such products alongside others because the smell can permeate. From a nutritional viewpoint, many fermented fish products are extremely salty (salt is usually used to control the fermentation and prevent spoilage bacteria), which is a health concern for modern diets (hypertension, etc.). Also, because fermentation is a natural process, the quality and safety of the end product can be inconsistent – if the fermenting conditions aren't right (not enough salt or not airtight, for example), there's a risk of spoilage or harmful bacteria proliferating. People have to trust traditional knowledge to get it right, and scaling that up

to commercial production with reproducible quality is challenging. In Nigeria, another weakness is simply lack of awareness and knowledge – unlike Asia where fish sauce is a kitchen staple, most Nigerian consumers and even food processors have very little familiarity with fermented fish processing, meaning there's a skills and recipe gap to overcome if expanding this method.

Opportunities

A niche but interesting opportunity lies in positioning fermented fish products as part of the "food heritage" movement. Just as other indigenous fermented foods have gained renewed interest, a unique Nigerian fermented fish condiment could be marketed to upscale restaurants or export to African diaspora who remember those flavors. There's also an opportunity in the health foods segment: fermented foods are globally seen as gut-healthy and flavorful; a mild form of fermented fish (perhaps a fish sauce or paste with controlled flavor) could be developed for Nigerian cuisine, offering a new flavor enhancer (much like stock cubes, but natural). The biggest opportunity, however, is likely in agro-industry – scaling up fish silage production. With Nigeria's push for more aquaculture and livestock production, a local supply of fermented fishmeal or silage to include in animal feeds could reduce feed import bills and create business ventures. Such silage production units could be set up near fish processing clusters or major landing sites, creating jobs and cleaning up waste in those communities. International cooperation (with countries like Norway or Iceland that have expertise in fish silage) could help jumpstart this. Additionally, the circular economy aspect could attract funding or support from environmental programs – an opportunity to get grants or soft loans to establish pilot projects converting fish waste to feed. If successful, Nigeria could showcase a model of sustainable fisheries waste management. For domestic food security, fermentation could allow inland communities that lack cold storage to store fish in peak season (fermenting some of it) and consume it over lean months, thereby improving protein intake year-round. Even a simple technique of fermenting and sun-drying small fish (like a salty fish jerky) could be promoted as an alternative to just letting excess catches spoil. • Threats: One of the main threats to fermented fish products is consumer perception and acceptability. If not handled carefully, these products can easily be stigmatized as "foul" or unclean due to their smell and appearance, which would prevent wider adoption. In a country where fresh and frozen fish are available (at least in urban areas), convincing people to try a strong-smelling fermented fish condiment might be an uphill battle. There are also regulatory threats: as food safety regulations tighten, some traditional fermentation practices might come under scrutiny. For instance, health authorities could potentially ban the sale of homemade fermented fish in markets if deemed unsafe, unless producers organize and meet certain standards. Another threat lies in overfishing and supply – fermentation traditionally was a way to use plentiful catches; if fish stocks are low, people might not have the surplus to ferment, and the practice could further dwindle (this is more a threat to the existence of the tradition than to a large market, since the market is small anyway). For fish silage, a threat would be if the end users (like feed mills) do not accept it – perhaps due to inconsistent quality or simply conservatism in feed formulation; this would undercut the viability of silage production businesses. Also, improper silage production could pose environmental or health threats (e.g., if a facility is not managed well, it could create a local odor nuisance or become a breeding ground for pests). In terms of competition, fermented fish products in food form might face competition from well-entrenched substitutes: for example, stock cubes and seasonings are everywhere in Nigerian cooking; a traditional fish ferment would have to compete with the convenience and familiarity of Maggi/Knorr cubes that provide umami in a dish. Lastly, cultural stigma could be a threat – as Nigeria modernizes, some may view fermented fish as a backward or "poor man's" food,

causing the knowledge and practice to fade among younger generations. Overcoming that stigma (if it exists) would be key to preserving and leveraging the benefits of fermentation.

CONCLUSION AND RECOMMENDATIONS

Fish processing and preservation remain vital components of Nigeria's fisheries value chain, contributing significantly to food security, income generation, and the reduction of post-harvest losses. The methods analyzed in this paper i.e. Freezing, heat-based techniques (smoking, drying, canning, extrusion cooking, and coated or fried products) fermentation, present distinct strengths, limitations, and growth opportunities within the Nigerian context. Freezing remains dominant, especially for imported fish and urban distribution, while smoking is extensively practiced in local settings. Although canning and retort pouch technologies offer significant potential, their development is hampered by infrastructural limitations and high capital requirements. Fermentation, while not yet mainstream, holds promise for both traditional food applications and fish feed production. Extrusion has been instrumental in driving Nigeria's aquaculture growth by reducing dependence on imported feed, although issues of scale and quality control persist. To unlock the full potential of these preservation methods, Nigeria must adopt a multifaceted strategy anchored in strategic investment, infrastructure development, and supportive policy frameworks. Strengthening infrastructure and cold chain systems is a fundamental first step. Targeted investments in reliable electricity, cold storage, and transport facilities—particularly in key fishing and processing zones—are essential. Such efforts should be supported by collaborative frameworks between government agencies and private investors. Promoting technology transfer and innovation is equally critical. The dissemination of improved smoking kilns, such as the Chorkor and FAO-Thiaroye models, alongside the adoption of retort pouch processing systems and local extrusion equipment, must be prioritized through capacity building, equipment subsidies, and public–private partnerships. Small-scale operators, who form the backbone of Nigeria's fish processing sector, require tailored technical assistance to improve product quality and safety standards. Facilitating the establishment of domestic canning and retort pouch industries offers substantial opportunity for import substitution and job creation. Government support in the form of tax incentives, concessional loans, and technology acquisition grants will be instrumental. Product development should align with Nigerian culinary preferences; such as spicy catfish in tomato-based sauces and market linkages should be built with institutional buyers, school feeding programs, and urban supermarkets. Strengthening local fish feed production is another key area. Encouraging the use of agro-industrial by-products, insect protein, and fermented fish waste in extruded feeds can help reduce Nigeria's dependence on imported ingredients. Ensuring consistent quality and wide distribution, particularly to smallholder fish farmers, will improve profitability and accessibility in the aquaculture sector. Improved regulatory oversight is necessary to guarantee product safety and build consumer confidence. Agencies such as NAFDAC and Standard Organization of Nigeria (SON) should be empowered to develop and enforce rigorous safety standards for processed fish products, including smoked and fermented varieties. Standards must address concerns such as excessive salt, PAH contamination, and general hygiene to facilitate both domestic sales and export compliance.

Consumer education and market development must also be prioritized. Public awareness campaigns highlighting the nutritional benefits of processed fish, coupled with improved branding and packaging, can help reposition these products as modern, safe, and convenient. Market expansion strategies should target urban consumers and Nigerian diaspora communities, leveraging cultural familiarity and convenience. Fer-

mentation presents a valuable opportunity, both for food and feed applications. Investment should be directed toward scalable fish silage production from processing waste, which can serve as a cost-effective input in aquaculture and livestock feeds. Concurrently, the development of fermented fish-based condiments should be pursued, particularly for niche and heritage culinary markets, with strict safety protocols to ensure product acceptability and compliance. Finally, strengthening research and development (RD) is indispensable. Enhanced collaboration with institutions such as the Nigerian Institute for Oceanography and Marine Research (NIOMR) and universities is essential for refining processing technologies, optimizing fish feed formulations, and developing product prototypes that are both locally appropriate and export-ready. Such RD efforts can drive innovation across the value chain, improve productivity, and support Nigeria's ambitions to become a regional leader in fisheries processing. In summary, the implementation of these strategies will significantly strengthen Nigeria's fish processing and preservation sector. It will reduce import dependence, enhance food security, create employment opportunities, and establish a more resilient and competitive post-harvest fisheries system capable of meeting both domestic and regional demand.

REFERENCES

References

Adedeji, T., Osundare, F. and Ajiboye, A. (2019). Profitability And Marketing Efficiency of Smoked Fish: An Empirical Evidence from Ondo State, Nigeria. *International Journal of Agricultural Extension and Rural Development Studies*, 6(3), 26–33.

Adewuyi, S. A., Phillip, B. B., Ayinde, I. A., and Akerele, D. (2010). Analysis of Profitability of Fish Farming in Ogun State, Nigeria. *Journal of Human Ecology*, 31(3), 179–184.

Agbeja, Y. E. (2004). Frozen Fish Retailing in Ibadan: Socio-Economic Analysis in Some Selected Markets. *African Journal of Livestock Extension*, 3, 69–73.

Agom, D.I., Etim, G.C. and Etuk, E.A. (2012). Analysis of Wholesale Frozen Fish Markets in Calabar, Cross River State, Nigeria. *Trends in Agricultural Economics*, 5, 61–69.

Akintola, S.L. and Fakoya, K.A. (2017). Small-scale fisheries in the context of traditional post-harvest practice and the quest for food and nutritional security in Nigeria. *Agriculture & Food Security*, 6(34), 17pp.

Ayeloja, A.A. and Jimoh, W. (2022). Fermented Fish Products in Sub-Saharan Africa. In *African Fermented Food Products- New Trends* (pp.251–263).

Ayuba, V.O. and Omeji, N. O. (2006). Effect of insect infestation on the shelf life of smoked and dried fish. *Proceedings of the 21st Annual Conference of the Fisheries Society of Nigeria (FISON)*, Calabar, 13–17 November, pp. 357–359.

Bhujel, R. C. (2014). *Manual for Tilapia Business Management*. CABI, ProQuest Ebook Central.

Brody, A.L., Bugusu, B., Han, J.H., Doetsch, C. and McHugh, T.H. (2008). Innovative food packaging solutions. *Journal of Food Science*, 73, R107–118.

Chirife, J. and Favetto, G.J. (1992). Some physico-chemical basis for food preservation by combined methods. *Food Research International*, 25, 389–393.

Choudhury, G.S. and Gautam, A. (2003). Effects of hydrolyzed fish muscle on intermediate process vari-

ables during twin screw extrusion of rice flour. *Lebensmittel Wissenschaft und Technologie*, 36, 667–671.

Chukwujindu, M.A., Iwegbue, G.E., Nwajei, F.O., Arimoro, O.E. (2009). Characteristic levels of heavy metals in canned sardines consumed in Nigeria. *The Environmentalist*, 29, 431–435.