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REVIEW

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Small-scale fisheries in the context of traditional post-harvest practice and the quest for food and nutritional security in Nigeria

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Abstract

Background: Existing scholarly works have paid little or no attention to the problems small-scale fisheries encounter within the context of food and nutritional security. Therefore, this work has examined the problem. Small-scale fisheries (SSF) are the dominant source of local fish production in Nigeria and, like many fisheries worldwide, receive inadequate attention for their significance within the context of food and nutritional security. A central theme to guaranteeing small-scale fisheries' contribution to sustainable food and nutritional security in Nigeria is addressing post-harvest losses (PHL). Considerable fish loss occurs between production and consumption. A narrative review was conducted to expose PHL practiced by SSF and discuss factors that prevent the adoption of locally available interventions.

Finding: Our study revealed that sun-drying and smoking are the major interventions practiced to mitigate PHL. Unfortunately, these methods of reducing PHL are constrained by gross under-capacity and improper handling during peak fishing periods and issues related to product safety. There are a handful of potential intervention mechanisms to address issues of PHL. Many of these PHL-reducing interventions have been designed bearing in mind local contexts and situations. However, general inertia and poor policy implementation currently hamper progress for reducing PHL.

Conclusion: A plethora of strategies are proposed to reduce PHL from SSF as contained in national and regional documents such as the National Policy on Food and Nutrition (NPFN), National Policy on Food and Nutrition in Nigeria (NPFNN), National Energy Policy (NEP), and Comprehensive Africa Agriculture Development Programme (CAADP). Recommendations are offered on identified gaps in areas of technological adoption, safety, and product quality issues, which are detrimental to traditional fish processing systems.

Keywords: Small-scale fisheries, Food security, Nutrient, Smoking, Sun-drying, Policy, Nigeria, Gender

Background

The quest to achieve or sustain fish food security and nutrition will continue to be difficult to realize when efforts are directed only at increasing production without corresponding efforts at reducing post-harvest losses (PHL) in fish. In Nigeria, the burden of supplying local fish needs to ensure food security and nutrition is borne mostly by small-scale fishers (Table 1). While there are considerable efforts aimed at increasing production from SSF, an important aspect of reducing fish loss, especially PHL, has not been given desired attention. There are huge fish losses at PHL levels in the artisanal fisheries sector as the SSF are not able to keep pace with harvest and preservation. Traditional methods of sun-drying and smoking (using mud kiln) remain popular especially where the facilities supporting ice production are inaccessible due to poor electricity supply and the prohibitive cost of ice-making machines. In tropical environments such as Nigeria, fish spoils within 10–20 h. Fish by nature is subject to rapid deterioration

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Table 1 Nigeria fish production by sectors (2000–2012) tonnes

S/no.	Sectors/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Artisanal: sub-total	418,069	433,537	450,965	446,203	434,830	490,594	518,537	504,226	511,382	598,211	616,981	638,486	668,754
	Coastal and brackish water	236,801	239,311	253,063	241,823	227,523	259,831	269,878	260,098	264,988	309,981	328,332	346,381	370,918
	Inland: rivers and lakes	181,268	194,226	197,902	204,380	207,307	230,763	248,659	244,128	246,394	288,230	288,649	292,105	297,836
2	Aquaculture (fish farm)	25,720	24,398	30,664	30,677	43,950	56,355	84,533	85,087	143,207	152,796	200,535	221,128	253,898
3	Industrial (commercial trawlers)	23,308	28,378	30,091	33,882	30,421	32,595	33,778	26,193	29,986	29,698	31,510	33,485	45,631
	Fish (inshore)	13,877	15,792	16,065	17,542	16,063	19,724	19,129	18,040	18,585	18,820	19,261	19,736	27,977
	Shrimp (inshore)	8056	12,380	12,797	11,416	12,469	10,946	13,767	5995	9881	10,878	12,249	13,749	17,654
	EEZ	1375	206	1229	4924	1889	1925	882	2158	1520	–	–	–	–
	Grand total	467,098	486,313	511,720	510,762	509,201	579,544	636,848	615,507	684,575	780,705	849,026	893,099	968,283

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once outside water because of its chemical composition, which may be made up of 70–84% water, 15–24% protein, 0.1–22% fat, and 1–2% minerals [1, 2]. Depending on the fish type, factors including high moisture and fat and protein contents promote rapid changes in quality in fish. Losses in fish without interventions could be as high as 27.3 ± 14.3% or more, while loss can be minimized as much as 14.7 ± 11.9% with interventions [3].

Purpose of study

Traditional fish processing is regarded with contempt and excluded largely in the food and nutrition schemes in Nigeria. This paper provides information on the importance of traditional fish processing interventions by the small-scale fishers to achieving food and nutrition security in the country. It seeks to redirect attentions of stakeholders towards activating the many provisions in the food and energy policy, as well as other documents that impact on food and nutrition. And which adopted will ginger a general renewal, standardization and safer product and at the same time remedy misgivings against traditional fish processing interventions.

Research context

In the sections following introduction, we present the definitions of key concepts in this paper including fish, food, and nutrition security. Explanations were offered on the principles of the pillars of food security with necessary connections that elucidate the concept of nutrition within the food and nutrition precepts. Next, fisheries as a food security mechanism were presented in relation to provision of important nutrients such as protein and omega-3 fatty acids crucial to sustaining good health in human. Other sections were presented that help concretise the narrative of traditional fish processing by the SSF in the context of food and nutrition security in the country.

Definitions of fish, food, and nutrition security

The terms "fish" and "seafood" are defined as finfish (vertebrates) and shellfish (invertebrates), whether of marine or freshwater origin, farmed or wild [4]. At the global level, fish and seafood consumption has gained increasing attention compared to other food sources. This development is easily adduced to greater understanding of the unique qualities of the nutrients found in fish.

Food security refers to the condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life [5]. Food availability, stability of supplies, and food access are related determinants of food security. In addition, the term "food and nutrition security" is used to emphasize the access and appropriate utilization of micronutrient-rich foods, including the process through which they are cooked and absorbed in the body, and then used in physiological functions at the individual level [6]. This outlook was adopted in this review. Nutrition security is achieved for a household when secure access to food is coupled with a sanitary environment, adequate health services, and adequate care to ensure a healthy life for all household members.

Fisheries as a food security mechanism

The importance of fish in seeking food and nutrition security for all is a frequently overlooked but extremely important part of global food and nutrition security [7]. Fish is nutrient rich and provides high-quality protein that is low in saturated fat and rich in polyunsaturated fats, especially the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [8].

The contribution of both fish protein in general and small-scale fisheries in particular to food and nutrition security has been recognized and advanced at the national and international level [6]. According to the Food and Agriculture Organization (FAO), all West African fishing grounds are either fully exploited or overexploited [9]. As a result, many development projects since the 1950s aimed at expanding fishing effort in West Africa have often ended in failure [10]. However, neither domestic fish stocks nor the sources of imported fish can be expanded to the drastic extent needed to meet at least the global average of 20 kg per capital consumption in a short timeframe. Moreover, the focus on fish within the food security context has been mainly limited thus far to questions of accessibility and stability, leaving huge gaps in policy implementation with respect to utilization and availability. Therefore, there is a need to consolidate management efforts towards directly reducing fish loss specifically within SSF in order to guarantee availability and utilization, social equity, and sustainability of the fisheries resource.

Using the United Nations International Children's Emergency Fund (UNICEF) conceptual framework [11] as a basis for analysis, this review discussed determinants of nutritional security of fish as a food resource at the level of SSF. The relationship linking traditionally processed fish and nutritional well-being is not causal, but is determined by many basic and underlying factors. The study provides insights into a number of intervention technologies available locally which currently are not being adopted but could ameliorate fish loss if adopted. Furthermore, this study recommends the adoption of creative and sustainable strategies for bridging identified

gaps and enacting enduring strategies with strong potential for increasing the competitiveness of traditionally processed fish.

Context of food security and fish consumption in Nigeria

Individual nutritional status is determined by various factors. In this review, the UNICEF [11] conceptual framework for nutritional status is employed (Fig. 1). The technology available at the national level defines the ability to translate or change the status of a resource from potential to available. The availability of a resource, particularly food-related resources, determines national nutritional outcomes in terms of survival, growth, and long-term development. Specifically, the level of technological development to harvest the fisheries resources is just localized and crude (Table 2). On a broader conceptual level, the political, ideological superstructure, and economic structure of Nigerian fisheries act to prevent traditional fish processing technology from realizing its own potential. For these reasons, there is a high level of post-harvest fish losses within the SSF sector. Within all fisheries, but especially SSF, resource constraints, institutional controls, and technological limitations hinder the full development of capture fisheries.

Food and nutrition security can only be achieved if adequate food (quantity, quality, safety, and sociocultural acceptability) is available, accessible, and satisfactorily used by all individuals at all times to live a healthy and active life. Household food security, maternal and child care, and health services and healthy environment are three pillars of underlying determinants of nutritional status. Diversifying livelihoods to increase household income sources is a way of improving household food security. Although fisheries-related literature often does not focus these other pillars, a consideration of children's nutritional status requires the examination of determinants such as child care, especially breastfeeding, and their importance in ensuring child nutrition. Access to health services and the living environment are also important factors in determining the risk of disease.

Therefore, adequate dietary intake and the absence of disease are immediate determinants of nutritional status. The three factors of household food security, care for children and women, and access to quality health services

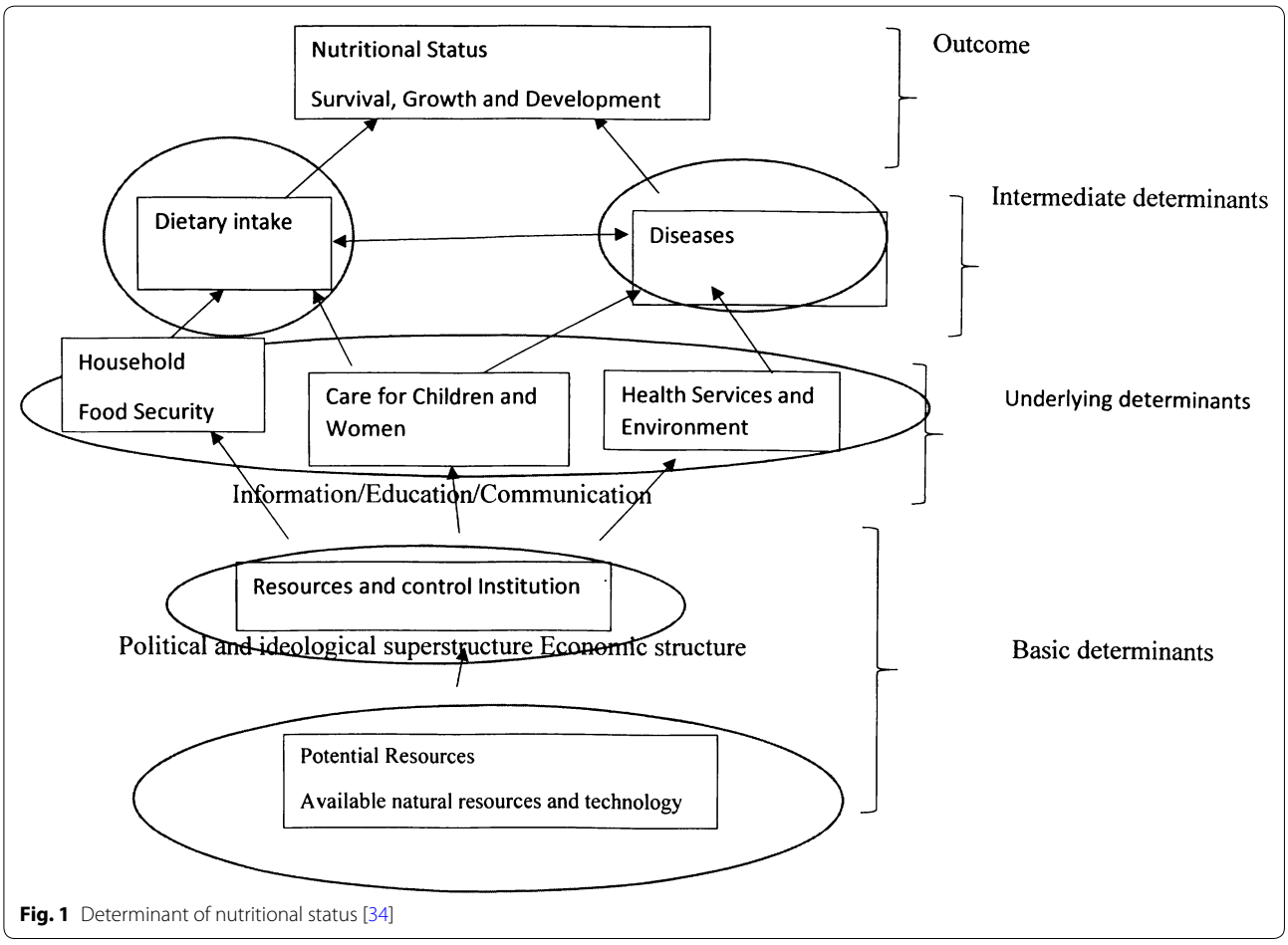

Fig. 1 Determinant of nutritional status [34]

Table 2 Intervention areas in traditional fish processing and national development

Activities	Basic determinant	Underlying determinant	Immediate determinant
Issues to address	Rustic technology and safety Per capital fish consumption	Utilization	Hidden hunger (micronutrient deficiency)
Focus	Inculcate tastes for fish/seafood especially processed forms	Improving on the chain management of traditionally processed fish to enhance household access Increasing household income	Increasing micronutrient intake by promotion of traditionally processed seafood and artisanal fisheries
Interventions	Modernization, adoption, and promotion of traditional fish processing technology by government agencies, viz. Federal Department of Fisheries, Energy Commission of Nigeria, Federal Department of Forestry, Ministry of Science of Tech Mass communication: National Committee on Food and Nutrition, National Agency for Food and Drug Administration and Control, Academic and Research Institution	Engaging traditional fish processor towards adoption more efficient and effective technology Granting repayable credit facilities guaranteed by the processors' cooperative and thrift societies for purpose of securing modern and improved local facilities Improving the quantity of smoked and sun-dried fish sourced from the cultured sources (marine and inland water)	Utilizing smoked and sun-dried fish as complementary food to improve nutritional status of children Encouraging consumption of smoked and sun-dried prawns, shrimps especially by children and women at household levels Improving diet of children to providing fish as a school lunch
Expected effects	Decrease in fish loss Increased production by fish processors	Safer and increased consumption of sun-dried and smoked fish products	Reduction in incidence of hidden hunger
Indicators	Better regulated traditional fish processing sector	Increased prosperous individuals	More virile and healthier citizens Reduced cases on nutrition related diseases such as obesity

and environment are necessary but not sufficient conditions for adequate nutrition. If all three are fulfilled, however, it is likely that dietary intake will be satisfactory, disease will be controlled, and adequate nutrition will be secured. Individuals with adequate dietary intake are able to develop appropriate immune systems and are thus better equipped to fight infectious diseases. As a result, breastfeeding mothers with adequate dietary intake will be able to pass on adequate and quality nutrients to their children during the first six months of exclusive breastfeeding, which required as foundation preparatory to subsequent life stages.

In several of the diverse cultures of Nigeria, a meal is not considered complete without some form of fish or fish product as the main animal protein component, or as a condiment. Fisheries' contribution to animal protein in the average Nigerian diet has been rising steadily and currently is at 28% [12]. Fish' contribution to animal protein consumption is 35% for urban and rural dwellers in Nigeria (national figure).[1] The value is very low compared to the Ghanaian average value of 63.2% [13]. Investment aimed at reducing food losses, therefore, offers an important pathway towards improving food security, alleviating poverty, and improving nutrition. In addition, reducing PHL in food generally has positive impacts on the environment as it enhances farm-level productivity and reduces the utilization of production resources or expansion into fragile ecosystems to produce food that will be lost and not consumed [14].

Nigeria's per capita fish consumption of 9.38 kg and population of 170 million classify it as a modest fish-consuming nation, yet in the NPFN 2001[2] document, fisheries were mentioned only in passing as a means of improving food intake compared to the greater emphases on grains or crops. Similarly, the National Plan of Action on Food and Nutrition (NPAN)[3] in Nigeria barely made mention of fisheries despite highlighting the need to improve food harvesting, processing, and preservation as a strategy towards enhancing food and nutrition security. The document also noted the need to improve the nutritional status of all Nigerians and particularly the most vulnerable groups such as children, women, and the elderly.

Through indigenous knowledge (IK) and traditional knowledge (TK), humans globally have employed salting,

[1] Values were calculated based on figures from Maziya-Dixon, B., I.O. Akinyele, E.B. Oguntona, S. Nokoe, R.A. Sanusi, and E. Harris, 2004 Nigeria Food Consumption and Nutrition Survey 2001–2003 Summary. IITA, Ibadan.

[2] The National Food Policy documents provide information on the government understanding of the challenges inherent in the nation's quest for food security and nutrition. We treat this document as the guideline for the operation of government 2001–2015. See http://www.foodbasketfoundation.org/downloads/download/?.

[3] This document is an improved document on the earlier version. It specified the actions government intend taken to solve the problems and challenges related to food security and nutrition. See https://extranet.who.int/nutrition/gina/sites/default/files/NGA.

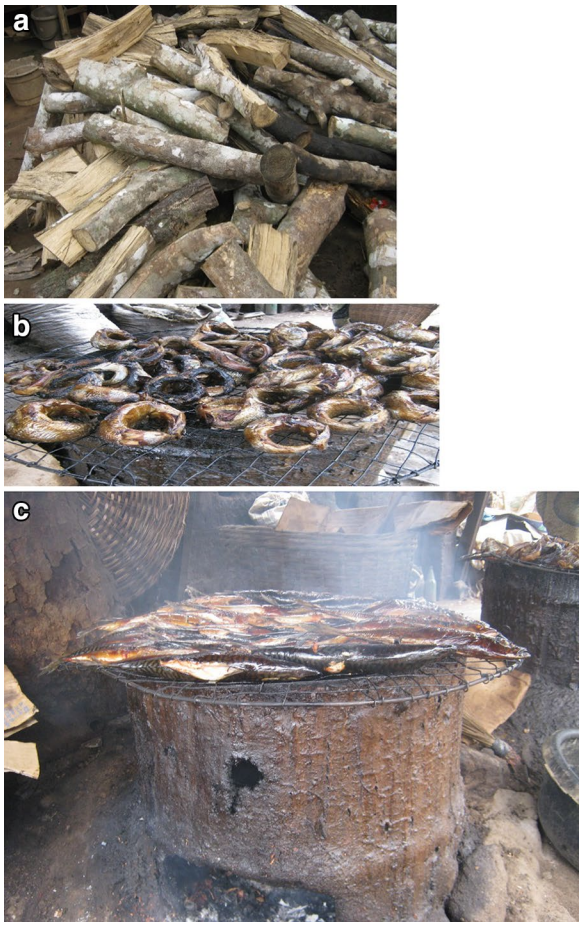

Fig. 2 Typical traditional smoking systems are shown in **a** wood fuel, **b** smoked fish, **c** drum kiln

frying, sun-drying, and smoking for centuries as means by which the process of spoilage in fish is controlled [15]. However, the literature on SSF has largely overlooked the reliance of this category of fisheries on these kinds of traditional preservation methods. These simple methods remain the prevailing means for distributing fish products for either household consumption or sale in local markets within the fishing community [15], as well as distant ethnic markets in Europe, Asia, and North America, and regional fish trade within Africa. Also, these methods are the precursors for advanced food preservation or processing procedures, including freezing and canning, which are undertaken to prevent fish spoilage and reduce PHL.

Case study of small-scale fish processing in Nigeria

Traditional fish processing methods enhance fish availability, affordability, and choice, thereby promoting nutrition, health, and well-being. Fish processing and sales in fishing communities in West Africa, including Nigeria, have been reported as a "gendered" activity comprising mainly women [16]. Governance structure for the traditional fish processing sector is a descriptive and adaptable framework which underscores the importance of these gender dimensions. Access to fish after harvest is determined by the relative position and scale of operation of women in fish processing. Scales at which women play these roles often attract different description by fishermen and male folks. Richly endowed women are able to influence happening within the value chain downstream dictating fish supply direction over the less fortunate women processor and attract better patronage from the fishers. Women are also able upset local arrangements with regards to credit scheme facilitated between the fisher and the female processors.

Overview of small-scale fisheries in Nigeria

Nigeria's fisheries sector is almost exclusively artisanal or small-scale, grossly underdeveloped, and highly heterogeneous. It contributes over 70% to domestic fish production, providing livelihoods to approximately 6.4 million fisher folk [12]. The main fishing and fishing-related activities are carried out in fishing settlements located in the Atlantic coastal area of the southern part of the country. Species-rich brackish water and estuarine canoe fisheries occupying about 12,904 km^2 exist in the creeks, estuaries, lagoons, and mangrove wetlands. Women fishers play prominent roles in this fishery [12]. Marine fishing is dominated by the coastal mechanized and canoe fisheries operating within five nautical miles of the sea shore, which is statutorily designated as non-trawling zone and 39,644 km^2 continental shelf area adjacent to the country's 853 km coastline.

Migrant fishers from neighbouring West African nations exploit fisheries resources 120 nautical miles within the extensive frontiers of the country's 216,325 km^2 Exclusive Economic Zone in the Gulf of Guinea [17]. Further inland, freshwater fisheries thrive consisting of nationwide network of rivers such as the Niger and Benue with several tributaries, natural lakes (e.g. Lake Chad), man-made lakes (e.g. Lake Kainji), reservoirs, and flood plains totalling an estimated 12.5 million hectares [17].

The SSF sub-sector is also multi-gear and multi-species in character. The craft and type of net depend on the type of fishery operated. Gears such as purse-seine net, set gill net, cast nets, encircling nets, traps, fyke nets, bag nets, pots, wounding gears, baskets and traps, drift and set gill nets, long lines, and trawl nets are used to target different fish species. Crafts (3–13 m long) used range from paddled, small-sized planked, or dugout canoes to larger, motorized canoes (half dugout/half plank) with outboard engines ranging from 15 to 45 hp, which are more like the vessel type commonly employed in Ghana.

Major freshwater fishes are fished year-round. Target species commonly caught include Nile perch (*Lates* spp.); tilapias (*Oreochromis* and *Hemichromis* spp.); catfishes (*Clarias, Heterobranchus* and *Synodontis* spp.): silver catfishes (*Chrysichthys* and *Bagrus* spp.); elephant snouts (*Gnathonemus* and *Momyrus* spp.); trunk fish (*Gymanarchus* spp.); tongue fish (*Heterotis* spp.); and moon fish (*Citharinus*) spp. [18]. The fish community inhabiting the estuaries, creeks, and coastal waters consists of small pelagics of the family Clupeidae. Bonga (*Ethmalosa* sp.) dominates the coastal pelagic fishery. Sardines (*Sardinella* sp.), shad (*Ilishaafricana*) various jacks (*Caranx* spp.), and Atlantic bumpers (*Chloroscombrus chrysurus*) are also caught in modest quantities. Croakers (*Pseudotolithus* spp.) constitute the main commercial demersal stock [18] in coastal and brackish fisheries. Other exploited species include grunters (*Brachydeuterus* sp.), soles (*Cynoglossu*s spp.), marine catfish (*Arius* sp.), brackish water catfish (*Chrisichthys*), *Sphyraena* spp. (barracuda), snappers (*Lutjanus* sp.), threadfins (*Galeoides decadactylus*, *Pentanemusquinquarius*), and groupers (*Epinephelus*). Common exploited shellfish resources are estuarine/white shrimps ("crayfish") (*Palaemon* sp.) which supports a major creek fishery in the Niger Delta, *Macrobrachium vollenhovenii* (African river prawn); *M. macrobrachion* (Brackishwater Prawn); marine and estuarine *Penaeus notialis* (Southern pink shrimp); *Parapenaeopsisatlantica* and (Guinea shrimp). Other shellfishes include crabs of the genus *Callinectes* in the families Portunidae and Geryonidae, molluscs such as the mangrove oyster (*Crassotreagasar*), periwinkles (*Tympanostomus* spp.), and certain bivalves [19].

Actual production figures from SSF could be grossly undervalued. There is limited information on the state of fisheries resources nationwide. Many water bodies have not been assessed for their fisheries potentials, and stock assessments available are very few in number and out-dated. There is potential underestimation in catches ranging between 100,000 and 180,000 mt annually for artisanal shrimp fisheries, part-time fishermen, and brackish water areas [20]. When combined with poor availability of data from freshwater fisheries, this implies an enormous gap in overall fish landings for the country. Fishing communities are numerous and generally highly scattered in remote, inaccessible settlements due to poor or non-existent access roads and susceptibility to flooding during the rainy seasons. They usually do not have access to basic social infrastructures. Facilities such as cold storage and processing plants are very poorly developed. There is, therefore, heavy reliance on traditional fish processing and preservation methods which, unfortunately, are bedevilled by gross under-capacity and improper handling particularly during the peak fishing period.

PHLs are characteristics of SSF in developing nations, and an accurate estimation of total losses is problematic. In Nigeria, these have been reported to exceed 30% of the total catch [21]. A seasonal glut occurs between November to May for sardines and Bonga (Clupeids). Under these circumstances, fisherfolk are unable to cope with heavy fish catches, resulting in substantial quantities of fish being wasted, leading to putrefying gluts of spoilt fish which litter the sandy beaches and buried spoilt fish in the sands [22, 23]. The difficulty experienced in the evacuation, distribution, and marketing of fish products further contributes to a high percentage of PHL along the entire value chain from harvest to consumption. Ultimately, regardless of the quantity of fish wasted, this waste also translates into huge financial losses, reduction in the quantity of available fish supplied, and animal protein for human consumption, respectively, thus threatening food security.

Fish trade and food and nutritional security: Nigeria scenario

Nigeria is ranked among 55 nations classified as being low-income food-deficit countries (LIFDCs). This list, created by the FAO in 2014, is based on three criteria. First, a country should have a per capita gross national income (GNI) below the "historical" ceiling used by the World Bank to determine eligibility for International Development Association (IDA) assistance and for 20-year International Bank for Reconstruction and Development (IBRD) terms, applied to countries included in World Bank's categories I and II. The 2014 LIFDC list is based on the GNI for 2011 (estimated by the World Bank using the Atlas method) and the historical ceiling of USD 1 945 in 2011.

The second criterion is based on the net (i.e. gross imports less gross exports) food trade position of a country averaged over the preceding three years for which statistics are available. Trade volumes for a broad basket of basic foodstuffs (cereals, roots and tubers, pulses, oilseeds and oils other than tree crop oils, meat and dairy products) are converted and aggregated by the calorie content of individual commodities. Thirdly, the self-exclusion criterion is applied when countries that meet the above two criteria specifically request to be excluded from the LIFDC category.

This designation means that the country must pursue a policy of balancing the quest for fish trade and food security in relation to fish as a food or commodity. Fish is an important component of the National Economy and Trade, since Nigeria is both a fish exporting and importing nation. Fish has an inherent tendency to be

commoditized, and seafood have been commodities that were preserved and traded since the Bronze Age [24]. Therefore, fish have played an important role in the first phase of the emergence of a global economy and a singular role in the international expansion of trade before becoming an internationally traded commodity in its own right.

Specific to fish, Nigeria has a positive net food trade averaged over the previous three years [12]. Products emanating from the industrial fisheries, and shrimp in particular, are destined for the European and American markets where they attract premium values. The protein needs for the domestic markets are, therefore, met largely by supply from the artisanal fisheries, importation, and, by far less, aquaculture. The poor state of infrastructure, especially electricity supply and irregularity of fish supply from SSF occasioned by unpredictability of catch, fuel the need to resort to traditional means of processing by fishmongers. Generally speaking, infrastructure required driving both the quest for fish food security and trade has been reported [25] and will include fish landing centres, processing facilities, link roads, stable electricity, portable water supply, housing, and sanitary and environmental engineering works. These infrastructures can be broadly grouped as livelihood and trade related.

The scenario we have today is that investment directions in infrastructure development have been tilted largely in favour of trade-related infrastructure development favouring exportation and importation. Although the traditional food processing business invariably benefits from increased link roads and improved electricity, it presently suffers from neglect over the years to ensure broad-based investment in provision of processing facilities, storage, good hygienic practices (GHP)/good manufacturing practice (GMP), or sanitation standard operating procedures (SSOP), or prerequisite programmes for food safety. In contrast, food safety and quality management have become standards in the formal fish trade markets. The fish processing business requires that effective hygienic, quality, and safe food be promoted. A good healthy environment is crucial if food supplies are to ensure food security and nutritional well-being.

Fish in the Nigerian Food Policy have been largely directed towards increasing production, with lessening emphasis on getting the processing and distribution right. Efficient and effective domestic fish marketing is the ground rules for achieving sustainable fish food, nutritional well-being, and, ultimately, sustainable development. Presently, traditional fish processing techniques of salting, smoking, and sun-drying are at the centre of guaranteeing fish protein, food security, and nutritional well-being. The more lucrative export fish trade is the focus of medium fish processors whose major supply is from the aquaculture supply. The traditional fish processing methods are faced with serious challenges in view of the increased consumers' awareness on matter of food safety and qualities.

There is a general sense of apathy from government for monitoring, regulating, and intervening in the business of traditional processing by means of interventions such as the modernization of PHL reduction technologies, product standardization, and regulation. The need for government to give direction is of the utmost importance, given that the small-scale operators are not organized to create the necessary structures that must be put in place to bring about the required changes. They do not enjoy the economic stimulus offered by foreign international markets.

Nutritional status of children in Nigeria

The 2013 Nigeria Demographic and Health Survey provided new insight on the nutritional status of children and adults in the country [26]. About 37% of children under 5 years old in Nigeria are stunted, thus reflecting chronic malnutrition. National figures show that approximately 10–20% encountered acute malnutrition and 29% are described as underweight, reflecting chronic or acute malnutrition or a combination of both [26]. Undernutrition is described as an outcome of insufficient food intake and repeated infectious diseases, while malnutrition refers to both under-nutrition and over-nutrition [27].

The problem of micronutrient deficiencies is different in nature as it results from an inadequate quality of diet. Micronutrient deficiencies increase the general risk of infectious illness (e.g. measles) and non-infectious diseases such as malaria and pneumonia, or even diarrhoea. Adequate intake of essential micronutrients, especially by pregnant women and young children, is important to attaining nutritional security. Appropriate nutrition includes feeding children with a variety of foods to ensure that nutrient requirements are met. It is well known that plant-based complementary foods (food given to a child after exclusive breastfeeding) by themselves are insufficient to meet the needs for certain micronutrients [1, 2]. It has been advised that meat, poultry, fish, or eggs should be eaten daily, or as often as possible. Fish has been variously suggested to be an important part of infant feed or complementary food [1, 2].

Contribution of fish and SSF to food security and nutrition in Nigeria

To understand the importance of SSF in contributing to food security, it is necessary to grasp the significance of underlying factors which affect fish consumption

patterns. In 2002, the FAO estimated that fish provide about 19% of the protein intake in developing countries with the following qualification: "the figure, however, represents an average at a global level and does not reflect the very large heterogeneity at the national or, even more importantly, at the local level. Similarly, fish contribution to animal protein consumption can be as low as 23% in Liberia and as high as 63.2% in Ghana" [13].

In Nigeria, fish is reported to be the most frequently consumed animal protein consumed by households [28]. Per capita fish consumption in Nigeria increased from an estimated 13.71 kg in 1993 to 14.49 kg in 2000 [20]. However, comparing Nigeria's per capita fish consumption of 13.9 kg to the global average of 18.9 kg in 2011 [29] shows that fish consumption is still inadequate. Disaggregating national data [25], (see footnote 1) the percentage of fish as animal protein at the national level is 35, or between 41.15 and 43.1 of animal source protein and 39.7 of animal-source food [29]. While cultural standards appear to have no bearing on motivations to consume fish [30], decisions around the consumption and choice of fish product form is governed by factors such as income and market values. Other important factors are the urban–rural divide, non-fishing households versus fishing households, and relative distance or proximity to common-pool resources. However, much of the sector's contribution to rural household consumption is often undervalued, and their importance ignored. In the Nigerian context, small-scale fisheries supply as much as 75% of animal protein intake in coastal or inland fishing communities [31]. Generally, fishing households have greater access to fish for direct consumption. Fish from common-pool resources or open-access regimes are literally free for harvesting and contribute in large part to nutritional security at the local level, particularly in the diets of poor people. Subsistence fishing of small fish, crustaceans, and molluscs, though almost marginal in terms of quantity, plays an important role in the food and nutritional security of household members. Consequently, per capita annual consumption of fish in fishing households (an average 230 g per day) is usually higher compared to non-fishing households [31].

Pathways linking traditional fish processing and nutritional security to national development

The national aggregate wealth generated from inland fish production and consequently traditionally processed fish are estimated between US$ 230–330 million and US$ 280 million per year.[4,5] Processing is an important activity within the fishing industry, although it is often ignored. However, it is very evident that traditional processing like small-scale fisheries, in general, is an activity that is too big to ignore. As a sub-sector, its economic output provides an important dimension and interlinked pathways to national development in many ways.

Directly, traditional fish processing contributes to food and nutritional security in terms of the utilization, availability, and stability of price at the individual or household, regional, and national levels. Increased levels of protein, carbohydrates, fat, and energy were recorded in boiled, grilled, and fried fish in comparison with the raw forms [32]. Smoked products offered the healthiest advantage with the lowest values of saturated fatty acids, index of atherogenicity, index of thrombogenicity, and the highest omega-3/-6 ratios, which are important for reducing coronary heart disease (CHD) in food consumption [1]. Furthermore, smoking increases the concentration of alanine, threonine, tyrosine, and cysteine and accounts for a sweeter taste of the shrimp over other product forms, while sun-dried specimens were found to have increased levels of histidine and arginine [1, 2].

In a country with high levels of malnutrition among children in many regions, the eradication of malnutrition is a critical national development goal. It is well established that fish products as a form of animal protein can effectively be used as complementary foods to fight malnutrition. In addition, since nutrients from seafood are cheaper than other sources of animal nutrients, consuming processed fish products (which are reported to compare even better than raw fish) provides affordable high-quality protein. It is cheaper to eat processed fish forms such as sun-dried, smoked, grilled, and boiled (authors' experience).

The present disdain and apathy with which traditional fish processing methods are viewed require a change in policy direction to ensure increased fish availability, particularly in a country where every gram of protein and energy is crucial for reducing considerably the nation's high protein–energy malnutrition (PEM). The national average protein and energy intake of 53 g and 2071 kcal is below the World Health Organization (WHO) standard. Thus, it is crucial to provide support to the traditional fish processing sector and to improve the access of citizens, especially children, to processed fish protein.

Traditional fish processing activities and gender

Fish value chains are highly gendered and fraught with inequalities, creating food security and nutrition challenges at local, regional, and national levels. It is well known that of workers in SSF, women working in processing outnumber men. Unfortunately, much of the work performed by women in post-harvest processing is

[4] Assumption: 60% of the imported and local production is consumed in process form.

[5] Assumption: average volume of fishes sold as smoked/sun-dried. Exchange rate of US$ 1.00 to N 100.

not compensated or is poorly recorded. Hence, to understand the gendered dynamics between actors in the value chain in the production of traditionally processed fish, it is essential to consider the governance structure for this important sub-sector.

In Nigeria, the traditional culture of the people is the basis of community-level governance structures, including in fishing communities [15, 33]. Artisanal fish processing and preservation activities are primarily carried out by women. However, in rare instances cultural norms restrict the participation of women in post-harvest activities at landing sites, thus leaving post-harvest activities to men. Women often engage in fish processing as their sole economic activity, or combine this with tasks upstream or downstream the value chain, or outside of fishing altogether [15]. Fish processing is carried out at different scales, depending on the quantity of fish being handled. The producer–processor group, which occurs the most, is prevalent in rural fishing communities and may involve male fishers [34]. Women processors obtain their supplies from within their family (usually the husband), while a small number of women engage in fishing themselves with the use of both trap setting and gear netting. Sometimes, women fishers obtain fish under different purchase arrangements from their male counterparts. Processor–sellers/traders form another category which mostly consists of women who combine functions of processing and marketing [35]. Lastly, women engaged solely in the trading of processed fish buy their products at either wholesale or retail markets. They also sell via commission agents or brokers to different market intermediaries. Sometimes commission agents or brokers serve as links between the many intermediaries along the value chain.

Evaluation of traditional fish processing technologies

Technology drives many human endeavours at all levels of human activities and history, from rudimentary tools to advanced modern-day technology. Community-based knowledge, which has evolved in every culture over a long period of time in many generations, is referred to as indigenous knowledge (IK) or traditional knowledge (TK). However, TK/IK may have borrowed extensively from the process of technological adaption as people began to borrow from other knowledge outside of their geographical location and traditional practices. In the case of fisheries and fish processing in particular, women employ the use of TK/IK in preserving fish in order to increase its shelf life and ensure value addition. Common traditional methods include gutting, washing, splitting, filleting, and sticking the fish, cooking, salting (brining), smoking, curing, fermentation, and sun-drying (drying).

Cooking

It is the most common and simple method requiring no more than basic household equipment which provides short-term preservation of fish usually for a few days before any deterioration becomes noticeable. Although warming after cooking does extend the period, a loss in value quickly becomes discernible. Different methods are used for cooking fish, but the principle of these processes is similar. The flesh of the fish softens, enzymes become inactivated, and the process kills many of the bacteria present on the surface of the fish.

Salting

Salting is by far the most influential form of fish preservation and trade, serving as the precursor for international commodity trading. The principle is based on the knowledge that food-poisoning bacteria cannot live in salty conditions and a concentration of 6–10% salt in fish tissue will prevent bacterial activity, thereby impacting a longer shelf life. However, a group of micro-organisms known as "halophytic bacteria" are salt-loving and will spoil the salted fish even at a concentration of 6–10%. Traditional methods of using salt usually involve removing the guts and gills and cutting the flesh into pieces before rubbing salt into the flesh or making alternate layers. The recommended levels of salt usage are 30–40% of the prepared weight of the fish.

However, the concentration of salt in the flesh is not sufficient to preserve the fish if it is not uniformly applied. Brining offers a better preservation over the direct application of salt to the fish muscle and tissues. This process involves immersing the fish into a pre-prepared solution (36% salt). The advantage is that the salt concentration can be more easily controlled and salt penetration is more uniform.

In most fish preservation, it is a usual practice to use salt in combination with other means of preservation. Nevertheless, the use of salt curing for food preparation must be approached with a high degree of caution, since high salt intake is deleterious to good health. The growing concern is founded in reports of increased heart palpitations in some individuals. This occurrence could predispose pre-hypertensive and hypertensive individuals to additional health risks. Thus, there is a need to investigate and ensure safe concentrations of domestic salt in fish preservation.

Sun-drying

This process consists of the use of the sun and movement of air to remove moisture and preserve the fish. In order to prevent spoilage, the moisture content needs to be reduced to 25% or less. The time it takes to dry fish products depends on the nature of the product, the intensity

of the sun, and the surfaces used for drying. The simplest form of drying involves exposing whole small fish or split large fish to heat from the sun by placing products either directly on the ground, roofs, nets, and mats placed on the ground or on racks. However, this technique makes the fish susceptible to predations by animals. This method is commonly used in the Northern parts of the country, due to the sun's intensity and other favourable conditions such as dry weather, low humidity, and clear skies [2]. Fish is typically sun-dried for three to ten days, but drying periods of one to three days are more common [36].

Sun-drying has found favour with fishmongers for centuries, producing fish meat that is condensed, saturated with oil, translucent and amber in colour, dense in consistency, and pleasant in taste. Impediments to the use of this method are related to product quality as well as safety. Sun-drying does not allow very much control over drying times, and it also exposes the fish to attack by insects or vermin and there are all possibilities of contamination by sand and dirt. Other constraints include considerable product losses, lower fish quality because of contamination by foreign materials, reduced protein quality, insects and micro-organisms as well as discolouring by ultraviolet radiation [36].

During the drying process, the fish surface dries faster and hardens, thereby locking moisture inside, which slows the drying process and encourages degradation of protein and fatty acid oxidation. Degradation of protein is accelerated when fish products are subjected to high temperatures for an extended period. Since traditional sun-drying is weather dependent, some losses in quality also result from inadequate drying.

Smoking

Smoking is used mainly to preserve fish, partly by drying and partly by adding naturally produced anti-microbiological constituents such as phenols from the smoke to the fish. Smoking is a preferred method of preservation because it dries the fish, melts some fat out of the fish, and reduces microbial growth. When this is achieved, smoking is expected to extend the shelf life of most fish products to several weeks. However, in recent times it is being used in addition to preservation to achieve the characteristic taste and appearance of the smoked fish. Heat from the fire causes drying, and if the temperature is high enough, the flesh becomes cooked. Both of these factors prevent bacterial growth and enzyme activity, thus preventing spoilage.

Fish smoking differs according to the type of kiln technology used and can be categorized as the following types:

- Cold smoking: In this method, the temperature is not high enough to cook the fish. It is not usually higher than 35 °C.
- Hot smoking: In this method, the temperature is high enough to cook fish. Hot smoking is often the preferred method. Traditionally, in West Africa in particular, fish smoking is the most extensively practiced fish preservation method in Ghana and Nigeria, which uses the traditional kiln with wood burning temperatures between 300 and 700 °C (for wood combustion) usually 70–80 °C of the oven temperature. This is because the process requires less control than cold processing and the shelf life of the hot-smoked product is longer because the fish is smoked until dry. Hot smoking consumes more fuel than the cold smoking method.

The wholesomeness of smoked fish products using the traditional kiln depends on the following factors: the type of wood used for the smoking process; the temperature used; the duration of smoking; the type of kiln used; the proximity of the fish from fire; the type of fish being smoked; and the fat content of the fish [37]. The primary challenge with the traditional kiln technology common across Nigeria, and West Africa in general, has to do with the temperature regulatory system of the design, which poses difficulties for the commercial fishmongers operating this type of technology.

Smoking temperatures result in the release of a wide range of antioxidant and antimicrobial chemicals like polycyclic aromatic hydrocarbons (PAHs), phenols, aldehydes, and acetic acids, some of which are known to be carcinogenic, mutagenic, and endocrine disrupting [38, 39]. PAHs produced in wood smokes are known to originate from the thermal pyrolysis (depolymerization) of lignin and subsequent condensation of the lignin components in lignocelluloses at temperatures above 350 °C. Charcoal used as filters in modified traditional smoking kilns is effective in removing PAHs from the smoke generated, thus potentially posing little or no health effects on consumers. Therefore, the adoption of this method may help reduce the levels of PAH-associated health effects like cancer and other cancer-related ailments which is reported to be on the increase in Ghana [40]. A typical system for traditional fish smoking in Nigeria is shown in Fig. 2.

Certain traditional fish processing practices constitute occupational and health hazards to consumers, processors, and the environment. A study in Nigeria indicated that smoked catfish/sole fish from commercial fishmongers using a traditional smoking kiln showed elevated levels of PAHs compared to the modern kiln [41]. The study postulated that this trend may be associated with

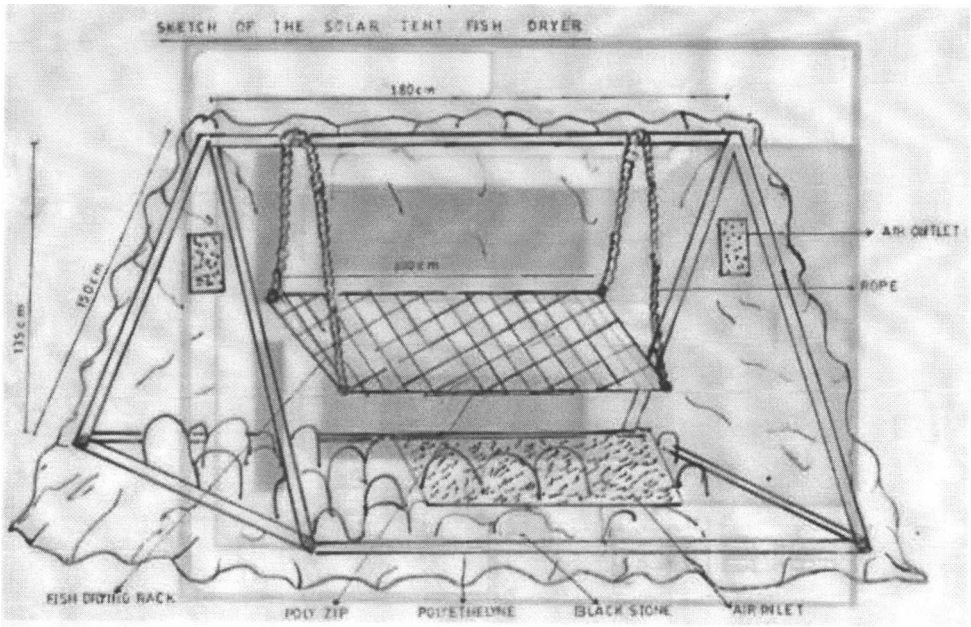

Fig. 3 The sketch of Kainji Solar Tent Dryer [48]

increasing cases of cancer and cancer-related ailments in the nation. Generally, fish that is smoke-cured with hardwoods (e.g. acacia and mangrove) for a longer duration (≥4 h) using the traditional kiln may be unsafe for consumption, but sugarcane bagasse-cured fish using the traditional kiln was both the safest and the best fish smoking practice for short-duration smoking [37]. There may be elevated risks of cancer and non-cancerous diseases associated with lifelong (70 years) consumption of mackerel and sardine that is smoke-cured with hardwoods, especially at longer smoking durations due to their high lipid content.

Long hours and many years spent smoking fish have negatively impacted the health of women processors. Exposure to smoke from the burning of biomass fuels, including firewood, is a major risk factor for several respiratory ailments, such as asthma, chronic obstructive pulmonary disease (COPD), respiratory tract infections, and lung cancer [42]. A study in the rural fishing community of Obaka has shown that women processors are exposed to increased risk of developing COPD compared to women who do not work in the fish smoking business [43]. The smoke also causes redness/swelling of the eye, poor vision, rashes, eczema, pile, rheumatism, diarrhoea, dysentery, and heat [44]. Fish processors could also be exposed to smoke particles that contain potential or confirmed carcinogens such as PAHs. Milder forms of occupational hazards linked to fish processing include sting from fish spines, minor cuts, and scrapes [45]. Overall, poor socio-economic status, poor nutrition, exposure to other sources of indoor air pollutants such as mosquito coils and kerosene lamps, and risk of injuries, combined with poor access to sanitation and healthcare facilities, increase risks of developing health hazards linked to fish smoking [45].

In addition, the use of firewood as the major energy source in traditional smoking kilns has drawn some other criticism on the bases of economic and environmental consequences. The supply of fuel wood is characterized by scarcity, rendering it costly for fish smoking [46]. The practice is also time-consuming and considered wasteful due to the small quantities of fish that are smoked at a time [45]. Exploitation and consumption of firewood for fish drying and other uses is a contributory factor to continued deforestation in the country, particularly in the arid Northern region where this practice is contributing to desertification [47]. Although heat treatments may impact on the nutritive values of traditionally preserved fish, the overall quality has been demonstrated not to have significant differences from the fresh or raw fish [1, 2]. In many instances, the reduction in nutritive value may be due to the method used for the analyses rather than due to impact of intervention [1].

Curing

Curing involves the techniques of drying, dry salting/brining (soaking in salt solution), or smoking. These may be used alone or in various combinations to produce a range of products with a long shelf life. For example:

- Drying–smoking–drying.
- Brining–smoking–drying.
- Salting–drying.
- Salting–drying–smoking.

These techniques reduce the water content in the flesh of the fish, thereby preventing the growth spoilage caused by micro-organisms. Curing is not widely used in Nigeria, along with fish fermentation and deep frying.

Strategies for bridging identified gaps

Traditional fish processors lack the financial and economic capacity to adopt new technological interventions which have been developed and tested at pilot levels but have since scaled up, therefore leaving these processors behind in the space of technological adoption dynamics and processes. The need for cost-effective loss reduction had been highlighted in the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication[6] and the Code of Conduct for Responsible Fisheries.[7] Specifically, these documents mention value addition, building on existing traditional and local cost-efficient technologies, the adoption of local innovations and culturally appropriate technology transfers, and the promotion of environmentally sustainable practices within an ecosystem approach.

In addition, the SSF Guidelines advocate for the inclusion of post-harvest actors in relevant decision-making processes and special support for vulnerable and marginalized group in the recognition of unequal power relationships between actors in the value chain. The document also highlights the need for improvements in the sub-sector by provision of amenities, services, appropriate infrastructures, promotion of cooperatives, and capacity development, which will support the post-harvest sub-sector in producing good quality and safe fish and fishery products for both export and domestic markets, and also enhance income and livelihood security.

Walking the talk: implementing the strategies on food processing in the National Policy on Food and Nutrition in Nigeria

The NPFNN document is over a decade old. Detailed study of the six-chapter document shows an excellent understanding of the situation, but it is unclear why not much has been achieved since its release. Clearly, the main challenge is not putting these commitments to practice; in other words, there has been no desire to walk the talk. Chapter 4 specifically deals with Institutional Arrangements:

> *The National Food and Nutrition Policy requires an effective institutional arrangement to ensure a results-oriented programme implementation. Past implementation efforts have been principally sectoral (health, agriculture, science and technology, and education, etc.], uncoordinated, inadequately funded and limited in scope and coverage. Such efforts, therefore, fell short of the desired outcome of solving the problems they were designed to tackle.*

The agency in charge of implementation is the National Planning Commission (NPC), with the National Committee on Food and Nutrition (NCFN) being the Siamese (being both connected to deliver food and nutrition security). There is a lot to be done in order to align these bodies to ensure the delivery of their mandates, especially regarding the utilization dimension of food security. These two agencies must devise ways by which fish: (a) is fully integrated into inter-sectoral national food security and nutrition policies and programmes and (b) is more systematically included in national nutritional programmes and interventions aimed at tackling micronutrient deficiencies, especially among children and women. The NCFN should pursue the multi sectoral approach in dealing with the issue of food and nutrition programming and bring to bear the utilization dimensions of fish in the context of food security. This approach will require regular monthly meetings of identified stakeholders within the food and nutrition spectrum to review their success at meeting departmental mandates and ensure the larger involvement of developmental agencies internationally and locally.

Voice and visibility to the role of fish and fishery products

Aside from the promotion of the accessibility, availability, and, perhaps, stability of food and nutrition security (as the cardinal principle which respective governmental agencies and ministry are following to make progress), there is an urgent need to promote the consumption of fish products as part of the overall objective of promoting food and nutrition security at the household and national level.

The 35% fish consumption rate out of all animal protein at the household, regional, and national level is grossly inadequate and far below some countries of Africa and Asia, where fish accounts for more than 50% of the total animal protein intake. There is the urgent need for the NCFN to work assiduously in promoting required change. The present dietary habit which favours consumption of staple plant-based food over that of animal protein has been proven to be grossly

[6] Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication 2015 accessed 16 January, 2016, at 20 p.m. http://www.fao.org/fishery/ssf/guidelines/en.

[7] FAO Code of Conduct for Responsible Fisheries Special Edition 2011 accessed 3 February, 2016, at 16.30 p.m. http://www.fao.org/docrep/013/i1900e/i1900e00.htm.

inadequate in meeting the present nutritional needs of the present generation in Nigeria, especially in the case of children.

In the same vein, the high preference for meat over fish consumption suggests that we are not doing enough to prevent, rather than treat, the malnutrition that affects a large population of children, as well as non-communicable diseases of aged adult such as diabetes, cancer, coronary heart diseases, and obesity. The activities of NPC and NCFN related to food and nutrition security need to be made transparent to the public. There must be concise efforts to promote the culture of fish consumption as well as the establishment of a national policy on dietary food intake in favour of fish products by means of establishing an Expert Consultative Forum on fish and fish products as food with an emphasis on: the neurological development benefits of fish consumption to the children of women of childbearing age; the reduction in mortality from coronary heart disease (and the risks of mortality from coronary heart disease associated with not eating fish) among the adult population; and the potential to use dried fish products, especially shell fish, as an ingredient in complementary or weaning food items for infants following the period of exclusive breastfeeding.

The Fisheries Act of 2014 pragmatically gave a holistic approach to understanding fish and fisheries governance. The framing of fish as food is an important step that is necessary for achieving food and nutritional security on a national level and strengthening the various pillars of food security. However, it is imperative that the Fisheries Act 2014 be signed into law. The 8th National Assembly should consider initiating this proposed legislation. NPC and NCFN should consider incorporating the voice of relevant fisheries and nutrition-based Civil Society Organizations (CSOs) and coordinate public engagement activities to include these groups in lobbying to pass the Act into law.

Proper nutrition, especially in terms of ensuring the standard protein–energy ratio (PER) balance, has been known to be an appropriate prevention method for malnutrition and diseases associated with old age. The current situation in Nigeria points to the need to revise the stale definition of food security in terms of caloric intake but widen food security indices to include such as food availability, affordability, percentage of fish caught with maximum sustainable yield, land areas affected by desertification as percentage of total land mass, per capita protein and energy intake, income indices, level of unemployment, average real income, and income distribution index. There is a need for a paradigm shift in the operational terminology of what constitutes food security and its unit of measurement.

Adoption of homegrown technological packages in small-scale fish processing

Small-scale fish processors are critical in fulfilling any mandate of making fish and fishery products, playing a vital role within the concept of fish as food and promoting household and national food security. The NPFNN document while proselytizing strategies for achieving food and nutrition policy objectives towards food security stated to:

1. Promote and support research on food processing and preservation technologies at the village and household levels; and
2. Introduce and expand such technologies and training through their inclusion in the curricular of schools and training institutions.

There has been remarkable progress in implementing certain aspects of these strategies. Researchers in academic institutes and tertiary institutions have helped in responding to this call. There are many homegrown technological packages that can modernize the traditional fish processing technologies of the sun-drying and smoking of fish. There have been many innovative and spectacular ingenuity creations of solar dryers (Kainji Solar Tent Dryer (KSTD), Plastic Driers, Mosquito Net Driers, Glass Driers, Aluminium Driers, and Glass Driers (which contain black stones). Localized fish drying technologies include the Kanji Solar Tent Dryer (Fig. 3) [48]. Solar and cabinet dryers, plastic drier (constructed using a thermopile plastic material), mosquito net drier [constructed by using plywood for the frame (edges) and subsequently covering the dryer with mosquito net all around the wooden frame), glass drier (made of transparent glass), aluminium drier (constructed from aluminium sheets and coated both inside and outside with black paint), and glass drier containing black stones. This is similar to the glass drier in every respect but with a black (igneous rock) stone placed in it. There have also been local variants of kiln which seek to replace the traditional mud and drum kiln which dominate the landscape.

The challenge has been that many of these technologies have not been adopted in the field. Thus, there is a need to demonstrate and situate the applicability of many of these technologies and their variants at the level of small-scale fishmongers in relation to their socio-economic status. Present outcomes of these research outputs offer a suite of opportunities which can be adopted based on the circumstances of state and local government areas. Once the fishmongers buy into any technology package, there is a need to have a credit scheme in place that is co-managed by the operators' thrift and cooperative societies as well as interested financial bodies.

Definite action implementing the energy issue with regards to fish smoking

Climate and energy smart food processing ultimately is the direction to move. Most of the modern kiln is not able to meet the disposition of the small-scale fish processors. The practice of traditional fish processors throws up many issues on environment, deforestation, health, and energy use. The adoption of the modern smoking kiln (Fig. 4) [49] is non-existent at the level of the small-scale fish processors, and therefore, emphasis should be laced on wood fuel technology. The NEP document provides enough strategic direction to take in ameliorating the conflict between conservation and utilization of wood fuel. However, no direct mention of the small-scale fish processors was made. In our views, they are too big to be ignored. Among the strategies on fuel wood proposed by NEP include:

1. Encouraging the establishment of private and community woodlots for supply of fuel wood in the short term.
2. Establishing micro-credit facilities for entrepreneurs, especially for women's groups, for the establishment and operation of commercial fuel wood lots and the production of renewable energy devices and systems.

While not being unaware of any efforts at implementing these freely imposed guidelines even when these options are to be followed, it is important to exercise discretion on the choice of wood fuel in order to produce the minimum amount of toxic PAHs. This should be promoted in line with the use of such fuel woods with the minimum risk of cancer and cancer-related diseases. The Code of Conduct for Responsible Fisheries an important international instrument in fisheries stated that activities are related to fish as food or commodity:

> *...do not result in environmental degradation or adversely impact the nutritional rights and needs of people for whom fish is critical to their health and well-being.*

The National Food and Drug Administration (NAFDAC) must step up its control mandate on food at the level of small-scale fish processors. This measure would ensure that the operators have safe fish while guaranteeing good health and well-being.

At the African level, the Federal Government adopted the CAADP. A highlight of the declaration is the resolve to halve the current levels of PHL, by the year 2025 [50]. Two years after the Malabo Declaration, it is encouraging that significant progress is being made towards including the development of strategies and key guidelines to support the CAADP country process and extensive engagements made at country, regional and continental levels.

Arising from findings from this study, the following recommendations are made:

1. The NPC and the NCFN are encouraged to generate sufficient political will to give deserve attention to fish and PHL mitigation strategies contained in NPFN, NEP, CAADP, and other national and international documents as concerned fish utilization within context of food and nutrition security.
2. The Fisheries Act 2014, yet to be assented, makes provision for the establishment of the Fisheries Commission, charged with sustainable utilization of fisheries resources, in order to meet the needs of present and future generations. There is the need to review urgently and passed to law the Fisheries Act.
3. Consolidate the traditional fish processing methods (with an emphasis on sun-drying and fish smoking) in terms of quality assurance and food safety within the food system at all levels of government.
4. With respect to solar drying technologies for fish drying, there is a need to determine and adopt the most efficient local technology.
5. Identified local technology should be promoted with the overarching objective of replacing traditional sun-drying with solar drying technologies.
6. Government at all levels should urgently implement the establishment of private and community woodlots for supply of fuel wood in the short term, as contained in the National Energy Policy, and establish micro-

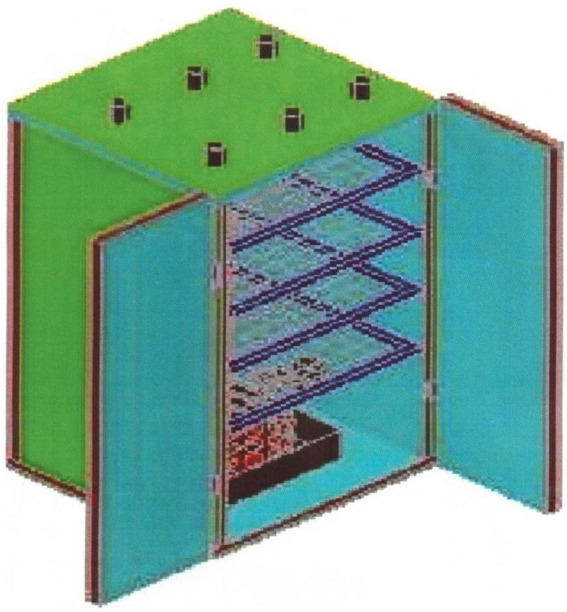

Fig. 4 Isometric view of smoking kiln [49]

credit facilities for entrepreneurs, especially women's groups, for the establishment and operation of commercial fuel wood lots and the production of renewable energy devices and systems.
7. Promote the culture of fish consumption and set a national policy on dietary food intake in favour of fish products by means of establishment of Expert Consultative Forum on fish and fish products as food.
8. Emphasize the benefits of fish consumption on reducing mortality from coronary heart disease (and the risks of mortality from coronary heart disease associated with not eating fish) for the general adult population.
9. Promote the use of fish products especially shell fish as ingredient of complementary or weaning food items for infants post-period of exclusive breastfeeding.

Conclusion

Nigeria is endowed with a wide array of aquatic systems for producing fish. However, production capacity is presently limited and the gap in the local fish demand is filled by importation. In the light of the fact that fish supply locally cannot be drastically expanded to meet the continually increasing demand, it is more appropriate to preserve and production by small-scale producers. Fish is highly perishable. There is need to ensure efficient and effective processing and preservation of the valuable fish protein towards achieving the objectives of the national food policy on food security. Small-scale fish processors using traditional methods of fish smoking and sun-drying dominate the fish processing business and are key to guaranteeing fish consumption. Medium- to large-scale processors target the more lucrative foreign markets.

Traditional fish processing is linked to food security in all dimensions of availability, accessibility, stability, and utilization, as well as national development in terms of healthy citizens, job creation, and income generation. In relation to utilization, traditional fish processing method provides seafood products with adequate nutrient to combat the challenge of malnutrition among children and other vulnerable groups. It can be modernized to overcome the challenges being faced with issues of safety and product qualities, and there are arrays of technologies to be adopted.

Fish should be managed as food ingredients whose consumption and preference over other sources of animal protein should be pushed to the national consciousness. National policy documents examined which have strong direct bearing or tangential to subject of food and nutrition indicated that our policy substantially is adequate, dynamic and meets the requirement of modern challenges, but we have substantially been too slow or failed at implementations. The thrust of this paper is pivoted on the notion that building a virile, prosperous, and healthy society requires that citizens must have food which makes them healthy. There is the need to inculcate the taste for fish in our diets and culture.

Abbreviations

SSF: small-scale fisheries; NPFN: National Policy on Food and Nutrition; NEP: National Energy Policy; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid; PHFLs: post-harvest fish losses; FAO: Food and Agricultural Organization; NPAN: National Plan of Action on Food and Nutrition; WHO: World Health Organization; MDGs: Nigeria Millennium Development Goals; PEM: protein–energy malnutrition; UNICEF: United Nations Children's Fund; LIFDC: low-income food-deficit countries; GNI: gross national income; IDA: International Development Association; IBRD: International Bank for Reconstruction and Development; GHP: good hygienic practices; GMP: good manufacturing practice; SSOP: sanitation standard operating procedures; IK: indigenous knowledge; TK: traditional knowledge; PAHs: polycylic aromatic hydrocarbons; NAFDAC: National Food and Drug Administration; NPC: The National Planning Commission; NCFN: National Committee on Food and Nutrition; COPD: chronic obstructive pulmonary disease.

Authors' contributions

SLA was responsible for conceptualizing, sourcing of the literature, and writing of the manuscript. KAF participated in the critical revision of the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

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References

1. Akintola SL, Brown A, Abdullahi B, Osowo OD, Bello BO. Effects of hot smoking and sun drying processes on nutritional composition of giant tiger shrimp (*Penaeusmonodon*, Fabricius, 1798). Pol J Food Nutr Sci. 2013;63(4):227–37.
2. Akintola SL. Effects of smoking and sun-drying on proximate, fatty and amino acids compositions of Southern pink shrimp (*Penaeusnotialis*). J Food Sci Technol. 2015;52(5):2646–56.
3. Affognon H, Mutungi C, Sanginga P, Borgemeister C. Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis. World Dev. 2015;66:49–68.
4. FAO/WHO: report of the joint FAO/WHO expert consultation on the risks and benefits of fish consumption. Rome, Food and Agriculture Organization of the United Nations; Geneva, World Health Organization. 2011.
5. FAO World Food Summit: Rome Declaration on World Food Security, Rome. 1996.
6. Kawarazuka N. The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: a literature review. The World Fish

Center Working Paper No. 2106. The World Fish Center, Penang, Malaysia. 2010.
7. HLPE: sustainable fisheries and aquaculture for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, P118 2014. www.fao.org/3/a-i3844e.pdf. Accessed 23 June 2015.
8. Hu FB, Bronner L, Willett WC, Stampfer MJ, Rexrode KM, Albert CM. Fish and omega-3 fatty acid intake and risk of coronary heart disease in women. JAMA. 2002;287:1815–21.
9. Food and Agriculture Organisation: Contribution of Fisheries to National Economies in West and Central Africa—policies to increase the wealth generated by small-scale fisheries, new directions in fisheries e a series of policy briefs on development issues. FAO, Rome. 2006.
10. Belhabib D, Sumaila UR, Pauly D. Feeding the poor: contribution of West African fisheries to employment and food security. Ocean Coast Manag. 2014;111:72–81.
11. United Nations International Children's Emergency Fund, UNICEF. Strategy for improved nutrition of children and women in developing countries. New York: the United Nations Children's Fund. 1990.
12. Food and Agriculture Organisation: Fact Sheet, FAO Country Profile, Nigeria; 2007. ftp://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_NG.pdf. Accessed 23 Feb 2015.
13. Béné C, Heck S. Fish and food security in Africa. Naga. 2005;28:1–8.
14. GIZ—Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ) GmbH. The Ecological footprint of cassava and maize postharvest losses in Nigeria. A Life Cycle Assessment. Eschborn: GIZ. 2013.
15. Kolawole OD, Williams SD, Awujola AF. Indigenous fish processing and preservation practices amongst women in south-western Nigeria. Indian J Tradit Knowl. 2010;9(4):668–72.
16. Udong E, Niehof A, Tilburg AV. The livelihood strategies of women fish traders in adapting to cultural and institutional constraints in Ibaka, Nigeria. MAST. 2010;9(2):65–93.
17. Sea Around Us. A global database on marine fisheries and ecosystems. 2015. www.seaaroundus.org. Accessed 10 Dec 2016.
18. Akinyemi O, Balogun AM, Mabawonku AF. Investment prospects in inshore trawling in Nigeria. In: 5th Annual Conference of the Fisheries Society of Nigeria (FISON), 22–25 September, 1986, Ilorin, Nigeria; 1987. p. 58–72.
19. Ssentongo GW, Ajayi T, Ukpe ET. Report on a resource appraisal of the artisanal and inshore fisheries of Nigeria. FAO/UNDP/FNDP/NIR/77/001, Rome. 1983.
20. Falaye AE. Illegal unreported unregulated (IUU) fishing in West Africa (Nigeria & Ghana). Report of a study prepared for Marine Resources Assessment Group (MRAG) Ltd. 2008.
21. Bolorunduro PI, Adesehinwa AOK, Ayanda JO. Adoption of improved fish preservation technologies in Northwestern Nigeria. Tropicultura. 2005;23(3):117–23.
22. Akande GR, Simpa J. Cottage level production of fishmeal. NIOMR Tech. Pap. 81: 1992.
23. Jim-Saiki LO, Alhaji TA, Giwa JE, Oyerinde M, Adedeji AK. Factors constraining artisanal fish production in the fishing communities of Ibeju-Lekki Local Government Area of Lagos State. Int J Innov Res Dev. 2014;3(13):97–101.
24. Thompson SJ, Cowan JT. Durable food production and consumption in the world economy. In: McMichael P, editor. Food and agrarian orders in the world economy. Westport: Praeger; 1995. p. 35–52.
25. Kurien J. Responsible fish trade and food security toward understanding the relationship between international fish trade and food security. Report of the study on the impact of international trade in fishery products on food security Conducted jointly by Food and Agriculture Organisation of the United Nations and the Royal Norwegian Ministry of Foreign Affairs. 2004.
26. National Population Commission (NPC) [Nigeria] and ICF International: Nigeria Demographic and Health Survey 2013. Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF International. 2014.
27. UNICEF: progress for children: a report card on nutrition. UNICEF-publications. 2006. http://www.unicef.org/progressforchildren/2006n4/index_undernutrition.html. Accessed 20 Feb 2015.
28. Adeniyi OR, Omitoyin SA, Ojo OO. Socio-economic determinants of consumption pattern of fish among households in Ibadan North Local Government Area of Oyo State, Nigeria. Afr J Food Agric Nutr Dev. 2012;12(5):6537–52.
29. Belton B, Thilsted SH. Fisheries in transition: food and nutrition security implications for the global South. Glob Food Secur. 2014;3(1):59–66.
30. Ibrahim FM, Osikabor B, Akinosho HO, Adesope AA, Ibrahim AG, Olatunji BT, Akanni OF, Ogunwale OG. Meat versus fish: health risk perception, convenience, price, ethnic value and consumption in Ibadan, Nigeria. Food Public Health. 2014;4(4):193–9.
31. Sustainable Fisheries Livelihoods Programme, SFLP Contribution of Fisheries Research to the Improvement of Livelihoods in West African Communities, Case Study: Nigeria, SFPL/DFID-FAO. 2002.
32. Bassey FI, Oguntunde FC, Iwegbue CMA, Osabor VN, Edem CA. Effects of processing on the proximate and metal contents in three fish species from Nigerian coastal waters. Food Sci Nutr. 2014;2(3):272–81.
33. Akintola SL, Fakoya KA. Governance and social-institutional arrangement of small-scale fisheries and relationship with non-fishery users in Badagry Creek, Lagos State, Nigeria. In: Song AM, Bower SD, Onyango P, Cooke SJ, Chuenpagdee R, editors. Inter-sectoral governance of inland fisheries. TBTI Publication Series, St John's, NL, Canada 2016. p. xx–xx. http://too-bigtoignore.net/wp-content/uploads/2016/08/final-Akintola-and-Fakoya.pdf. Accessed 23 June 2016.
34. Madugu AJ, Edward A. Marketing and distribution channel of processed fish in Adamawa State, Nigeria. Glob J Manag Bus Res. 2011;11(4):1–7.
35. Dambatta MA, Sogbesan OA, Tafida AA, Haruna MA, Fagge AU. Profitability and constraints of three major fisheries enterprises in Kano State, Nigeria. Glob J Sci Front Res I Interdiscip. 2016;16(1):1–7.
36. Tiwari GN, Sarkar B. Greenhouse drying and other applications. Fundamentals of aquaculture greenhouse. 1st ed. New Delhi: Anamaya Publishers; 2007. p. 93.
37. Essumang DK, Dodoo DK, Adjei JK. Effect of smoke generation sources and smoke curing duration on the levels of polycyclic aromatic hydrocarbon (PAH) in different suites of fish. Food Chem Toxicol. 2013;58:86–94.
38. Okuda T, Naoi D, Tenmoku M, Tanaka S, He K, Ma Y, Yang F, Lei Y, Jia Y, Zhang D. Polycyclic aromatic hydrocarbons (PAHs) in the aerosol in Beijing, China, measured aminopropylsilane chemically-bonded stationary phase column chromatography and HPLC/fluorescence detection. Chemosphere. 2006;65:427–35.
39. Kjhallstrand J, Petersson G. Phenolic antioxidants in wood smoke. Sci Total Environ. 2001;27:69–75.
40. Essumang DK, Dodoo DK, Adjei JK. Effective reduction of PAH contamination in smoke cured fish products using charcoal filters in a modified traditional kiln. Food Control. 2014;35:85–93.
41. Yusuf KA, Ezechukwu LN, Kafaya KA, Akintola SL, Agboola JI, Omoleye TO. Influence of fish smoking methods on polycyclic aromatic hydrocarbons content and possible risks to human health. Afr J Food Sci. 2015;9(3):126–35.
42. Salvi S, Brashier B. Fish smoking and COPD: a fishy affair. Lung India. 2014;31:105–6.
43. Umoh VA, Etete P. The relationship between lung function and indoor air pollution among rural women in the Niger Delta region of Nigeria. Lung India. 2014;31:110–5.
44. Udoh JP, Okoko AC. Perception of impact of donor agencies on the socioeconomic wellbeing of fisher folks in southeast Nigeria. Croat J Fish. 2014;72:77–82.
45. Olaoye OJ, Adegbite DA, Oluwalana EO, Vaughan IO, Odebiyi CO, Adediji AP. Comparative evaluation of economic benefits of earthen fish ponds and concrete tanks in aquaculture enterprises in Oyo state, Nigeria. Croat J Fish. 2014;72:107–17.
46. George FO, Ogbolu AO, Olaoye OJ, Obasa SO, Idowu AA, Odulate DO. Fish processing technologies in Nigeria: a case study of Ibeju-Lekki Local Government Area, Lagos State. Am J Food Technol. 2014;9(6):302–10.
47. Ikurekong EE, Esin JO, Mba AC. Rural fuelwood exploitation in Mbo Local Government Area—a Nigerian Coastal Settlement. Ethiop J Environ Stud Manag. 2009;2(3):44–55.
48. Olokor JO, Omojowo FS. Adaptation and improvement of a simple Solar Tent Dryer to enhance fish drying. Nat Sci. 2009;7(10):18–24.
49. Olayemi FF, Raji AO, Oyelese OA, Oyewole SN, Omodara MA. Effective fish smoking kiln for developing country. Int J Sci Eng Res. 2013;4(1):1–7.
50. Africa Union. http://www.au.int. Accessed 12 Jan 2017.