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Promotion of Indigenous Food Preservation and Processing Knowledge and the Challenge of Food Security in Africa

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Abstract Africa is faced with dire food security challenge. Despite the fact that Africa remains the continent with greater arable land to feed it growing population and beyond, yet the continent remain the most impoverished in food security. Nearly 240 million people in sub-Saharan Africa lack adequate food for a healthy and active life. There is therefore an urgent need to look for more practical ways to tackle this challenge. One of such ways is the promotion and utilization of indigenous knowledge (IK) of food processing, preservation and storage. Africa is blessed with various types of food produce and also possesses diverse indigenous knowledge systems for their preservation and storage. Using of indigenous knowledge (IK) in solving food shortage therefore remains a powerful means of sustaining household food security. These indigenous methods of food preservation such as sun drying, fermentation, germination and soaking are time tested and has been used by locals over generation to preserve their produce after harvest thereby serving as a survival strategy. Simple, low-cost, traditional food processing techniques are also the bedrock of small-scale food processing enterprises that are crucial to rural development in Africa. Traditional/indigenous foods also provide inexpensive, safe, nutritious foods throughout the whole year thus boosting overall food security. Traditionally, long-term methods like fermentation and drying have been used for fruits and vegetables. They also provide an economic means of preserving food thus making it available during the period of scarcity. Unfortunately, despite these benefits, IK is fast eroding. Factors enhancing this gradual destruction include influence of western culture, changing socio-cultural status of women, lack of documentation, high illiteracy level among women. This review recommends that there is an urgent need to preserve and promote IK as a very important resource. All stakeholders must therefore be involved - governmental, and non-governmental bodies as well as the local people themselves. The inclusion of indigenous knowledge of food processing and preservation into any policy of program geared towards reduction of food insecurity will not only boost the peoples' confidence on themselves but also in their ability to be part of the solutions to the challenges facing them, thus increasing the chances of success of such programs.

Keywords: *indigenous knowledge, food security, food preservation, food processing, food storage*

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1. Introduction

Africa remains the continent with greater arable land to feed it growing population and beyond, yet the continent remain the most impoverished in food security. High post-harvest food losses, arising largely from limited food preservation capacity, are a major factor constraining food and nutrition security in the developing countries of West Africa, where seasonal food shortages and nutritional deficiency diseases are still a major concern. Protein-energy malnutrition (PEM) and the various micronutrient deficiency disorders including vitamin A deficiency (VAD), nutritional anemias due to deficiencies of iron, folic acid and vitamin B12, and iodine deficiency disorders (IDD) remain important public health problems. A high level of malnutrition is, particularly reported among rural children with figure varying from 56 percent in rural communities in South West to 84.3 percent of those in Northern Nigeria [8]. It has been documented that Sub-Saharan Africa is home to 30 million under nourished children i.e. about one in five [18] and this figure is expected to increase by 2015 [38].

High post-harvest food losses, arising largely from limited food preservation capacity, is a major factor constraining food and nutrition security in the developing countries of Africa, where seasonal food shortages and nutritional deficiency diseases are still a major concern. Greater portions of this amount is lost due to various factors such as poor infrastructure, low levels of technology and low investment in the food production systems, pest, inadequate policies, storage, climate and other factors [46]. It has been estimated that the in sub-

Saharan Africa more than 40% of food losses occur at post harvest and processing levels, while in the industrialized countries more than 40% of the food losses occur at retail and consumer levels. [34] Tanzania, for instance, is known to have 30% of cereals and 70% of fruits and vegetables lost every year due to poor handling, storage and processing [40]. This loss is huge considering that in these countries food represents as much as 80% of household spending and crop production remains the principal source of income for most households [99]. One way the arrest this huge post harvest losses and improve food security is the recognition, promotion and utilization of African indigenous knowledge, skills and practices in food processing, preservation, and storage. This is because indigenous knowledge (IK) has been used at the local level by communities as the basis for decisions pertaining to food security, human and animal health, education, natural resources management, and other vital activities [44]. World Bank [102] has recognized that African indigenous knowledge is innovative and unique among the local producers and can help in the fight against hunger and malnutrition. While indigenous agricultural knowledge is of immense value in improving food preservation, its documentation and dissemination remain a big challenge confronting librarians and other information professionals, particularly in Africa where cultural practices are prevalent. Indigenous knowledge is important because it often the only asset for many poor, rural societies and its significance increases as other resources disappear or dwindle.

Indigenous knowledge refers to what indigenous people know and do, and what they have known and done for generations –practices that evolved through trial and error and proved flexible enough to cope with change [61]. According to Sundamari and Ranganathan [88], African indigenous knowledge (AIK) is an unwritten body of knowledge. It is held in different brains, languages and skills, in as many groups, cultures and environment as are available today. Indigenous people have developed indigenous practices and technology for the storage, processing and preservation of food.

By storing and preserving food, households ensure that they secure food without jeopardizing future food consumption [53], thus translating into access, entitlement and security. In most parts of Africa, the bulk of the agricultural produce is preserved and processed using simple indigenous knowledge and practices. Women use these techniques predominantly and they provide income and employment. For example, cereals and legumes play an important role in the diet of the majority of the population and in issues related to their production, storage, marketing, and processing are very important. The outcome expected is to provide Africans with adequate and nutritionally balanced diets at affordable prices, both now and in the future. The cereals grown in Ghana can be used in many various foods using indigenous knowledge and technology. Some of the foods from maize include fried cakes (*akpiti*), steamed or baked dumplings (*abolo*), boiled maize porridge, corn-wine (*nmeda*), or just corn on the cob. Legumes are used in various forms in Ghana, such as boiled beans, cakes (*akara*), bean stews, bambara porridge (*aboboe*), roasted or boiled groundnuts, ground-nut paste, groundnut soup, and groundnut cakes. Certainly in Africa indigenous knowledge and practices cannot be overlooked.

IK is being a locally owned and controlled resource, could be harnessed into a developmental tool in improving the quality of life of the rural poor. Indigenous knowledge represents valuable source of local solutions to the food insecurity in terms of accessibility by the rural population, particularly during seasonal food shortage or major stress periods such as droughts Building on IK can be particularly effective in helping to reach the poor since IK is often the only asset they control, and certainly one with which they are very familiar [44]. In sub-Saharan Africa in general people have also traditionally utilized indigenous knowledge and skills, most often locally developed and handed down in the course of centuries [76].

These benefits notwithstanding, IK is regarded as inferior because people regard traditional practices as primitive and outdated which has led to a decline in its effectiveness in the enhancement of food security. There is therefore an abandonment of the indigenous ways of food storage and preservation that used to help a great deal in sustaining food security in most households [53]. Colonialism, commercialization, globalization and modernization, lack of efficient codification, breakdown of the traditional family structure and function, developmentally induced human displacements, the decline in the practitioner base and many other reasons. Eyong, [30] have hastened the reduction in IK practices. Parawira and Muchuweti [81] also noted that Zimbabwe is rich in traditional and indigenous foods but unfortunately little research has been undertaken to show their nutritional values and methods of improving their processing and preservation.

The need for improvement in food availability and access calls for innovations in the manner post-harvest staples, vegetables, fruits surplus and meat products can be processed and preserved and sold cheaper and safer for consumption by human and non-human (household and farm animals and birds including fish). Utilization of the IK of the locals could achieve this. There is therefore a need for a paradigm shift in terms of agricultural food security that would emphasize a thrust on the promotion, the adoption, adaption and utilization of traditional knowledge and technologies for food security [23]. The potential for indigenous knowledge to contribute to the achievement of household food security is tremendous because the livelihood of the rural poor depends almost entirely on indigenous skills and knowledge which are essential for their survival. It is logical then that for any developmental plan and process to be effective, indigenous knowledge is of particular relevance. Unfortunately, indigenous knowledge is a resource widely ignored by development planners and policymakers [50].

In order to position IK of food preservation and processing into the mainstream of efforts to reduce food insecurity especially among the rural poor, this paper aims at x-raying the indigenous knowledge systems with which African rural farmers process, preserve and store the abundance of food crops available in the continent. Improvements or changes that have taken place in some of the local methods have also been highlighted with a view to securing the harvest. The paper also discusses some of

the challenges of utilizing indigenous food preservation and processing knowledge and suggests way forward.

2. IK and Food Security

World population is expected to reach 9 billion by 2050 [95]. The expected demands by this large population for food, shelter and medicines will have to be met. One area which is of great concern to the world is how to ensure food security for all nations and eliminate extreme poverty and hunger [49]. Hunter and Fanzo [49] again assert that there is an urgent need for collective action to address food and nutrition security at the global level. Food and nutrition security can only be achieved when adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily used and utilized by all individuals at all times to live a healthy and active life [22]. Food security is built on four pillars: (i) Food availability: sufficient quantities of food available on a consistent basis; (ii) Food access: having sufficient resources to obtain appropriate foods for a nutritious diet; and (iii) Food use: appropriate use based on knowledge of basic nutrition and care; (iv) Stability in food availability, access and utilization [93]. Food security also involves the quality of food, the continuity and regularity of its supply as well as distribution among different population groups and areas, and within households [63]. Access to adequate and nutritious food is limited by low income of the majority of the populace. Consequently, access to food is now perceived by many as a privilege rather than a basic human right.

High post-harvest food losses, arising from limited food preservation capacity, are a major factor constraining food and nutrition security in developing countries of Africa where seasonal food shortages and nutritional deficiency diseases are still a major concern. It is estimated that about 50% of perishable farm produce including fruits, vegetables, roots and tubers and about 30% of food grains including maize, cowpea, millet, rice and so on are lost after harvest in West Africa [75]. This high post harvest losses could be minimized by promoting traditional food processing and preservation techniques with the view of upgrading them. Traditional technologies of food processing and preservation date back thousands of years and unlike the electronic and other modern high technology industries, they long preceded any scientist understanding of their inherent nature and consequences. Traditional foods and traditional food processing and preservation techniques form part of the culture of the people. They constitute a vital body of indigenous knowledge handed down from parent to child over several generations, which should be properly guided, documented and promoted. These simple low-cost, traditional food preservation techniques are indeed the bedrock of small scale food processing industries. Unfortunately however, this knowledge is often undervalued which has consequently led to the loss of some of them.

Indigenous knowledge has been defined in different ways but all have the same focus. It is the local knowledge, which has been institutionalized, built upon and passed from one generation to the next [72,79,98]. Indigenous knowledge systems (IKS) are a body of knowledge, or bodies of knowledge of the indigenous people of particular geographical areas that they have survived on for a very long time. IKS is local knowledge that is unique to a given culture or society [58]. Indigenous knowledge encapsulates the common-good-sense ideas and cultural knowledge of local peoples concerning the everyday realities of living [87]. It is the local knowledge that is unique to the given community and forms the basis for their local level decision making in agriculture and connects people directly with their environment [14]. This knowledge is passed down from generation to generation by word of mouth and generally relies on intuition. Indigenous knowledge usually includes the cultures, traditions, values and beliefs of the local community [14]. Rural women particularly are one group within a community who hold enormous indigenous knowledge of food production, storage and processing which can assist modern efforts of reducing food insecurity and hunger. In fact, Brown [19] noted that women play a significant role in food security, though they are constrained by various factors. Makamure *et al*. (2005) are also of the view that it is women who tend to be responsible for food crops, storage, processing and preservation. Parawira and Muchuweti [81] also cited that in Zimbabwe processing and storage is mostly done by women.

In surveys conducted in rural western Sudan, 80.4 percent of those surveyed confirmed that indigenous processed and preserved food products represent essential sources of foods and this is not limited to times of food shortage [50]. Walingo [97] noted that indigenous methods are a cheaper, acceptable, economically feasible and sustainable means for improved zinc status. During seasonal food gaps, rural people are entirely dependent on the preserved foods as the only food source until the onset of harvest later in the year. Indigenous methods of food preservation in many parts of Africa vary but generally not without serious problems [67]. Some of these problems are the tenacious continuity of practices and beliefs that lack openness and flexibility to necessary or constructive changes [89].

Table 1. The extent of use of some indigenous food processing methods in some parts of Anambra State Nigeria

Indigenous practices	Frequency	Percentage (%)
Sun drying	113	94.2
Pounding with locally made mortar	43	35.8
Roasting and frying food	75	62.5
Grinding with stone	48	40.0
Early harvest with hand	91	75.8
Use of sacks	82	68.3
Burying in moistened soil	20	16.7
Mixture of red pepper	92	76.7
Wood ash application	56	46.7
Placing under fire	102	85.0

Source: [71].

Sun drying and fermentation are among the common indigenous methods of food processing and preservation being practiced by a majority of people living in the rural areas. Table 1 shows the extent of use of some indigenous

food processing methods in some parts of Anambra State Nigeria. Processing of such foods using indigenous practices and technologies could therefore enhance food availability and access to household in periods of scarcity [69]. They also enhance food security by stabilizing foods supplies beyond the area and season of production. Utilization of IK in food processing and preservation also promotes great diet diversity and gives people access to a wider choice of products and hence to a higher level of nutrients such as vitamins and minerals than they would otherwise consume.

3. Sun Drying and Food Security

Drying is one of the oldest methods of food preservation. It is important in food security because when water is removed from farm products to a reasonable level, the shelf-life is extended. The dried products is later rehydrated prior to use in order to produce a food that resembles the fresh crop especially during the dry season when the people have to eat products preserved in various ways. Drying is also an intermediate process in the processing of food e.g. foods need to be dried before they are ground into flour. Drying is therefore a prominent means of preserving surplus food products for the off-season. Drying can be in the form of the ordinary sun-drying which involves spreading the food material on the bare grounds, road sides or on roof tops. Sun drying is a key traditional and inexpensive method of food preservation. This is because of its versatile application to numerous foods. Almost all food items can be sun dried – tubers, cereals, vegetables, fruits, fish, meat etc. Sun drying has been used to keep foods for a long time without spoiling; examples of food that can be sun dried are maize, peeled cassava, peeled yam, vegetables etc. Meat and fish are dried over smoke which adds flavor besides increasing shelf life [97]. Other food is first salted if there is danger of decaying during the drying process, as is the case with meats and tomatoes and afterwards stored in dry place at room temperature. Dried-tomatoes are then soaked in warm water to be turned into tomatoes sauce.

In Sudan, meat from slain animal sheep, goats, cow, and camel is first cut in long pieces, salted, smeared with powdered coriander, and dried for about a week to give a product called “shermout” [50]. In Ethiopia and northern Kenya, among the pastoralists, meat that is cut into long pieces (*quanta*) is smeared with powdered pep-per, salted, and dried by hanging it above the fireplace for 5-7 days [76]. Among the Somali, dried meat (*otkac* or *nyirnyir*) is prepared from camel meat (*hilib gel*). Strips of sun-dried meat are cut into small pieces that are fried (usually in oil with garlic and *iliki*) and immersed in camel ghee (*subag*). *Nyirnyir* can last for several months and is usually eaten with tea, honey, chapatti, and *enjera* [54]. In Nigeria tomatoes are sun dried and the soaked in warm water, ground and used to prepare sauce. These dried tomatoes can keep to up to a year. In Malawi, dried vegetables are prepared by parboiling them, followed by sun-drying for some days, depending on the intensity of the insulation. They were stored in large pots called *mtsuko*, in order to maintain their flavour. These pots were not used for other storage; only for these preserved vegetables [54]. These vegetables would be kept for over a year. In Zimbabwe, vegetables are sun-dried after boiling in salted water for a few minutes. These are then stored in a safe, dry place. This method is also used to dry edible insects such as white ants, termites, and caterpillars [76].

Another method is to directly spread the food in the sun. The food is first salted if there is danger of decaying during the drying process, as is the case with mushrooms and tomatoes. Food drying is an important activity for women as they bear responsibility for food preparation, even during the dry seasons [37]. These indigenous knowledge help in maintaining food access at all times [53]. Food crops like maize, beans and groundnuts were sun-dried before storage to increase their shelf life for about six months. A study carried out in Uganda revealed that as many as 95% of respondents still used sun drying as the major indigenous practice for food processing [5], while a survey carried out in Anambra state of Nigeria, showed that more than 80% of the respondents still used sun drying for food preservation [71].

Traditional African drying methods include spreading the material on flat stones, linen, canvas, wire-mesh, or leaves and even on the soil where there is little control of the drying process. Products dried in this traditional method are therefore subject to spoilage from unsuspected or abrupt rains, windborne dirt, vermin, vermin excrement, insects, insect parts, and worms including dirt from the activities of the workers. Toxins can also develop in such uncontrolled drying set-ups leading to degradation of quality beyond edibility. The greatest disadvantages of drying food however include loss of colour, loss of flavour and loss of vitamins, some of these losses can be mitigated by not drying the food too long. To minimize these contaminations, sun-drying could be done on raised platforms rather on flat surfaces.

4. The Role of Fermentation in Food Security

Fermented foods are defined as those foods which have been subjected to the action of microorganisms and enzymes [20] for the production of foods with distinct quality attributes that are quite different from the original agricultural raw material. When food ferments, it produces acids that prevent the growth of organisms that cause spoilage and confers some desirable attributes to the food such as pleasant flavours, textures, consistencies, improved cooking qualities, improved digestibility etc. According to FAO [35], during the fermentation of raw vegetables, lactic acid bacteria develop, transforming the natural sugars present and the added sugar into acid. The characteristic flavour and texture of fermented vegetables is produced by the action of lactic acid bacteria. It is a technique that has been employed for generations to preserve food for consumption at a later date and to improve food security.

Fermentation is one of the oldest, traditional method of food preservation and has become part of people's culture.

The fermentation technology constitutes an important body of indigenous knowledge used for food preservation, acquired by observations and experience, and passed on from generation to generation [74]. Fermented foods and

beverages are estimated to make up approximately 1/3rd of the human diet [96]. Fermentation is a traditional way of preserving vegetable surpluses which, when used, enhances the overall flavor of the meal. The technique provides a suitable environment for lactic acid bacteria to grow, thus imparting an acid flavor to the vegetable. On the other hand, roots and tubers are mainly fermented to add variety to the diet. Cassava and sweet potatoes are the most commonly fermented ones. Two well-known types of fermented cassava are *gari* and *fufu*, products of natural fermentation. Other traditional fermented foods include products sourced from cereals, fruits, legumes, meat, fish, milk and wild foods. These traditional fermented foods are of great importance because they provide and preserve vast quantities of nutritious foods in a wide diversity of flavors which improve the value of foods [50]. Banana beer, a popular drink in Uganda, Rwanda, Burundi, Gabon, and Cameroon, is made by allowing banana juice to ferment. Palm wine and coconut wine are made through the same process. The examples cited are few of many hundreds of foods produced by fermentation processes that are consumed all over Africa. Fermentation also provides a low-cost way of preserving meat and fish, as well as adding variety to the diet. There is a wide range of fermented meat products from Sudan that include fermented strips of fatty meat, and similar products made from intestines and offal [83].

Some traditional fermented foods in Nigeria include gari which is fermented cassava, ogi (fermented product from maize), fufu, lafun, dawadawa (fermented product from African locust beans), ogiri, (from castor oil seeds) ugba (from African oil beans), *kunu zaki* (from maize), palm wine, *shekete* and the traditional fermented milks, cheese etc. Lactic acid bacteria and yeasts are responsible for most of these fermentations [24]. The nomadic tribes of Sudan make a type of cheese called *kush-kush*, which is eaten with sorghum porridge. Another kind of sour milk consumed is Sudan is fermented camel milk, called *gariss*. The milk is fermented in a skin bag hitched to the saddle of a camel that is allowed to go about its business as usual [27].

Fermentation enhances the nutritional quality of foods and contributes to food safety particularly under conditions where refrigeration or other foods processing facilities are not available [66]. Fermentation enhances food security in that it provides an economic means of preserving food thus making it available during the period of scarcity, it could also contribute to food safety by controlling the growth and multiplication of a number of pathogens in foods especially in the developing countries where economic problems pose a challenge to food safety [2]. This control of growth of pathogens consequently reduces the risk of pathogenic diarrhea, a leading cause of infant death in sub Saharan Africa. Microbial analysis of the sorghum before and after fermentation revealed that coliform bacteria, *E. coli* counts exceeded 2.400 colony forming unites per gram (cfu/g) in the raw sorghum flour but the counts were very low in the fermented dough [104]. Salmonella detected in the different sorghum varieties also disappeared in the fermented dough after 24 hours fermentation. This might be due to the reduction of pH and accumulation of organic acids in the fermented sorghum flour or/and to production of certain microbial byproducts which eliminated these pathogens [104].

Fermentation improves digestibility of food by enzymatic modification of primary food products through the hydrolysis of polysaccharides, proteins and lipids [3]. It may lead to significant improvement in the nutritional quality of foods by increasing the digestibility of proteins through hydrolysis of proteins to amino acids, increasing bio-availability of minerals such as calcium, phosphorus, zinc and iron through hydrolysis of complexing agents such as phytate and oxalate, and increasing nutrient levels, especially B-vitamins, through microbial synthesis [75]. Fermentation processes can result in increased levels of vitamins in the final product. *Saccharomyces cerevisiae* is able to concentrate large quantities of thiamin, nicotinic acid and biotin and thus form enriched products. Fermentation technology therefore plays important role in the nutrition of infants and young people as it is used for the preparation of complimentary foods [106].

FAO [33] also confirms that nutrient level of some fermented beverages are enhanced during fermentation. For instance Sorghum beer in Southern Africa contains relatively high levels of riboflavin and nicotinic acid, which are important for people consuming a high maize diet. Pellagra (a vitamin deficiency disease associated with high maize diets) is unusual in communities in which sorghum beer is consumed. Even children benefit from consuming the dregs which contain relatively little alcohol but are rich in vitamins. Palm wine in West Africa is high in vitamin B12, which is very important for people with low meat intake, and who subsist primarily on a vegetarian diet.

In southern Sudan, duma (a type of alcoholic drink) is made by fermenting diluted honey. The duma-making process is unique to southern Sudan, it is very fast, taking less than 12 hrs; organisms which tolerate heat are involved; and the key link in the process is a special starter culture called *iyal*-duma (seeds of duma) [28]. The most widespread indigenous dairy products of Sudan are roob, kush-kush cheese and mish (spiced traditional yoghurt) which are usually produced during the rainy season and can be stored for use for the whole year [50].

During fermentation, detoxification by the elimination of naturally occurring nutritional stress factors (anti-nutritional factors) occurs. Other benefits of traditional fermentation include reduction of mycotoxins such as aflatoxins and the conversion of otherwise inedible plant items such as African locust seed and bean to foods [11]. In natural or pure mixed-culture fermentation of plant foods by yeasts, molds, and bacteria, anti-nutritional components (e.g. phytate in whole wheat breads) can be reduced by up to 50%; toxic components, such as lectins in fermented foods made from beans, can be reduced up to 95% [11].

Some fermented foods like fermented milk contain high concentrations of probiotics which have health benefits. Some of the beneficial effect of lactic acid bacteria consumption include: (i) improving intestinal tract health; (ii) enhancing the immune system, synthesizing and enhancing the bioavailability of nutrients; (iii) reducing symptoms of lactose intolerance, decreasing the prevalence of allergy in susceptible individuals; and (iv) reducing risk of certain cancers [82].

Fermentation is an important food processing technology usually developed by women in most Africa

and Asian countries. For instance, Sudanese women invented unique fermented products which are white and red abreh/hulu-mur, a non-alcoholic fermented sorghum refreshing soft drinks for Ramadan (the holy month of fasting). Ogi a fermented starch is a major complimentary food for infants in Nigeria and many West African countries. The potential therapeutic effects of lactic acid bacteria and ogi, including their immune-stimulatory effect, are due primarily to changes in the gastrointestinal (GI) microflora to suppress the growth of pathogens [26].

The conversion of cassava (*Manihot esculenta, Crantz* syn. *Manihot utilissima* Pohl) to gari illustrates the importance of traditional fermentations. Without the benefits of modern techniques, a process for detoxifying cassava roots by converting potentially toxic roots into gari was developed, presumably empirically, in West Africa [13]. The production of gari from fresh cassava tubers is a major way of cassava utilization in Nigeria. This is because Nigeria is one of the leading producers of cassava in the world with an annual production of 57 million metric tons (FAO, 2015). Over 40 varieties of cassava are grown in Nigeria and cassava is the most important dietary staple in the country accounting for over 20% of all food crops consumed in Nigeria. Gari is a popular product in Nigeria, consumed by both the poor and the rich. It is either prepared with hot water into a stiff gel and eaten accompanied by a sauce/soup or it can be soaked in cold water and taken with groundnut, palm kernel or cooked bean porridge.

Processing cassava roots into gari is the most effective traditional means of reducing cyanide content to a safe level by WHO standards [39] of 10 ppm, and is more effective than heap fermentation and sun drying, commonly used in eastern and southern Africa [21]. This cyanide reduction during gari processing is very significant because despite its vast potential, the presence of two cyanogenic glucosides, linamarin (accounting for 93% of the total content) and lotaustralin or methyl linamarin, that on hydrolysis by the enzyme linamarase release toxic HCN, is the most important problem limiting cassava utilization. Apart from acute toxicity that may result in death, consumption of sub-lethal doses of cyanide from cassava products over long periods of time results in chronic cyanide toxicity that increases the prevalence of goiter and cretinism in iodine-deficient areas. Symptoms of cyanide poisoning from consumption of cassava with high levels of cyanogens include vomiting, stomach pains, dizziness, headache, weakness and diarrhea [7]. Chronic cyanide toxicity is also associated with several pathological conditions including an irreversible paralysis of the legs reported in eastern, central and southern Africa [47], and tropical ataxic neuropathy, reported in West Africa, characterized by lesions of the skin, mucous membranes, optic and auditory nerves, spinal cord and peripheral nerves and other symptoms [80].

Gari is a popular product and its production is the most improved technology in cassava processing. Gari with a moisture content of 6 to 10% has a long shelf-life when appropriately packaged. It's wide consumption is attributed to its relatively long shelf life compared to other food products from cassava, as well as its ease of preparation for eating [85]. Processing gari from cassava involves fermenting cassava pulp from peeled, grated roots in cloth bags and after dewatering, the mash is sifted and fried to produce a pre-gelatinized grit with varying particle. During fermentation, endogenous linamarase present in cassava roots hydrolyze linamarin and lotaustralin releasing HCN. Crushing of the tubers exposes the cyanogens which are located in the cell vacuole to the enzyme which is located on the outer cell membrane, facilitating their hydrolysis. Most of the cyanide in cassava tubers is eliminated during the peeling, pressing and frying operations though all the unit operations involved contributes to the detoxification of cassava [15,25].

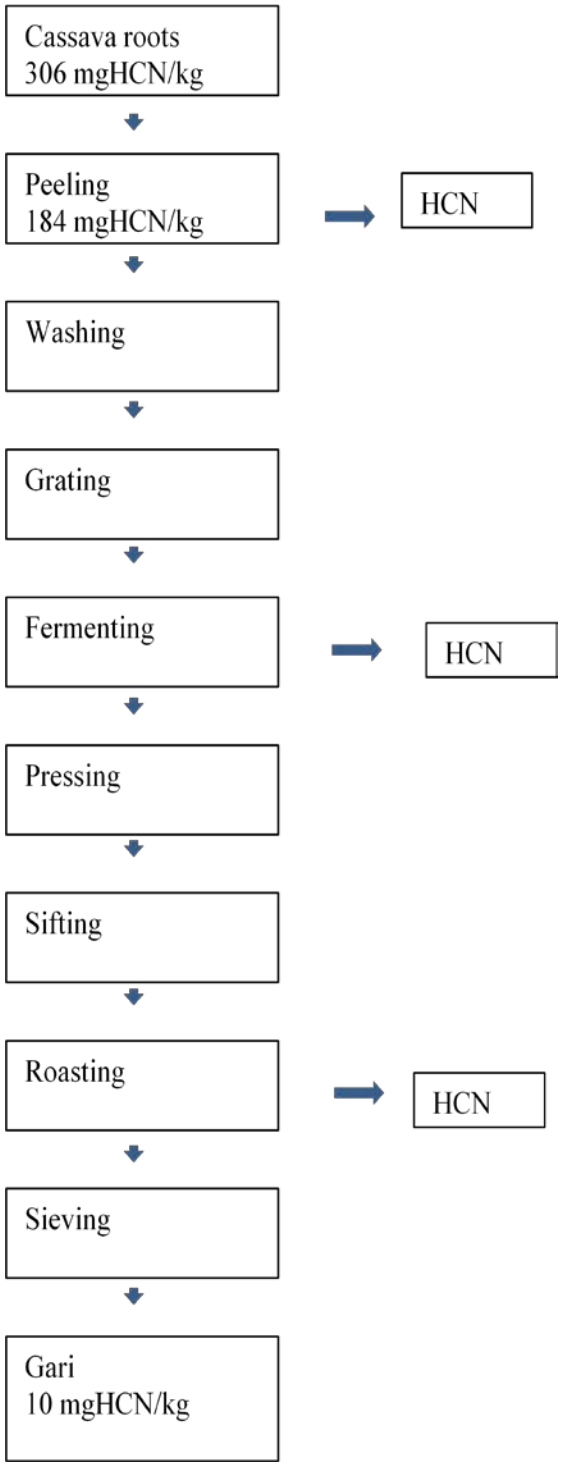

Figure 1. Process flow chart for gari production showing points of cyanide removal (HCN values cited from [78])

The technologies adopted for the intermediate and large scale production of gari are similar to the traditional process, in many respects but differ in not having the simultaneous but slower in the bag dewatering/fermentation step. Instead, hydraulic presses are used to dewater the grated cassava after fermentation of the mash in separate aluminium tanks. Another difference between the traditional and industrial processing of gari manufacture is the replacement of the predominantly manual steps with some level of mechanisation. Well packaged gari with a moisture content of about 6 – 8 percent can keep for about one year. Gari for use within the shortest possible time may be dried to about 12 – 24 percent moisture content.

Lactic acid fermentation which is generally employed in processing cassava products also assists in hydrolysis of the cyanogenic glycosides to sugar and volatile HCN which is removed during further processing by heating. Apart from the detoxifying effect on cassava, it is safe to presume that lactic acid fermentation also confers on cassava products such as fufu and fermented flours the same advantages it confers on milk, nuts and other proteinous products, e.g. increased digestibility, increased protein content, improved protein quality and increased vitamin content. Increased protein contents have also been reported in the conversion of cassava into gari [6].

Other beneficial effects associated with fermented foods include reduced loss of raw materials, reduced cooking time, increased shelf life and microbiological safety of a food and improved bioavailability of micronutrients, general improvement in the texture, taste, aroma and elimination of toxic and anti-nutritional factors (Iwuoha and Eke, 1996; Mensah, 1997; Motarjemi, 2002). Combination of two or three indigenous food processing techniques is common practices among women for example fermentation and drying or salting, fermentation, and drying germination for enhanced shelf life. Processing of some products by women entails a complicated multi-step process, especially those involving double methods of fermentation and sun-drying, are rather complicated and may take up to two weeks to complete. Fermented products are usually stored for a long period regardless of the weather conditions.

5. Other Processing Methods and Food Security

Traditional treatments such as soaking, cooking, germinating as well as fermenting have been used to improve nutritional quality of the legume [92]. Sprouting or germination is a complex metabolic process during which storage proteins, carbohydrates and lipids are broken down to provide energy necessary for the developing plant [107]. As seeds are soaked, enzyme inhibitors are disabled and the seed explodes to life [16]. Germination then proceeds, and enzymes trigger elaborate biochemical changes [108]. Ascorbic acid which is practically absent in dry grain legumes [102] increased in significant amount after sprouting [55,86]. The metabolic changes during sprouting improve the bioavailability, palatability and digestibility of essential nutrients. Soaking and/or sprouting of grains help to reduce antinutrients, oligosaccharides and enzyme inhibitors, thereby increasing the bioavailability of important elements, such as iron, zinc [4] and other minerals [41]. Processing techniques such as soaking, germination and fermentation have been found to reduce significantly the levels of phytates and tannins by exogenous and endogenous enzymes formed during processing [4]. Soaking oats followed by sprouting the oats reduces phytate content and doubles the amount of absorbed zinc in comparison with untreated oats. Zinc content is improved when leavened products are used [43]. Lou and Xie [57] also reported that soaking and sprouting decreased phytate content in green and white faba bean. The in vitro availability of iron and zinc were significantly improved as a result of soaking and sprouting treatments. Initial sprouting can also increase the content of important vitamins and reduce the cooking time required. Sprouting has been found to increase digestibility of legumes and cereals [74]. The increase in protein content after germination was also found in other legumes such as soybean [65], mungbean [68], fenugreek [29] and dry bean, lentils, faba beans [48].

Sprouting also increases protein digestibility [10]. Crude fibre also appreciated significantly during sprouting [60]. This increase in dietary fibre was reported to be mostly due to changes in the polysaccharides found in the cell wall such as cellulose, glucose and mannose, suggesting that the changes were due to an increase in the cellular structure of the plant during germination [59]. Sorghum, for example, is soaked, germinated and eaten or ground to flour and added to ungerminated cereal flour, reducing the cereal viscosity and activating endogenous cereal phytases that break down phytate into lower inositol phosphates. Soaking and germination enhance enzymic hydrolysis of phytates [97]. The initial enzymic changes which precede germination result in both transfer and increase of the B-complex vitamins. It also breaks down the higher carbohydrates and other storage molecules such as calcium, magnesium and phytate [9].

6. Indigenous Methods of Food Storage and Food Security

People are accustomed to traditional food crops, know how to cultivate them and prepare them, and enjoy eating dishes made from them. For example, to see them through the hungry season, rural people grow traditional food plants near their homes. Many of these crops are drought-resistant, can be grown without expensive inputs, and have good storage qualities [54]. Indigenous people hasve therefore developed methods of storing these crops since time immemorial. Proper crop storage plays an integral part in ensuring domestic food supply [91] and that seed quality and vigour is maintained [1].

Insect pests are one of the major organisms that are responsible for the decline in quantity, quality and germination potential of seeds in storage [52]. This makes proper storage an imperative. Storage facilities not only offer the opportunity to provide a supply of food between staple crop harvests but farmers are able to improve farm incomes by storing crops and selling at premium prices when demand outstrips supply later in the post-harvest period [73]. In Kenya, as an indigenous grain storage

strategy, sneeze wood is used for storing maize. 'Sneeze wood' (*Ptaeroxylon obliguum*) leaves and bark are used for storing maize. Branches of sneeze wood are used to store unshelled maize. The bark of the tree is burnt and the ash is also mixed with grains while storing. The powdered bark is also an effective pest repellent. The smoke out of burning sneeze wood also helps in warding off insects during storage of maize. The use of ash for grain preservation has a long history in the Bar-Sauri, Kenya and continues to be popular with the farmers. Apart from the use of sneeze wood, the farmers also use leaves from some trees which have been known to have medicinal values. The leaves are then burnt and the powder used to preserve the grains

Dried foods like corn, dried pepper and dried vegetables are stored over the fireplace to prevent spoilage, grains. They are also stored in bags with the combination of local pesticides like pepper, tobacco, neem leaves, wood ash etc. Weevils could be prevented from burrowing all kinds of grain by putting dry gum tree leaves between layers of grain in the sacks or granary [23]. A survey carried out in Uganda showed that majority (77%) of the households reported to be using locally-made pesticides red pepper, banana juice, wood ash, citrus lemon leaves, neem tree, tobacco and tephrosia leaves to control array of pests such as maize stem borers and cabbage diamondback moths that destroy food crops while in the gardens and those such as rodents and bean weevils (bruchids) that destroy foods in storage. Only about 5% of households interviewed depended on synthetic pesticides. Modern synthetic pesticides were said to be costly to buy thus its low use by the farmers [5]. Other storage structures include a traditional silo that is made of mud and twigs. This structure is relatively inexpensive but it is not airtight and often exposes the stored maize to harsh environmental conditions such as sun and rain. This method, especially when combined with local bio-pesticides have been proved effective. A study carried out in Senegal confirmed that the most effective method proved to be the storage of maize in granaries with intermittent layers of *H. spicigera* (a local mint plant), which resulted in full protection of the commodity against any insect damage [45]. It is therefore thought that the mode of action of both *Hyptis* species is due to the release of bioactive molecules contained in the essential oil [70,90].

In Malawi, a raised wooden structure known as the *msanja* constructed above the fire place is used as a storage place for grains such as millet, sorghum, maize and all sorts of peas. The reason for storing harvested crops in this structure was to protect them from weevils and other pests. The soot coating made grains bitter and not edible by both pests and rodents. This was not only a cost-free technology but an effective way of ensuring food security [53]. Some of these structures were sometimes weak and so could allow insects to enter and provide an environment for storage fungi to thrive [64]. In Zimbabwe, local granaries known as *matura*/*tsapi* in Shona or *izipala* in Ndebele which were cleaned, smeared with cow-dung before being filled with grain and then latter completely sealed. The sealing itself was very critical and it was informed by a lot of local wisdom on the life cycles of pests and pest control systems. Sealing the granary ensured that no living organism accessed oxygen for respiratory and reproductive purposes [23]. In most situations, maize is traditionally left to dry in the fields prior to harvesting [73].

In Nigeria, yams are stored in barns, which are usually built on an open ground but is usually shaded to protect the yams from the scorching effect of the sun. barns basically consist of walls of vertical poles cut from the bush or planks bought from the market, if left unbarked, will take root when set on the ground [31]. Barns are effective for yam storage especially in the dry season when yams can store for up to six months. In the rainy season however, the tubers stored begin to deteriorate rapidly.

Other indigenous methods of food storage include storing in baskets, storing cocoyam and potatoes in the soil to prevent spoilage. Various traditional methods of sweet potato storage such as heap storage, in-ground storage, platform and pit storage methods have been practiced in Nigeria and across African countries by farmers but the most common traditional method is the pit storage. Pit storage of sweet potatoes has been reported in Indonesia, Zimbabwe, and Malawi by Woolfe [100] and in Nigeria by Awojobi [12]. Pit storage can generally be considered to be cheap for the rural communities since it requires minimum materials. Sandifolo *et al.* [84] reported that the chemical composition of sweet potatoes was not much affected after 4 months storage. According to Yakubu [105] the pit storage method appeared to be the best traditional method because deteriorations such as sprouting moisture loss and pathological losses were minimal compared to other storage methods. This agrees with earlier results of Mbeza and Kwapata (1995) who also stated that in Malawi the pit storage method is the most common traditional method of sweet potato storage. This pit is called *nkhuti* and they helped maintained their sweetness and could be kept for one year [53].

7. Constraints to Using Indigenous Knowledge

In most parts of Africa, the bulk of the agricultural produce is processed using simple indigenous knowledge and practices. Women use these techniques predominantly and they provide income and employment. For example, cereals and legumes play an important role in the diet of the majority of the population and in issues related to their production, storage, marketing, and processing are very important. The outcome expected is to provide Africans with adequate and nutritionally balanced diets at affordable prices, both now and in the future. The cereals grown in Ghana can be used in many various foods using indigenous knowledge and technology. Some of the foods from maize include fried cakes (*akpiti*), steamed or baked dumplings (*abolo*), boiled maize porridge, corn-wine (*nmeda*), or just corn on the cob. Legumes are used in various forms in Ghana, such as boiled beans, cakes (akara), bean stews, bambara porridge (*aboboe*), roasted or boiled groundnuts, ground-nut paste, groundnut soup, and groundnut cakes. Certainly in Africa indigenous knowledge and practices cannot be overlooked. The traditional methods are therefore affordable, acceptable, economically and socially feasible as well as a sustainable

means for reduction of food insecurity and hunger, but that notwithstanding, there are some constraints to the use of IK [76]. According to a survey carried out by Onoh *et al.* [77], the major constraints to IK utilization were their labour intensiveness, the custodians of IK were unwilling to divulge information and practice of IK was time consumption. Some of these constraints are highlighted in Table two. This agrees with the findings of Nnadi *et al.* *[71]*, who also identified the major constraints of IK use as lack of documentation, time demanding and poor recognition.

The changing socio-economic status of women on one hand and the influence of western culture have also negatively affected IK utilization. Lifestyles, diet and tastes are constantly changing to suit the western culture. Time has also become a major constraint in food preparation with populations resorting to convenience and easy to prepare foods that are generally of low nutritional quality, monotonous and lack variety [97]. Indigenous methods of food preparation, preservation ad processing should be therefore improved to reduce time and drudgery. Research should be geared towards the development of simple and affordable labour and time saving devices for some traditional processes. Tremendous success has been recorded with small-scale gari processing factories in which some of the tedious manual operations of traditional cassava processing such as grating, pressing and sifting are replaced by machines while still retaining other manual operations. Such improvements is needed in other indigenous food processing e.g. in the production of *ogiri*, machines to peel the locust beans instead of the tedious manual peeling. Since women are largely involved in traditional food processing, reducing the drudgery associated with traditional food processing operations, through the introduction of simple machines, would make life a lot easier for women with attendant benefits for the well-being of the family and society at large [13].

Lack of documentation is another major drawback to IK utilization. The custodians of IK are unwilling to divulge such information to others and consequently the die with such valuable information. When IK is not documented, useful information that could be exploited to enhance food security are lost from one generation to another [14]. Concerted efforts must be made to document these IK for the future generation. Collected data should be carefully documented, preliminary findings shared with local communities through interactive workshops and seminars. The final outcome of research on collective memories should be taught in basic, secondary and tertiary institutions of learning as well as specialized training schools to ensure continuity [30].

Rural women possess an enormous amount of indigenous knowledge about food processing, preservation and other important survival skills. Hence, women are major custodians of IK, through their indigenous knowledge of food storage and preservation; they have contributed immensely to food security in many nations [101]. The use of indigenous knowledge by rural women is critical to the development in African countries. As such, it should be recognized and given precedence on the developmental agenda. Effort should be made to increase the literacy level of the rural women, through adult education programs with a view to documenting indigenous knowledge. Stakeholders should encourage and support the rural women to confidently use their indigenous knowledge and integrate indigenous knowledge into policymaking and extension practice. There is a need for developing agricultural and nutritional training programs which address ways of preserving indigenous knowledge for sustainable food security [50].

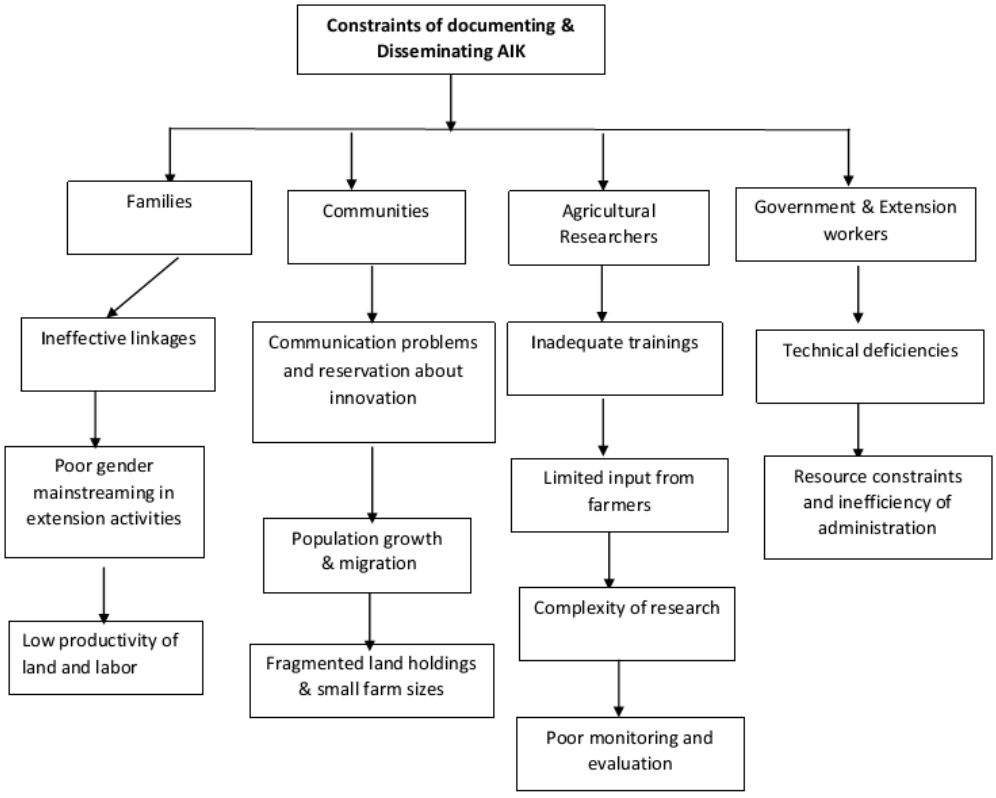

Figure 2. Constraints of documenting and disseminating African indigenous knowledge

IK is often perceived by people as inferior and primitive, this has led to the decline and/or abandonment of the indigenous ways of food storage and preservation, which used to help a great deal in sustaining food security in most households. Information professionals should make efforts to capture, store, and disseminate indigenous knowledge through the use of information technology. Simple, low-cost, traditional food processing techniques should serve as bedrock for small-scale food processing enterprises that are crucial to rural development in West Africa. The death of research on IK is a hindrance to its utilization therefore interdisciplinary researches on indigenous knowledge related to food should be developed to better utilization of the resources. Research into the nutritional values of the indigenous food should be undertaken with the aim of a positive change of attitude towards IK and the possible future propagation of those indigenous foods. The findings of such analysis should be disseminated through publications and extension workers to benefit the population at large. These will help in identifying and documenting what already exists [50]. Government should provide ICTs such as computer, internet, digital cameras and camcorders and so on, to allow libraries to make indigenous knowledge accessible. The constraints of documenting and disseminating African IK is summarized in Figure 2.

8. Conclusion

Developing the agricultural sector remains a critical factor towards the achievement of sustainable food production and, indeed, global food security. Recent development in the field of agriculture and rural development has seen a steady rejuvenated recognition of indigenous knowledge for sustainable development. However, this recognition has not downplayed the role that modern scientific knowledge has played. It is therefore justifiable to advocate for a marriage-of-convenience between the two knowledge systems for effective output and eventual sustainability. IK is cheap, available and have been used over the years by indigenous people. The decline in the use of IK as a result of influence of western culture and because many of the carriers of this knowledge are dying without the documentation of this knowledge will definitely undermine developmental efforts to reduce food insecurity in Africa. The loss of such knowledge will not only lead to increased food insecurity, but also increased conflicts, livelihoods decline and biodiversity loss.

There is therefore an urgent need to preserve and promote this very important resource. To preserve such knowledge, a new path must be charted and a paradigm shift is imperative. All stakeholders must be involved - governmental, and non-governmental bodies as well as the local people themselves. Nigeria as in most developing countries, the traditional skill and low level technology small-scale sector exist side by side with sophisticated technologies. These simple, low cost IK of food preservation, processing and storage serve as the bedrock for small scale food industries that would produce low-cost products for mass consumption leading to improved food security of the people. The promotion of IK should therefore be an important policy objective of the government and the government should provide the necessary technical assistance to these units through national research and development, extension services and adequate financial assistance.

In conclusion, we posit that inclusion of indigenous knowledge of food processing and preservation into any policy of program geared towards reduction of food insecurity will boost the peoples' confidence on themselves and in their ability to be part of the solutions to the challenges facing them. Building on this IK to ensure food security in Africa can be particularly effective as this is an asset that the people of Africa control and certainly one with which they are very familiar. Utilizing IK will help increase the sustainability of food security efforts because the IK integration process provides for mutual learning and adaptation, which in turn contributes to the empowerment of local communities. Building on IK systems will empower local communities in Africa, enabling them to shape their own food security agenda by actively participating in it.

Statement of Competing Interest

I declare that I have no significant competing financial, professional or personal interests that might have influenced the performance or publication of the work described in this manuscript.

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