FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

AGRICULTURAL PRODUCT VALUE ADDITION FOR FOOD SECURITY, JOB CREATION AND POVERTY ALLEVIATION

By

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Introduction

I give glory to God almighty, the creator of heaven and earth, for giving me life and for enabling me to achieve this feat to stand before this distinguished gathering of men and women to deliver the 40th Inaugural Lecture of this great University. This is made possible by the special Grace of God and by two persons who played special role in my life.

When I finished my secondary education, all I wanted as a young girl was to get my dream job and start earning money. However, my beloved father who himself being a teacher knew the value of education, had a different plan for my life. He insisted that I must proceed to acquire University education. It was of course not even a matter for discussion, as it has already been decided and I had to simply obey. After completing my University education and after a lot of water had passed under the bridge, I found myself in the employment of the Federal University of Technology, Minna in May 1990. Those who were with the university system in the early 1990s knew how difficult life was then, being a lecturer with the very poor salary. I still remember the popular slogan of ASUU at that time ***"my take home pay cannot take me home"***. It was indeed a time of frustration. However, I was again frustrated from another angle. In contrast to my other colleagues who were offered tenured appointment, I was given a contract appointment which had to be renewed every two years. I was told then that I can't be given a tenured appointment as a non Nigerian. Well that is still ok. The problem however was I was also not to enjoy the privileges attached to contract appointments. When I applied for those privileges, I was told that as a foreigner married to a Nigerian my domicile is my husband domicile so I cannot enjoy those privileges. This discrimination affected me negatively culminating in my lack of enthusiasm neither to pursue a PhD programme nor even to remain in academics. It took the intervention of my husband at this point, with regular counselling and advices that made me pull myself together to take up the challenge of pursuing a PhD programme in this university, and of course the rest is history as they say.

Mr. Chairman, distinguished audience, I stand here today to present the 40^{th} Inaugural Lecture of this University. This is the tenth Inaugural lecture from the School of Engineering and Engineering Technology, the fourth from the Department of Agricultural and Bioresources Engineering, (the only Department in the University to achieve this feat for now), the first by a sitting Chairman of the University Seminar and Colloquium Committee, the fourth by a female Professor in the University and the first by a female professor in School of Engineering and Engineering Technology.

Mr. Chairman, the topic of my lecture *"Agricultural Product Value Addition for Food Security, Job Creation and Poverty Alleviation"* was chosen to show how we can achieve food security, job creation and poverty alleviation by adding value to our agricultural products at the right time and at the right place. When we talk of food security the first thing that comes to mind is increase in food production. However, the problem of food security is not just a matter of food production alone. High post-harvest food losses constitute a major problem constraining food security in Nigeria and in other developing countries where food preservation and storage remains a major challenge.

Value addition generally is an economic terminology, however the Agricultural and Bioresource Engineer has a lot to do with agricultural product value addition. Thus, I start my lecture by defining what the profession of Agricultural and Bioresources Engineering is.

Agricultural and Bioresources Engineering Profession

Agricultural and Bioresources Engineering is a profession that deals with the set of techniques, systems and machines concerned with the application of engineering principles and technology in agricultural production, processing, transportation and storage in a sustainable way. It deals with the utilization of any or all branches of engineering, science and technology, in the art, science and business of crop production, animal husbandry, as well as in handling, processing and preservation, storage, manufacture and distribution of products that feed, shelter and cloth mankind (Odigbo, 1985). It involves the design, development, testing, manufacturing, marketing, operation, maintenance and repair of all agricultural tools, implements, machines and equipment which are used in agricultural operations, with the objective of raising the productivity of human labour and the land and protect the natural resources essential for agricultural production. In the past and even presently, the tendency is to take Agricultural Engineering as being synonymous with tractor technology or farm mechanization. But the definition above has shown that it is much more than that. It is a profession that ensures that engineering principles and technology are utilized to achieve sustainable agricultural production. Prof. Pandya, a renowned Indian Agricultural Engineer, stated that agricultural engineering may prove to be the "Aladdin's lamp" in the task of feeding the growing population and agricultural based industries of the world particularly in the developed world (Ojha and Micheal, 2006).

The scope of Agricultural and Bioresources Engineering is both wide and varied, covering a diverse area. It is as extensive as agriculture and as diversified as engineering. Various authors have listed a number of options in Agricultural and Bioresources Engineering. However, according to Ojha and Michael (2006), all can be summarized into four main areas of the discipline. These are:

- Farm Power and Machinery Engineering
- Soil and Water Engineering
- Farm Structures and Environmental Control Engineering and
- Agricultural Product Processing and Storage (or Post Harvest) Engineering.

Farm Power and Machinery Engineering also known as Agricultural Power and Machinery Engineering deals in part with sources of power used for all phases of agricultural production, processing and distribution; and also with the design, construction, operation, maintenance of machines particularly those used for field operations.

Soil and Water Engineering deals with the harnessing and management of the basic natural resources used in agricultural production - land and water. It therefore covers soil erosion and conservation, design and operation of irrigation and drainage works and systems, land reclamation, water supply, hydrology of watersheds and hydraulics.

Several structures are used in agriculture. These include structures for farm families, animals, storage of farm products and machinery, as well as farm roads. These structures require specialized design and also the environment in this structures (temperature, humidity and air composition) need to be controlled for their optimum performance. Planning of farm buildings layout, structural design of farm buildings and structures, mechanization and control of the environment within the buildings are the responsibilities of the Farm Structures and Environment Control expert.

Agricultural Product Processing and Storage Engineering also known as Post-harvest Engineering deals with the process and machines required for converting agricultural raw materials or products into finished consumer goods. Agricultural processing includes those operations which maintain or raise the quality of raw material, change its form, or prepare it for market. It is also understood as value addition or conditioning of agricultural products including food grains, oil seeds, fruits and vegetables, fodder crops etc. The operations connected with this include unit operations like cleaning, grading, drying, decortications, soaking, steaming, boiling, concentration etc. Ojha and Micheal, (2006) stated that any physical, mechanical, thermal, hydrothermal, pneumatic, operations performed on the food material will improve the quality and increase the shelf life of the product. Consequently, the usefulness of the finished or semi finished product is improved. During these operations or at all the stages of processing, value is added to the product. Storage is done to fulfil the domestic cum national need for food, feeds and seed between two consecutive harvests.

Aworh (2010) stated that post-harvest technology can be said to be the most important aspect of food production. In most cases, especially in developing countries, the importance of post-harvest technology has been either neglected or underestimated. Much attention is paid to improving the species or strains of crops for pest resistance or increase in area of production. The result is that millions of dollars have been spent on producing food while this has not been matched either by investment or an awareness of the need to reduce post-harvest losses due to poor and inadequate post-harvest technology.

Mr. Chairman, this is my area of specialisation and this will be the main focus of my discuss for the next few minutes.

Agricultural Product Processing, Storage and Value Addition

Agricultural processing can be defined as any treatment given to the agricultural product from the time it is harvested to the time it goes to the market. Igbeka (2013) stated that agricultural processing and storage are value added processes, and accomplishing these efficiently is a function of the process and equipment used. The rising demand by consumers for better quality crops, food products and fibre has made agricultural processing of crops inevitable. The processing of agricultural raw materials is increasing both on the farm and in the central location. This has created new industries to supply better quality products in more easily available forms. The need to make products available all year round calls for processing into stable products or storage of the raw products.

Post-harvest actions are all succeeding actions after harvest. The post-harvest period of time thus begin at separation of the food item from the medium of immediate growth or production. It is defined here as ending when the food enters the process of preparation for final consumption (Igbeka, 2013). This period also corresponds to the agricultural marketing and distribution period. In all the ways of value addition to agricultural product during the post-harvest period, engineers, food scientist, food technologist, nutritionist, agricultural economists, marketers and other related professionals have a role to play. The processing and storage engineer or post-harvest engineer approaches the value addition from the engineering perspective, this is because the operation involved are closely linked with thermodynamics, fluid flow, heat and mass transfer, reaction kinetics and other engineering principles. The engineer not only designs and develops processing equipment, storage methods and structures but also optimizes processing parameters.

In general, adding value is the process of changing or transforming a product from its original state to a more valuable state. A more narrow definition would be to economically add value to an agricultural product (such as wheat) by processing it in to a product (such as flour) desired by customers (such as bread backers). Processing aims to make food more digestible, nutritious and extend the shelf life. Due to the seasonal variations, high levels of wastage or shortages can arise if adequate measures are not taken to preserve and store the food. Processing covers all the processes that food items go through from the farm to the time it arrives the market or on the consumer's plate. It includes basic cleaning, sorting, grading and packaging of agricultural products and also alteration of the raw material by size reduction, extraction, heat treatment and make it ready-to eat food, like, bakery products, instant foods, flavoured and health drinks.

During all the stages of processing and storage, value is added to the commodity thereby creating value to the consumer. According to Nakamoto and Curtis (2009) value addition into agricultural product can be achieved in different ways. These are:

- Form value
- Location value
- Time value
- Information value

Form Value:

In this case the form of the commodity is changed into a desired product which can be consumed or has a longer shelf life. A raw material is converted into finished or semi-finished product. Changing the form usually:

- Increases the usability of the product
- Maintains or improves product quality
- Extends the shelf life
- Reduces the size
- Increases availability of nutrient.

Processing of agricultural products plays a big role here. Unit operations in agricultural processing such as size reduction, heat processing, drying, dehydration, cooking, malting, concentration, filtration, mixing etc all change the form of the product and add value to it. A typical example of form value addition is wheat to flour to bread, Cattle to meat, cassava to garri etc.

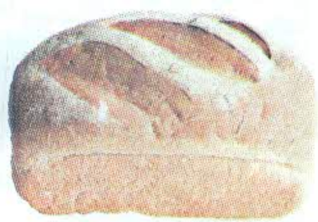


Plate 1. An example of 'form value' addition to agricultural product (wheat → flower → bread)

Among the numerous advantages of processing or form value addition according to Ojha and Micheal (2006) are:

- Produce which are now being wasted because of inadequate transport facilities and excess supply can be preserved and used later.
- The processing may serve as a small scale industry, providing additional employment facilities.
- Perishable product can be changed into stable commodity such as canning of fruits, drying of fruits etc.
- Processing can prevent products from being affected by micro-organisms, insects and pests during storage which render them completely unusable.

Location value:

In this value creation, the agricultural commodity is brought closer to the consumer. Agricultural products are transported from the farm to markets, supermarkets, department stores etc.

This provides the commodity or the product in the desired place; and also increases assortment and access to exotic products. Agricultural products in raw, finished or semi-finished forms are transported by road, by air or by sea to bring it closer to the consumer.

Plate 2. An example of 'location value' (products from farm to markets / supermarkets)

Time value:

In this value creation, agricultural products are provided at the desired time in spite of their seasonality. This is achieved by storage and preservation. Storage implies the "holding on" of a food product either on temporary or permanent basis before it is used. It is a repeated phase in the process of conveying products from the farm to the processor and from the processor to the consumer.

Some agricultural products are available for consumption throughout the year in spite of their short production period. This is achieved by the use of appropriate preservation and storage facilities, such as silos, cold storage, controlled atmosphere storage and Modified atmosphere storage.

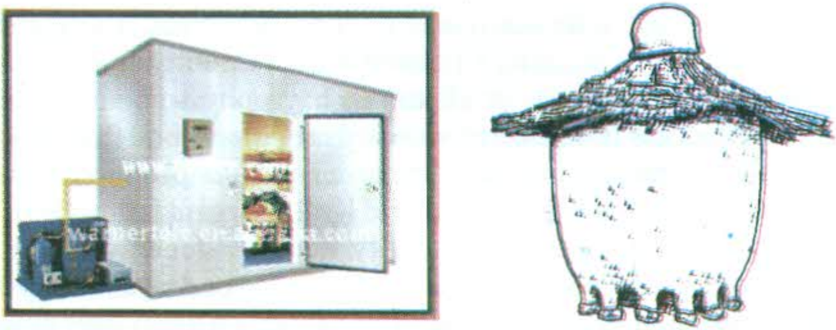


Plate 3. An example of 'time value' (preservation of products in storage facilities)

Information value:
Value is added here by informing and educating the consumer about the product he/she is purchasing and consuming. This is often done through marketing functions, advertising, promotion, packaging and labelling.

Plate 4. An example of 'information value' (products packaging and labelling)

Value Addition for Food Security, Job Creation and Poverty Alleviation

Wikipedia defines food security as the availability of food and one's access to it (Wikipedia, 2013). A household is considered food secured when its occupants do not live in hunger or fear of starvation. Food security situation in a community or a country exists when 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 a productive and healthy life (FAO, 1996). The World Health Organization (WHO) defines three facets of food security, namely: food availability, food access and food use (WHO, 2013). Food availability is having available sufficient quantities of food on a constant basis. Food access is having sufficient resources both economic and physical to obtain appropriate foods for a nutritious diet. Food use is the appropriate use of food based on knowledge of basic nutrition and care, as well as adequate water and sanitation. FAO (2012) added a fourth dimension, that is, the stability of the first three facets of food. The stages of food security range from food secure situations to full-scale famine. Famine and hunger are both rooted in food insecurity. Food insecurity can be categorized as either chronic or transitory. Chronic food insecurity translates into a high degree of vulnerability to famine and hunger; ensuring food security presupposes elimination of that vulnerability.

Raghavan (2003) identified different levels of food security. These are household food security, village level food security and national level food security. At house hold level food is grown by individual farmers mostly for sale and partly for consumption by themselves. Generally household food access is determined by the combination of household food production, household income, and household assets (food stock, other assets and capital) that may serve as a buffer in periods of food shortages. Moving up, the problem appears at the village level, where community action becomes necessary to tackle the challenges. The next dimension involves densely populated urban centres linked with rural production areas for their food supply; and at the top, the problems appear at the national level where the solutions are linked to government policies and macroeconomic factors. Food prices play a complex role in food security. Higher prices may increase income for net producers, but may reduce food security for net consumers. It will be important to consider trends in food prices relative to wages or other price indices.

Current statistics indicate that , at least 805 million people, or one in nine, worldwide do not have enough to eat, while up to 2 billion people lack food security intermittently due to varying degrees of poverty (FAO *et al.,* 2014). The paradox is that the highest quartile of the food insecure live in rural areas where food is produced, yet they are net food buyers rather than food sellers.

Abubakar (2012) describes the Nigerian food situation as follows

- Domestic food production is increasing, but at a lower rate than the population growth, resulting in excess of national food demand over supply or food deficit.
- Food import is increasing steadily
- There is no stability of food supply.
- Due to the inefficient harvesting, processing and storage techniques usually deployed, post-harvest losses are between 20 to 80% resulting in unstable supply and food insecurity.

In Nigeria access to adequate and nutritious food is generally limited by low income and poverty, largely because nutritious foods are usually expensive. Nigeria is a large food importer, importing foods such as wheat, rice, sugar, fish and vegetable oil. Imported foods are far from the reach of the low income earners. Food utilization is yet another important index of food security. Food in-take and nutritional well-being of many households in

Nigeria are of relatively low quality, which is usually as a result of their low economic status. About 61% of Nigerians are malnourished and deficiency diseases such as Fe deficiency, which affects physical capacity, and in severe cases leads to death and susceptibility to infections and *protein-energy malnutrition* (PEM), which causes growth failure in children, and weight loss in adults are very common (Abubakar, 2012). The food security situation is further compounded by human induced climate change. Nigeria ranked 20th out of 42 African countries studied on the 2006 Global Hunger Index (GHI). It improved to 18th position on the 2009 GHI and 46th out of the 84 developing countries captured globally for the study in 2009 (Abubakar, 2012).

The story is the same for the other Sub-Saharan African (SSA) countries. Currently Africa ensures food supply by a mix of domestic food production and overseas food imports. West Africa for example depends to 40% on imports in ensuring sufficient rice supply with Thailand as the main rice supplier (FAO, 2013a). The total volume of cereal imports in Africa was around 66 million tons in 2010. This means that for the whole of Africa 30% of all cereals consumed were imported and cereal exports are negligible (FAO, 2013b). Despite domestic production and import efforts there were 239 million undernourished people living on the African continent in 2012, most of them in Sub-Saharan Africa. During the last two decades the number of undernourished people in Africa has increased by more than 35% (FAO, 2012). This shows that food insecurity is already of increasingly relevant concern.

Food represents about 10 – 20 percent of consumer spending in developed countries and as much as 60 – 80 percent in developing countries including SSA countries. Crop production remains the principal source of income for households in SSA roughly 70 percent on average, of which grain crops (predominantly maize, sorghum, millet, and rice) account for about 37 percent of total household income, while non-crop income averages about 30 percent of total income (Hodges *et al.*, 2011).

By the year 2050 the world population is expected to reach 9 billion people and demand for food will increase by 70 percent. Almost all of this growth will occur in less developed countries (FAO, 2012). Generally in Tropical Africa today there is a widening imbalance between food production and demand. The urgency of the problem of food production in these areas is further compounded by increasing population growth which now has outstripped food production in most SSA countries. Therefore, there is an urgent need for increased food production in the region. To achieve this different strategies have been adopted (Seiler, 2013).

These are:

1. Expansion of cultivated land (increasing present area of land under production)
2. Increasing yield per unit area, through the use of fertilizer, manure, improved seed etc.
3. Multiple cropping systems that is harvesting more than once per year from the same land area.

There is no doubt that these strategies have recorded some successes in improving the food production outlook in tropical Africa. However, to implement these strategies additional production resources are required and also intensive agriculture and increasing the land under cultivation has an adverse effect on the environment. A healthy, sustainable food system is one that focuses on environmental health, economic vitality, and human health and social equity as shown in Figure 1 (FSN, 2014).

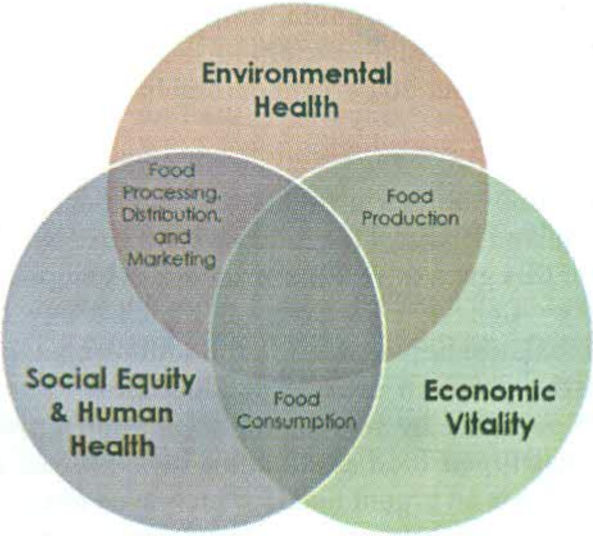


Figure 1. A Healthy Sustainable Food System Source *(Source: FSN, 2014)*

- Environmental health – ensures that food production and procurement do not compromise the land, air, or water now or in future
- Economic vitality - ensures that the people who are producing our food are able to earn a decent living wage while doing so. This ensures that producers can continue to produce food
- Human health & Social equity - ensures that particular importance is placed on community development and the health of the community, making sure that healthy foods are available economically and physically to the community and that people are able to access these foods in a dignified manner.

In all this the main goal however, is not only to increase the production per se but to put more food into the mouth of the people. Long and complex activities exist between the harvest of agricultural product in the farm and its ready conversion into food to be eaten. Within these complex processes that take food from the farm to the tables, there are many opportunities for the food to be lost, the result being that much of the food produced on the farm never reaches the consumer for whom it is intended. Therefore, food availability and accessibility can be increased by increasing production, improving distribution and reducing the losses. Thus, reducing post-harvest food losses is a critical component in ensuring future global food security (Figure 2).

Figure 2. Paradigm of Food Security *(Source: Ani et al., 2014)*

Post-harvest begins when the process of collecting or separation of food of edible quality from its site of immediate production has been completed. Losses may occur from harvest to the point of consumption. Two kinds of food loss recognized are:

1. Direct loss, that is, disappearance of food by spoilage, mechanical damage, or consumption by birds and rodents.
2. Indirect loss, which is the lowering of the quality of food to the point that there is an economic loss, refusal out rightly or lowering of price index.

Losses could occur during processing, transportation and storage. All these are referred to as post harvest losses.
Tropical countries have a number of problems in their battle to reduce post-harvest food loss that are not common in the temperate climates (Woertz, 2011). These problems include among others:

1. ***High temperature*** - High temperature provides ideal condition for rodents and mites to multiply throughout the year. It also favours the growth and multiplication of insects and molds. Physiological changes like sprouting in tubers, maturing and senescence in fruits and vegetables, and respiration and transpiration take place faster in hot climate conditions thus reducing the shelf life of the commodities. Chemical and biochemical changes in stored food proceed at a faster rate at higher temperatures and this causes the quality of the food to deteriorate.

2. ***High humidity*** - similarly, the high relative humidity in tropical countries which is usually about 70% or above for most part of the year provides an ideal environment for mold growth on stored food commodities. When the moisture content in a food product is low, there is a resistance to mold growth. However, when the humidity is high, the dried product absorbs moisture from the surrounding air until it is in equilibrium. This brings the moisture content above the safe level, thus facilitating mold growth.

3. ***Ignorance*** - food losses are related as much to social phenomena as to physical and biological factors. Cultural attitude and practices form the critical, inescapable backdrop for post-harvest operations and loss reduction activities. Even the perception of what constitute loss often varies greatly among cultures. The techniques of food conservation are frequently dictated more by traditional beliefs than immediate utility. Thus, national effort to reduce food losses cannot rely solely on technology or empirical data, technology and information must be culturally and socially acceptable if they are to be useful.

Effect of Post-harvest Loss on Overall Food Availability

Food loss varies from season to season, among different crops from location to location and based on post-harvest treatments. During the harvesting season there is surplus supply of food and consequently high food loss; while during off season there is scarcity of food and food loss is lower. Typical example can be seen in fruits and vegetables. Even at present level of production large amount of agricultural produce is lost due to various causes of post-harvest loss (Osunde and Fadeyibi, 2011). Overall, there is a higher food loss in perishables, and roots and tubers compared to grain and legumes; and the extent of loss increases as the time of storage is lengthened. Research results have shown that about 22% of yam, 12% of cassava and sweet potato is lost annually due to different agent of losses in Niger State (Osunde *et al.,* 1996a). A whooping amount of 209×10^3 MT of grains was reported to have been lost in six local government areas of Niger state in 1995 alone (Osunde *et al.*, 1996b)

Post-harvest loss (PHL) happens at every stage of the supply chain, but in developing countries losses are the most significant. Both quantitative (physical losses caused by rodents, insects or infestations) and qualitative (loss of quality and value) losses occur at all the stages (harvesting, drying and storage) along the supply chain. The estimated annual post-harvest losses of various agricultural commodities in Nigeria in the year 2010 are shown in table 1.

Table 1. Estimated Annual Production and Percentage Loss of Agricultural Commodity in Nigeria

Commodity		Production x 10^3 metric tons	Estimated Loss
Cereals	Maize	4186.6	20 – 30 %
	Millet	1955.4	20 – 30 %
	Sorghum	5751.1	20 – 30 %
	Rice	6831.19	5%
Tubers	Cassava	106,785.00	10 – 25%
	Yam	86,229.00	20 – 67%
	Cocoyam	336.00	10 – 40%
	Sweet potato	5853.00	50 – 80%
Legumes and oil seeds	Soybean	5090.4	30 - 40 %
	Cowpea	809.7	30 - 40 %
	Bambara nut	371.10	30 - 40 %
	Groundnut	10748.10	30 - 40 %
	Beni seed	7685.5	20 – 50%
	Melon	874.8	10 – 30%
	Palm nut	2555.10	10 – 15%
Fruits and vegetables	Citrus	32,013.90	20 – 95%
	Mangos	29,590.50	20 – 80%
	Garden eggs	739.80	40 – 100%
	Okra	893.70	30 – 70%
	Pepper	304.20	10 – 20 %
	Tomatoes	565.50	20 – 50%

Adapted from Gernah et al., 2013

The Table shows estimated loss of 20 – 30 % for cereals, 10 – 80% for tubers, 10 – 50 % for legumes and oil seeds and 10 – 100% for fruits and vegetables (Gernah *et al.*, 2013).

A recent upsurge of interest in PHLs of cereals led to the development of the African Post-harvest Losses Information System (APHLIS – www.aphlis.net), which includes a network of local experts, a loss calculator and a free access data base of key information (Hodges *et al.*, 2011). The network contributes the latest agricultural data and verifies loss estimates, so that APHLIS provides well-founded percentage weight loss data based on transparent calculations.

The APHLIS presents detailed weight loss estimates for eight different cereals in 16 countries of East and Southern Africa. Post-harvest losses typically range from 0·05 to 0·35 (5 – 35%), varying by crop and geographical location. Quality loss, lost market value and lost opportunity were not estimated. The aggregate gross post-harvest weight loss for six major cereals in these countries is US$1.6 billion or (15%) of total production value of US$11 billion (Table 2). This estimate can be extended to the whole of SSA. If it is assumed that PHLs are similar in other countries of SSA that produce cereals, then annual weight losses from SSA are valued at around US$4 billion a year out of an estimated cereal production value of US$27.4 billion. This is enough to feed 8 million people for one year (World Bank, 2010). A mere 1% reduction in this loss could be worth about US$40 million annually.

Table 2. Annual Production of Grains in Tons, Tstimated % Post-harvest Loss and its financial Value for 16 Countries in East and Southern Africa for the Year 2007

Grain type	Annual production (million tons)	Average local production price (US$/tons)	Estimated value of production (US$ million)	Regional average % weight loss estimate	Value of weight losses (US$ millions)
Maize	27.01	194.71	5258	17.5	920
Sorghum	4.72	250.05	1181	11.8	139
Millet	1.67	305.34	510	11.7	60
Rice	5.15	405.53	2080	11.5	240
Wheat	5.25	274.36	11	13.0	187
Barley	1.71	281.53	481	9.9	48
Totals	46.18		10960		1594

Source: (World Bank, 2010)

The need to increase food production has become a policy mantra. Populations are growing, so we need more food. But much of what is produced never makes it past the farm gate, especially in developing countries. Eliminating those losses is a way to increase food availability without requiring additional resources or placing additional burdens on the environment.

Table 3. illustrates the increase in the production necessary to offset various levels of post-harvest food losses. This required production to offset post-harvest food loss is calculated as given by Bukanga (1991).

$$\textit{required production} = \frac{100 \text{ x amount needed}}{100 - \text{post-harvest loss}} \quad \ldots\ldots\ldots\ldots 1$$

This means that if we need 100 tons of grain with 20% loss we need to produce 125 tons of grain. And if we reduce the loss by 50% (i.e to 10% loss) we will save 14 tons of grain. It must however be stressed here that these figures and computations are only illustrative and they are included to show the magnitude of the problem and the potential benefit of its alleviation.

Table 3. Increase in Production Necessary to Offset Various Levels of Post-harvest Food Losses

Post harvest loss (%)	Consumable food (tons)	Required production to offset loss (tons)	Increase in production to offset loss (tons)
0	100	100	0
10	100	111	11
20	100	125	25
30	100	13	43
40	100	166	66
50	100	200	100
60	100	250	150
70	100	333	233
80	100	500	400
90	100	1000	900
100	100	infinite	Infinite

One of the main arguments in favour of PHL reduction is that it is a more resource-efficient means of increasing food supply than just producing more food. The wasted lands, water, labour and agricultural inputs need to be taken into account, not only the lost food. In Least developed Countries (LDC), the incentives to reduce PHLs are much greater as loss reductions can directly improve the livelihoods and food security of the poor, and, potentially, food safety and quality with associated health benefits.

At the level of individual households in SSA, reduced PHLs could increase food availability by both reducing physical losses and increasing income from the improved market opportunities that could be used to buy food (World Bank, 2010 FAO, 2010). Furthermore, reducing PHLs instead of increasing the amount of food grown would save scarce production resources and may lessen environmental harm.

A number of interventions are needed to reduce post-harvest losses and make food available to the teeming population. Some of these interventions include:

- Wide spread education of farmers on causes and impact of post-harvest losses
- Better infrastructure such as development of all weather feeder roads so that crops can get to the market at the right time.
- More efficient value chains that provide sufficient financial incentives and
- Improved post-harvest technologies, which can be adopted by small holder producers, such as processing and storage technologies.

New technology approaches can be introduced through research and innovation systems. However, adoption by small producers will depend on producers seeing clear direct or indirect advantage, particularly financial benefit.

New and improved technologies lead to mechanized post-harvest systems. Figure 3 shows the estimated losses (weight and quality) from the post-harvest chain for rice in South Asia in a traditional and mechanized post-harvest value chain. From the

Figure it can be seen that the loss in a mechanized value chain is far less compared to that in the traditional value chain at all the stages of value addition.

Post-harvest technologies can contribute to food security in multiple ways. They can reduce PHL, thereby increasing the amount of food available for consumption by farmers and poor rural and urban consumers. The benefits to consumers from reducing losses include lower prices and improved food security. In addition, post-harvest activities such as processing and marketing can create employment (and thus income) and better food security in the agricultural sector. Therefore, reducing PHL clearly complements other efforts to enhance food security through improved farm-level productivity. While the gains from reducing post-harvest losses can be significant, there are also costs associated with those efforts, which need to be considered when formulating PHL reduction strategies. Nevertheless, there are significant opportunities for promoting food security through PHL reduction, especially in the current era of high food prices.

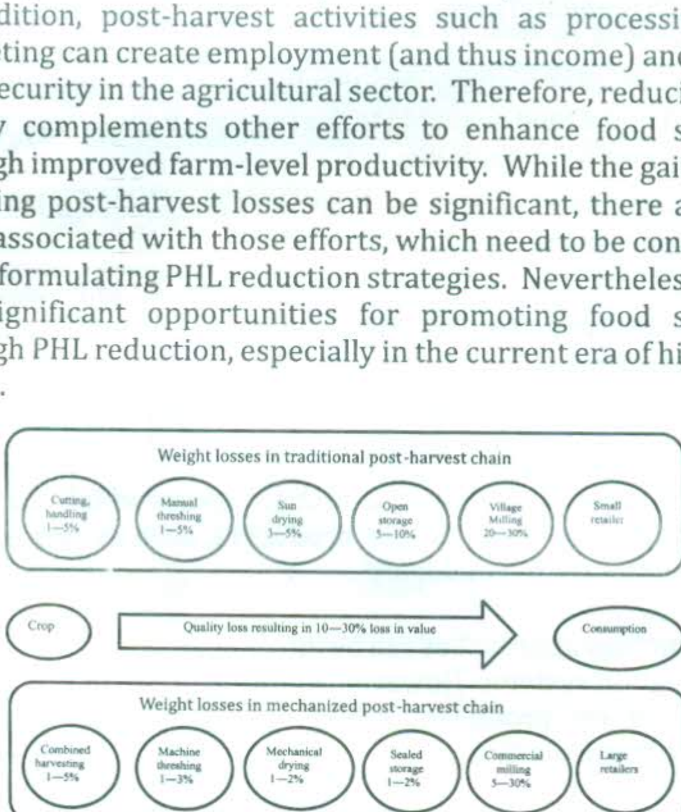


Figure 3. Estimated Losses (Weight and Quality) from the Post-harvest Chain for Rice in South Asia
(Courtesy of Martin Gummert, IRRI) cited by Hodges et al., 2011

Thus, efforts to increase production need to be balanced with corresponding efforts to achieve gains in reducing PHL. With only 1 percent reduction in PHL, annual benefits of US$40 million may be possible, benefiting not only producers but also other actors along the chain, including processors, marketers and consumers.

Job and Wealth Creation

The dynamic role of Micro, Small and Medium Enterprises (MSMEs) as the engine of growth and job creation in developing countries has long been recognized. MSMEs have accelerative effect in achieving objectives such as job creation, income distribution, development of local technology as well as diffusion of management skills and stimulation of indigenous entrepreneurship.

The agro industry is an important and vital part of the manufacturing sector in developing countries and the means for building industrial capacities. More than 50% of Sub Saharan African countries manufacturing jobs are currently in industries related to agricultural products such as food and beverages, textiles and leather goods. Gernah *et al.*, (2013) stated that Agro processing is the most promising and sunrise sector of the economy in developing countries, in view of its large potential for growth and likely socio economic impact specifically on employment and income generation. The agro processing sector is a highly fragmented industry, with a high potential to drive economic growth and enhance rural incomes. It has several segments like dairy, grain processing, packaging and storage, fruits and vegetable processing, fisheries, consumer foods including packaged foods. This makes it especially suitable to creating micro medium and small industries in the developing countries.

Agro processing industries has tremendous potential in job creation and poverty alleviation in rural and semi urban areas.

This is because

- Food is vital for life and always demanded by the target group
- The raw material are readily available often in surplus
- The technology is suitable for small scale operation and it is accessible and affordable
- Equipment can be manufactured locally, creating further employment
- It has few negative environmental effects
- Compared to some other industries, agro processing industries are particularly suitable for women entrepreneurs.

The Federal Government of Nigeria has begun the development of Staple Crop Processing Zones (SCPZ) across the country, with the intention to attract the private sector to set up food manufacturing plants in areas of high production, for import substitution (Daily Independent, 2013). This is a welcome development, however it is also important to encourage small scale food processing industries in rural and semi urban areas and encourage the development of indigenous technology which will be used by these industries. This will increase the development of micro, small and medium scale industries closer to the production (farming) areas which will in turn help in more job and wealth creation for rural dwellers.

Farmers usually capture a fraction of the consumer food dollar. However, introducing value addition closer to the production location will increase farmers' share of the consumer dollar. Success of food processing industries in Nigeria and other SSA countries must depend on indigenous technology initiatives and efforts. Indigenous design and manufacturing of agro processing machinery has tremendous advantages, which includes amongst other:

1. The development of machines and equipment that mee

the needs of local raw materials and processors will reduce dependence on imported (and often times inappropriate) equipment and ensure self sufficiency.

2. It will boost the image of local manufacturers, improve their technological and industrial capability and bring about rapid industrialization with the consequent creation of more job opportunities.

3. The maintenance and repair of the machines and equipment can be done easily and their spare parts sourced locally.

My Contributions

Mr. Chairman, my contributions in post-harvest engineering and value addition to agricultural products focused mainly on the areas of 'form value' and 'time value'.

One of the challenges facing Agricultural Engineers in Sub Saharan African countries is the upgrading of the traditional technologies of food processing and preservation. In most cases, the traditional methods of food processing and preservation in SSA remain at the empirical level (Aworh, 2010). The processes are often laborious, time consuming and associated with low quality end product and high loss. 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 the society at large (Aworh, 2010). Improved technologies help in reducing post-harvest loss, create job opportunities, improve the diet of the populace and generally improve living standard in the rural communities.

Several indigenous appropriate technologies for food crop processing have been designed and developed by research and academic institutions all over the country. It is however, disheartening to note that most of these technologies have remained on the shelf and never adopted nor commercialized.

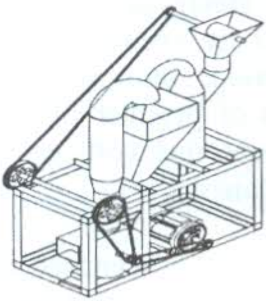
Some examples of processing equipment which have been designed and developed in Nigeria and are in use by local farmers are cassava and rice processing machines. Tremendous success has been recorded with small scale gari processing factories in which some of the tedious manual operations, such as grating, pressing and sifting are replaced by machines which are locally produced (Odigbo, 1985; Okechukwu *et al.*, 2012). However, other unit operation such as cassava peeling is still a bottle neck, which is currently still done manually by women and children. Also there is the need to develop a technology to fully utilize the by products such as starch and cassava peels. The small scale gari processing factories have sufficient flexibility, allowing processing capacity to be matched with raw material supply. They have provided employment in rural areas, reduced post-harvest losses and provided a good source of income for farmers and processors (Aworh, 2010).

Some success has also been achieved in the mechanization of rice processing. There is wide range of rice parboiling, milling and drying machines developed and are in use by farmers and processors. However, rice destonning still constitute a bottle neck, as such machines are still being imported into the country (Babatunde, 2012).

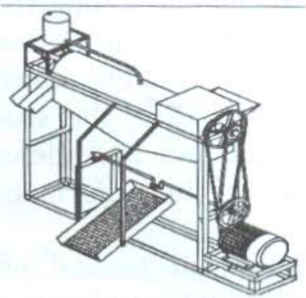
Development of Processing Machines

My work over the years included development of appropriate processing machines for food crops. Such machines include rice destonner (Osunde *et al.*, 1992); multipurpose winnower

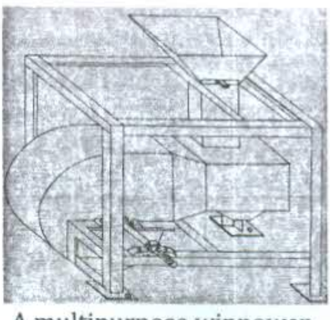
(Osunde and Epapala, 1999); shea nut mixer and crusher (Osunde *et al.*, 2001); soybean grinder and milk extractor (Kwaya and Osunde, 2004); cashew nut cracker (Osunde and Oladeru, 2006); fish smoking kiln, melon seed extractor washer (Osunde and Kwaya, 2012); extruder mixer (Fadeyibi *et al.*, 2014). Figure 4 shows some of such developed machines.



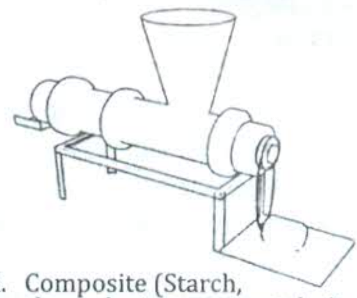
a. Rice destoner



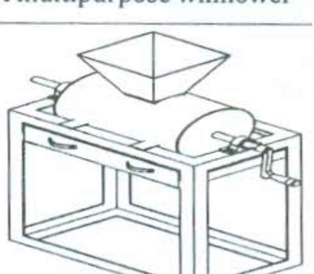
b. Egusi melon seed extractor



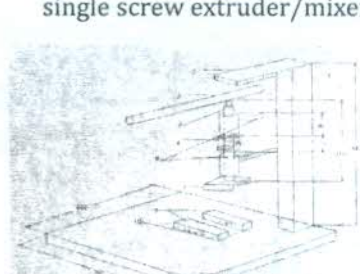
c. A multipurpose winnower



d. Composite (Starch, glycerol, zinc-nanopartcles) single screw extruder/mixer



e. Mixer for Shea butter production

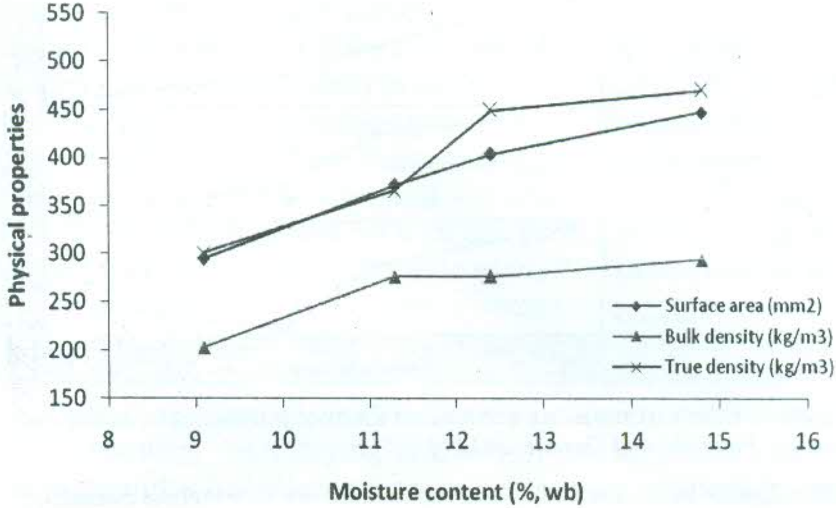


f. Cashew nut shelling machine

Figure 4. Some of the processing machines designed and developed

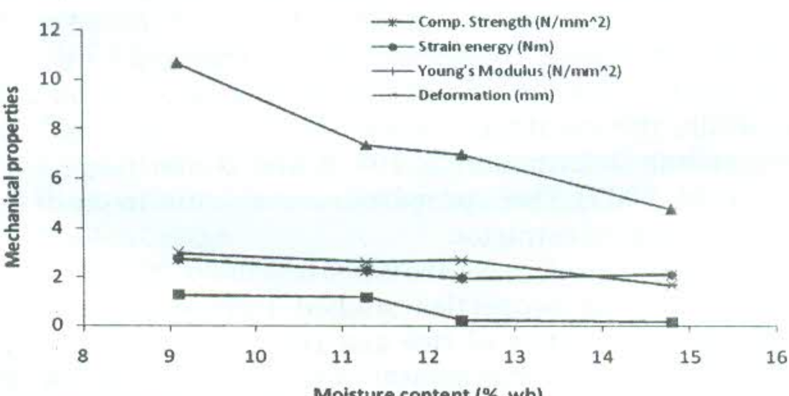
In any engineering design and development the study of properties of materials is the first consideration. This is applicable to all agricultural machinery as well. The main factors that govern the design and development of agricultural product processing machines are the engineering properties of biological materials, such as physical properties, mechanical properties, aerodynamic properties, thermal and electrical properties. Agricultural materials are hygroscopic; these properties might vary at different environmental conditions and method of packing. Thus, the study of the effects of product moisture content and bulk density on these properties will give the engineer clear information on their variation.

Physical, mechanical and thermal properties of rubber seed were studied at four different moisture levels. The results showed that the physical and thermal properties increase linearly with increase in moisture content, while the mechanical properties decrease linearly with increase in moisture content of the seed (Fadeyibi and Osunde, 2011; Fadeyibi and Osunde, 2012 a,b). Figures 5 to 7 show the effect of moisture content on some of the properties studied. A predictive equation was developed to predict the engineering properties in relation to the moisture content of the product. The equations and the respective R^2 values are as indicated in the figures.



$A = 31.207M + 25.767$, $R^2 = 0.8975$ $\rho_b = 26.716M + 62.098$, $R^2 = 0.9697$ $\rho_t = 15.48M + 78.628$, $R^2 = 0.7988$

Figure 5. Effect of moisture content on some physical properties of rubber seed *(Source: Fadeyibi and Osunde, 2011)*



$\tau = -0.1151M + 3.6297$, $R^2 = 0.6673$ $\varepsilon = -0.2227M + 3.3568$, $R^2 = 0.7644$ $E = -1.0059M + 19.407$, $R^2 = 0.9611$ $\delta = -0.2235M + 5.1471$, $R^2 = 0.8445$

Figure 6. Effect of moisture content on some mechanical properties of rubber seed *(Source: Fadeyibi and Osunde, 2012 a)*

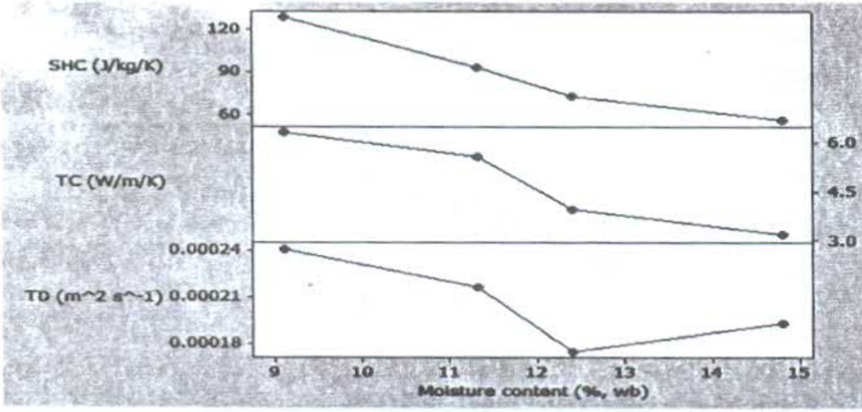


Figure 7. Effect of moisture content on thermal properties of rubber seed
(Source: Fadeyibi and Osunde, 2012 b)

(SHC = specific heat capacity, TC = thermal conductivity, TD = thermal diffusivity)

Shc = -12.94M+ 241.6	TC = -0.581M + 11.66	TD = 3E-0.6M2 – 8E-05M + 0.0007
R^2 = 0.9559	R^2 = 0.9162	R^2 = 0.5967

Physical and mechanical properties of melon fruit of different sizes were studied. The point of linear limit (POLL), bio-yield point and rapture point were determined by subjecting the melon fruit to compression and shear stress test. Based on the results the minimum compression force required to deform melon fruit is 506 N with the corresponding deformation of 16 mm, while the minimum shear force required and the corresponding deformation is 297 N and 8 mm respectively (Kwaya *et al.*, 2009). These properties are essential in the design of egusi melon seed extractor.

Other engineering properties studied include physical and aerodynamic properties of rice and rice chaff (Osunde *et al.*, 1992), physical and mechanical properties of cashew nut (Osunde and Ogunwumi, 2000), Effects of Moisture Content on Physical and Mechanical Properties of seeds of *Novella pentadesma* (Fabunmi *et al.*, 2013), Flow and Properties of Cassava and Yam Starch (Fadeyibi *et al.*, 2014b).

Drying of Agricultural Products

Nigeria is blessed with different types of fruits and vegetables which are grown abundantly in various parts of the country. The types of fruits and vegetables grown in the country differ with climatic conditions. These fruits and vegetables are abundantly available during the season and are scarce during off season. During the season, about 50% of the produce is lost between harvest and consumption (Osunde *et al*., 2006a). Preservation technologies such as cold chain systems, control atmosphere storage and modified atmosphere storage are beyond the reach of the producers and marketers. Other preservation methods such as salting, sugaring and brining are not commonly practiced in the country. Sun drying is the only preservation method available and affordable for the producers and marketers. It is the oldest and widespread preserving method throughout the world. It is commonly used for cereals and leguminous plants. Sun drying has been successfully adopted to preserve highly perishable foods such as vegetables, fruits, fish and meat. It is a preservation method that is cheap and can be practiced all year round in tropical countries such as Nigeria. However, sun drying has many limitations, which include:

- Rate of drying could be low especially during unfavourable weather which increases the risk of spoilage.
- The direct exposure to sun light (ultra violate radiation) can greatly reduce the nutritional content due to direct sun rays
- High risk of contamination by dust, insects, animals and even human beings
- Change in colour and texture reduces the market value of the product.

The use of solar drying greatly reduces or eliminates all these limitations. Solar drying relies, as sun drying on the sun as its source of energy. Solar drying differs from sun drying in that a structure, often of very simple construction, is used to enhance the effect of the insulation (Rozis, 1997). In many cases solar drying is a sensible alternative to sun drying for the African farmer, particularly when it is used to supplement or replace artificial drying.

Osunde and Musa-Makama (2007) studied the effect of sun drying of common vegetables (tomato, sweet pepper and okra) on their nutritional values. The nutritional properties evaluated are ascorbic acid, β-carotene, calcium, potassium and sugar. The study shows that β-carotene retention in sun dried vegetables were quite low in all the vegetables studied, with tomato recording the highest percentage loss of 80%, sweet pepper 65% and 50 % for okra. Ascorbic acid loss was 46.5 % for okra, 69.7 % for sweet pepper and 74 % for tomato. Calcium and potassium changes were statistically insignificant while sugar concentration in sun dried vegetables were high (Osunde and Musa-Makama, 2007). This shows that adult intake of β-carotene and ascorbic acid from dried tomato, pepper and okra which are used in most Nigerian diets during off season will be inadequate compared to recommended daily allowances.

A mathematical model was developed to determine the optimum angle of inclination of collectors for solar dryers. The results show that the optimum angle of inclination varies widely and is dependent on location and month of the year. For Minna, Nigeria, the value ranges between 10.63 to 33.3 degrees (Oje and Osunde, 1995).

In another study the efficiency of three different types of solar dryers (direct, indirect and tent solar dryers) were compared with the local method of sun drying using dry vegetables fruits (tomato, pepper and okra) and fish as test materials (Osunde and Sheriff, 2012). The results showed that drying rate and colour retention of the dried products were highest in the direct solar dryer followed by the solar tent dryer. The local method of open air sun drying was less effective than the others. Figures 8 to 10 show the different types of solar dryers used.

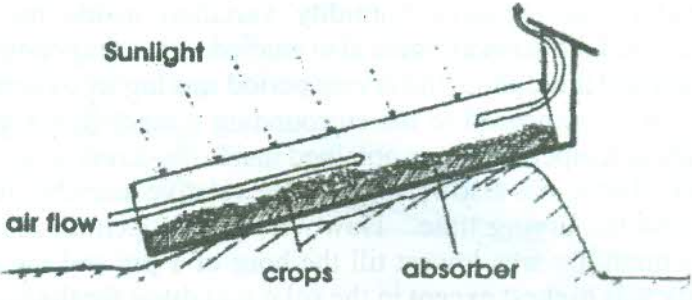


Figure 8. Schematic drawing of a direct solar dryer
Source: Fellows and Hampton, 1997

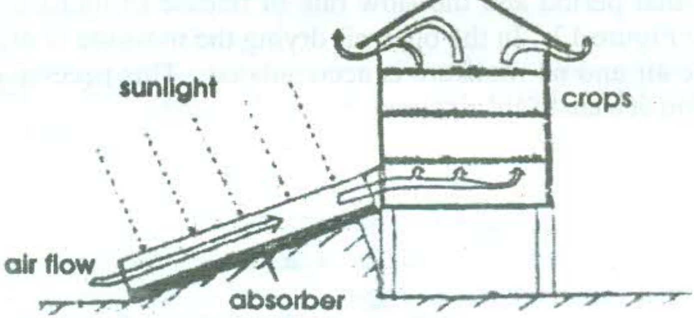


Figure 9. Schematic drawing of an indirect solar dryer
(Source: Fellows and Hampton, 1997)

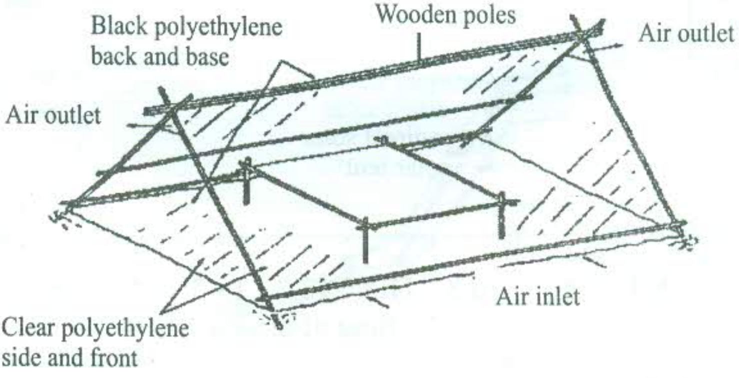


Figure 10. Schematic drawing of a solar tent dryer
(Source: Fellows and Hampton, 1997)

Temperature and relative humidity variation inside the drying chambers and the open air were also studied. The temperature in all the dryers and throughout the drying period was higher by an average value of 6 °C compared to the surrounding temperature Figure 11. The highest temperature was obtained inside the direct solar dryer at 12 noon. There was also variation in the relative humidity in all the dryers and the drying time. However, in the open air drying the relative humidity was lowest till the hour of 1 pm and the relative humidity was highest except in the solar tent dryer for the rest of the drying time. The relative humidity in the solar dryers was higher in the morning between 8 and 12 hours, due to the high rate of drying during that period and the slow rate of release of moist air to the outside Figure 12. In the open air drying the moisture is dissipated into the air and no moisture is accumulated. This necessitated the inclusion of a fan to aid air circulation in the dryers.

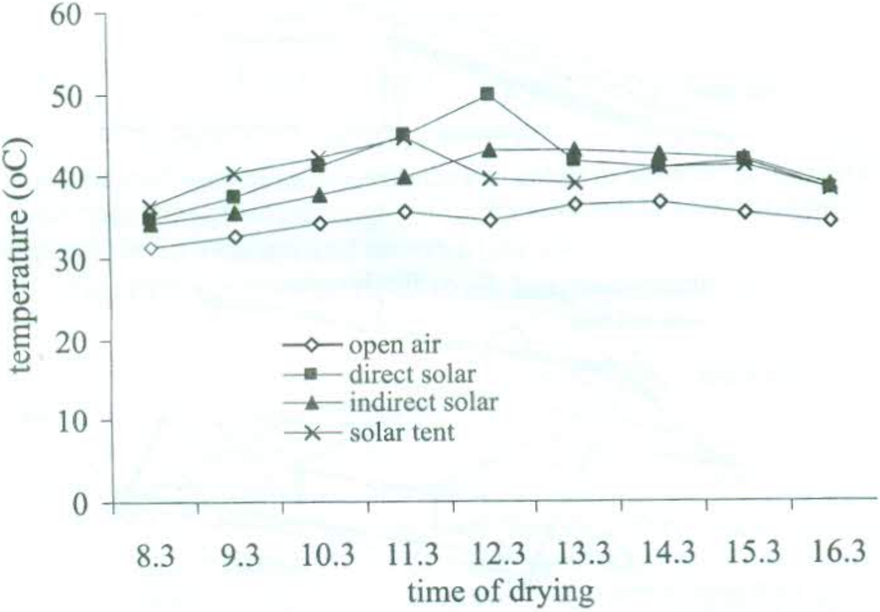


Figure 11. Daily Temperature variation in all the dryers
(Source: Osunde and Sheriff, 2012).

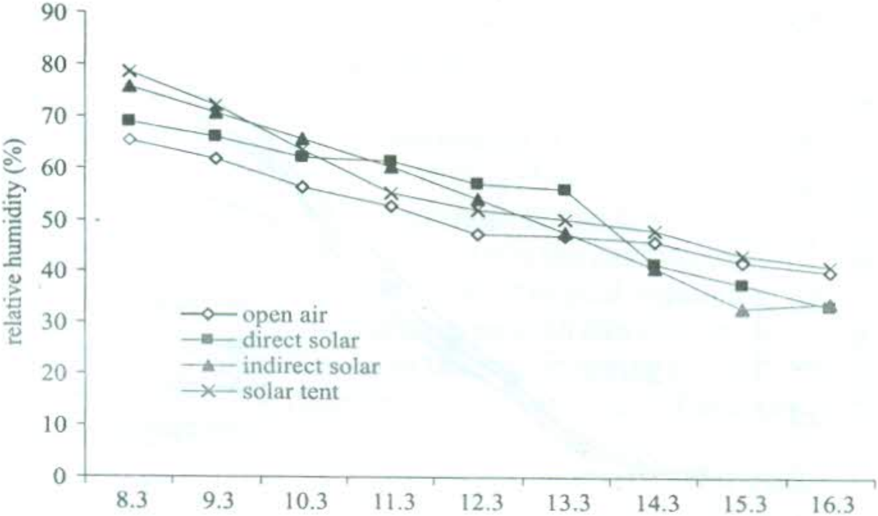


Figure 12. Relative humidity variation in all the dryers
(Source: Osunde and Sheriff, 2012)

The drying rate, which is an indication of moisture removal, was studied for tomato, pepper and okra. Figures 13, 14 and 15 show that the open air drying has the least drying rate for the entire period of drying indicating a longer drying period which exposes the product to be dried to environmental pollution and the ultra-violate rays of the sun. The solar tent dryer and the direct solar dryer have the highest drying rate.

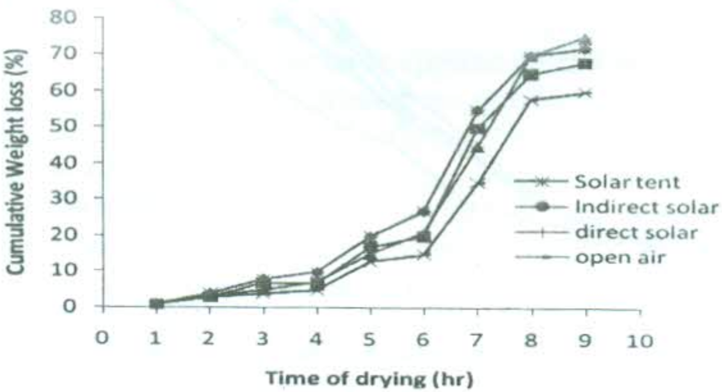


Figure 13. Percentage weight loss for tomato *(Source: Osunde and Sheriff, 2012).*

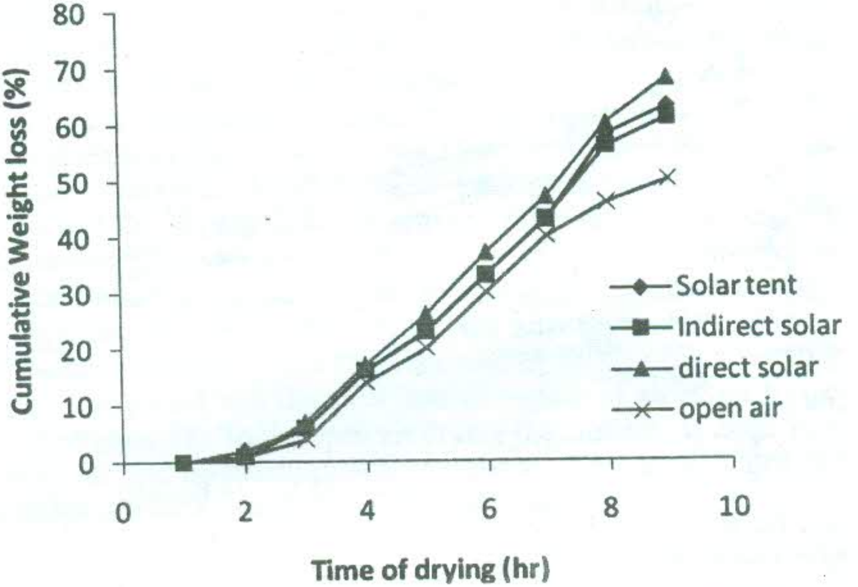


Figure 14. Percentage weight loss for pepper *(Source: Osunde and Sheriff, 2012)*

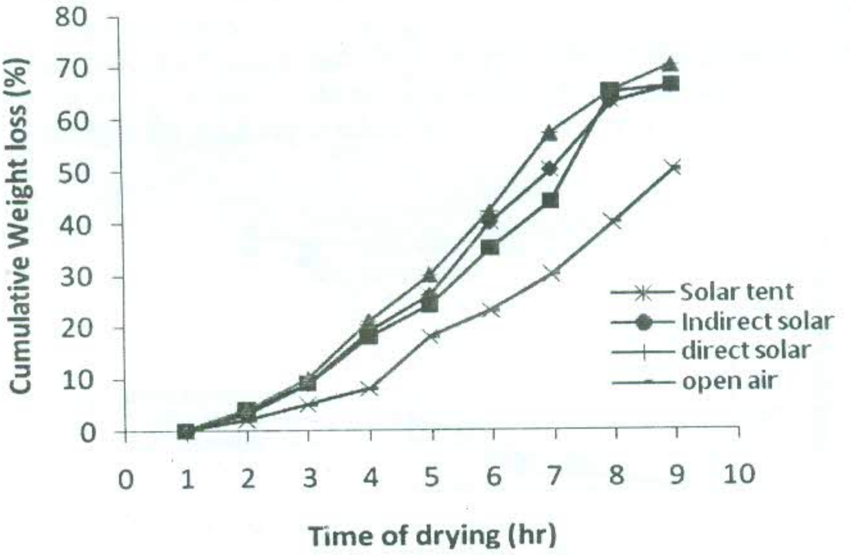


Figure 15. Percentage weight loss for okra *(Source: Osunde and Sheriff, 2012)*

In another study a natural convection solar dryer for on farm drying of vegetables was compared with sun drying for sliced tomato and okra of different sizes. The dryer had a collector efficiency of 42.9% and 53.9% system efficiency. The maximum temperature obtained in the drying chamber was 56°C against 34.5° C under the open sun drying. Sliced tomato and okra of different thicknesses were used to test the developed dryer. The result showed high retention of ascorbic acid, colour and texture of the dried product. In comparison with sun drying, solar drier showed 66% improvement in the rate of drying for both tomato and okra and 50% improvement in retention of ascorbic acid, colour and texture of the dried product. Fifteen mm thickness of slice was recommended for both tomato and okra for maximum dryer capacity utilization (Komolafe and Osunde, 2005 a,b).

Solar dryers were also used to dry fish. Two different types of direct solar dryers namely the tent and cabinet solar dryers were used to dry Tilapia Fish (*Tilapia galaliticus*) and African Arowana Fish (*Heterotis niloticus*). The results show that in just 6 hours of drying there was over 50 % reduction in moisture content in both driers. However, the cabinet solar dryer gave a higher drying rate. The drying rate was also higher for Tilapia fish compared to African Arowana Fish.

Different pre-treatment methods applied on the product to be dried before drying has improved the nutritional and sensory properties of dried fruits and vegetables. Pre-treatment methods generally used include sulphating, blanching, sucrose and honey dip, ascorbic acid and salting. The effect of pre-treatment and drying methods on the quality parameters of dried banana, mango and pawpaw was investigated (Adepoju and Osunde, 2015). The treatment methods used were ascorbic acid dip, honey dip and steam blanching while the drying methods used were sun drying, direct solar drying and oven drying. Drying curves showing the rate of drying were developed. Sensory analysis, proximate composition, vitamin C and β-carotene content of the dried fruits were determined. The results showed that for all the drying methods honey treated samples retain the highest amount of vitamin C and β-carotene. There was also an improvement in the colour for all the treatments compared to the sun dried products.

Storage of agricultural products

Crop storage is an important post-harvest activity to small scale and large scale farmers as well as government of any nation. It is the art of holding agricultural crops essentially in their original form under either natural or artificial environmental conditions to retain their quality over a specific period of time beyond their natural shelf life without deterioration (Musa-Makama and Onwualu, 2012). Storage is one part of the post-harvest system or value addition through which agricultural products are provided at the desired time in spite of its seasonality. Agricultural produce are stored for different reasons depending on who is storing them. Farmers store food crops for household food supply, for planting during the next cropping season and to make higher profit during off-season period. Traders store crops to make profit during off-season or to maintain continuous supply of raw materials to processing industries, while government stores food to regulate price stability, national political stability, to assure food security, for export market, to preserve seeds of different cultivars and for research purposes (Musa-Makama and Onwualu, 2012). No matter the purpose of storage, a storage structure should protect the crop from environmental hazard

Yam is one of the major crops cultivated and produced in Niger State. Yam production in Niger state is estimated to be 2,054 x 10^3 in 2002, out of this between, 22 and 25% is lost due to different causes (Osunde and Yisa, 2000). The main causes of loss during tuber storage are mechanical damage, infection by decay organisms, pest infestation, and physiological changes within the tuber. The first two causes of loss can be controlled by good agricultural practices (GAP), while the physiological changes are functions of temperature, relative humidity and age of the tuber. The physiological changes in yam are respiration, transpiration and sprouting which cause weight and quality loss. A number of experiments were conducted to reduce sprouting and weight loss due to respiration and transpiration. Some of the work done is summarized below.

Improving the storage condition by intermittent provision of forced ventilation, treatment of yam tuber with neem extract and with Chloro Isopropyl Phenyl Carbamate (CIPC) on weight loss and sprouting were studied. Forced ventilation was provided in a traditional yam barn six hourly, this helped in dispersing the heat and moisture created by the respiration of the stored tuber. The results show that the rate of sprouting and weight loss reduced significantly during storage period of six months. Also percentage rotting of stored yam was minimum in the ventilated barn (Osunde and Orhevba, 2009).

In another study, tubers of yam were treated using neem tree bark extract and neem tree leaf slurry and stored for six months. The results show that neem tree extract treatment significantly reduced sprouting and weight loss in stored tuber while neem tree leaf slurry shows higher effect compared to neem tree bark extract (Osunde and Orhevba, 2011). Chloro Isopropyl Phenyl Carbamate (CIPC) solution and powder which has been successfully used in suppressing sprouting and extend the shelf life of stored potato in developed countries did not have any effect at all levels of application in suppressing sprouting in stored yam tubers (Orhevba and Osunde, 2006).

An improved storage structure was developed by combining the pit storage and the traditional yam barn. The developed structure was used to store yam tuber alongside the pit structure and the traditional yam barn. Temperature, relative humidity in all the structures, the sprouting and weight loss of the stored tubers were monitored for six months. Using the environmental data and the storage period of the traditional yam barn a model was developed to predict sprouting and weight loss of the stored yam. The model developed for sprouting is:

$$Y_s = -9.87 + 0.172X_2 + 0.322X_3 - 0.00392X_2X_3 - 0.000016X_1X_2X_3 - 0.000114X_2^2 \ldots 2$$

With R^2 values of 0.808. While the model developed to predict weight loss is:

$$Y_w = 8 - 0.00399X_1X_2 + 0.00491X_2X_3 - 0.00832X_3^2 + 0.000027X_1^2X_2 + 0.795Y_s \ldots\ldots\ldots 3$$

With R^2 values of 0.735.

The model was validated using data from the other two structures and a close relationship was established between the measured and computed values Figures 16 and 17.

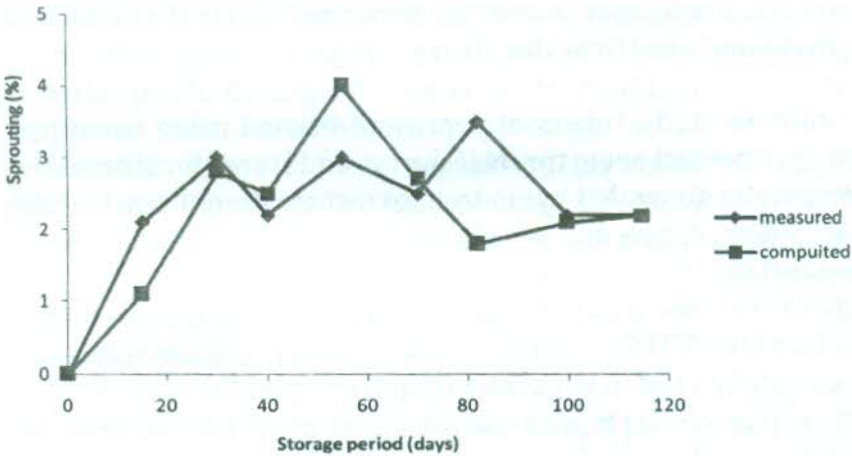


Figure 16. Measured and computed sprouting in stored yam *(Source: Osunde et al., 2006).*

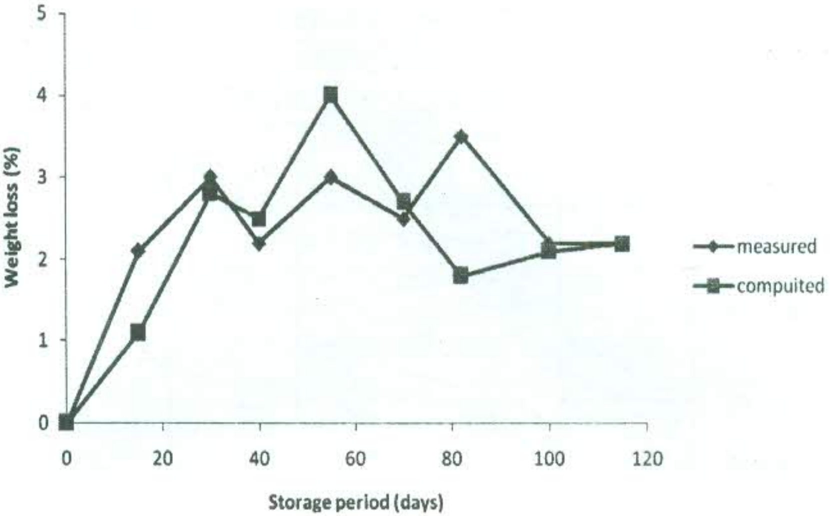


Figure 17. Measured and computed weight loss in stored yam
(Source: Osunde et al., 2006).

The model was used to estimate the cumulative weight loss for a given period of storage and a combination of humidity and temperature values. Figures 18 and 19 shows the estimated weight loss after 12 and 16 weeks of storage (Osunde *et al.*, 2006). The values on the Figure were computed using the model for different combinations of temperature and humidity and 12 and 16 weeks of storage period. In Figures 18 and 19 the contour lines represent the weight loss. For any combination of temperature and humidity within the range of 12 weeks of storage the weight loss can be estimated.

After 12 weeks of yam storage at a temperature range of 26 °C to 29 °C and a relative humidity range of 58 to 64%, the estimated weight loss from Figure 4 will be 2.6 to 8.6% of the tuber initial weight (Osunde *et al.*, 2006b).

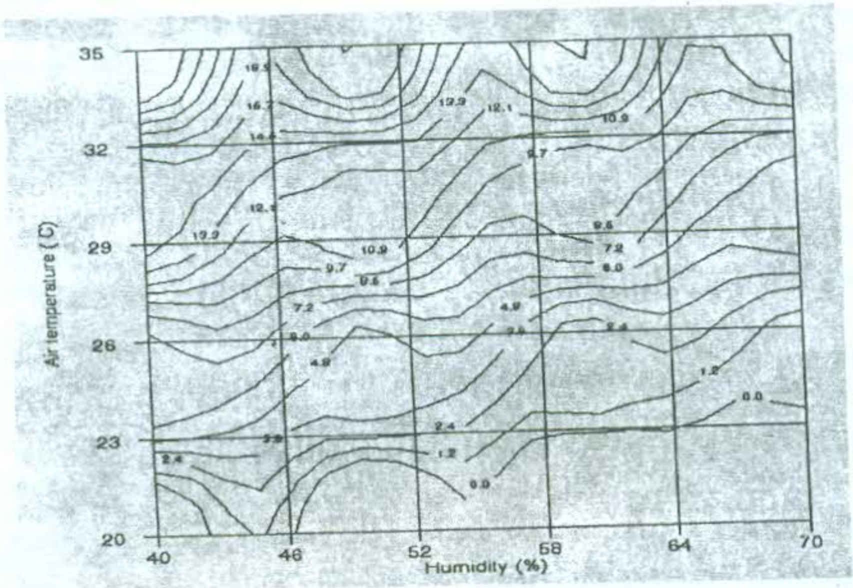


Figure 18. Estimated weight loss after twelve weeks of storage
(Source: Osunde et al., 2006).

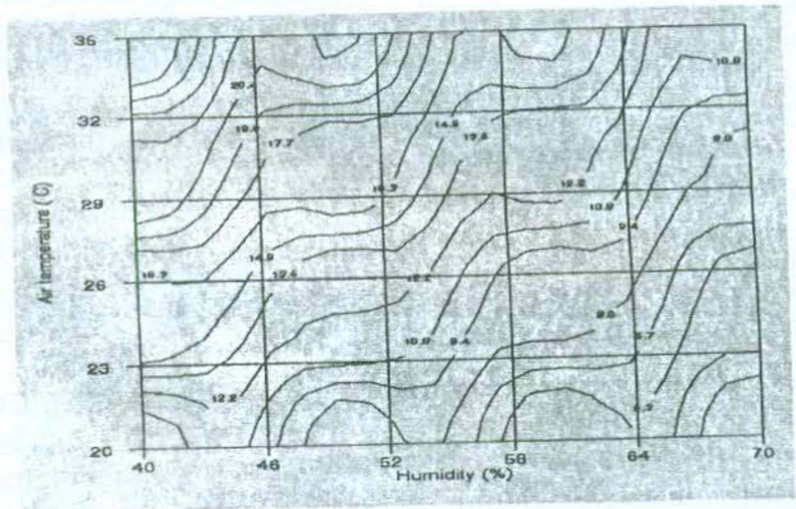


Figure 19. Estimated weight loss after sixteen weeks of storage
(Source: Osunde et al., 2006).

Concluding Remarks

This Inaugural Lecture whilst focusing on the subject matter of *product value addition* has underscored how National Food Security, job creation and poverty alleviation could effectively be achieved through deliberate and pragmatic actions aimed at reducing post-harvest losses, making agricultural products more appealing, safe, available all-year-round with increased shelf life. It should be noted that food security does not necessarily imply more production. Reduction of post-harvest losses to the barest minimum will ensure that more food will be available. Four distinct and elaborate levels of products value addition namely form, location, time and information values have been discussed. Each of these provides a wide and complex range of industries which are capable of creating millions of jobs in the process alleviating poverty and ensuring food security.

The capacity to adequately preserve agricultural products is directly related to the level of technological development and engineering knowledge. My research in the last two and half decades or so has leveraged on form value and time value addition with specific emphasis on design and development of processing equipment, development of crop drying technologies and improvement in storage methods with modest achievements.

There is no doubt that agricultural engineers will continue to make tremendous impact in this area through the development and improvement of indigenous processing and storage technologies which can be adopted by small scale producers. However, there is the need for commercialization and mass production of these technologies to make them available to the processors and farmers. Adoption and use of these technologies by the processors and farmers will not only transform the agricultural sector but also shift the economy from consumption to production based economy.

Acknowledgment

I wish to first and foremost give gratitude to God Almighty for directing my life and for all great things He has done for me. I cannot thank Him enough but to continue to glorify and praise Him for His mercy, blessings, guidance, sustenance and protection.

Abundance of appreciation goes to all my teachers at all levels, primary, secondary, and University. You were all wonderful. You made me who I am today. I thank you all for the discipline, encouragement and for filling me with knowledge.

My special thanks go to all my friends worldwide, particularly those of my secondary school and University days. Thanks to the social media through which I got connected with some of you recently after separating for almost three decades. I thank those of you who connected with me online to relieve the memories of our ties in the early 70s to late 80s.

I wish to thank the present Dean of the School of Engineering and Engineering Technology Prof. Salawu Sadiku and all the past Deans of the school for their cooperation and support over the years. My special appreciation goes to all the Heads of Department of Agricultural and Bioresources Engineering in the Federal University of Technology, Minna starting from Prof. M. G. Yisa, Prof. E. S. A. Ajisegiri, Dr. D. Adgidzi, Prof. P. Idah, Dr. A. A. Balami and Dr. (Mrs.) B. A. Adejumo. I thank you all for your support and encouragement. I however wish to specially acknowledge the contribution of Prof. M. G. Yisa to my academic development in this University. He was a two time Head of my Department between the early and late 90s; he was one of the panellists that interviewed me when I applied for job here, he was my PhD major-supervisor and he also assisted in proof reading and editing this manuscript. Sir, I thank you very much

for everything and I pray the good Lord bless you and your family richly. I also wish to appreciate the support and encouragement of all my other colleagues in the Department of Agricultural and Bioresources Engineering, the School of Engineering and Engineering Technology and the University at large.

To all members of the Nigerian Society of Engineers, Minna Branch I say thanks for giving me the opportunity to serve. I acknowledge and appreciate you all. I believe strongly that my years as a member of the executive of the society have contributed immensely to enhancing my ability to organize lectures and seminars. I urge you all to keep the flag of NSE flying. I also wish to use this opportunity to appreciate the support I have continued to receive from members of the Association of Professional Women Engineers of Nigeria (APWEN) Minna Branch. We have come together a long way. Please keep on contributing your quota towards encouraging, enhancing and developing the girl child in every nook and cranny of our immediate community.

I am sincerely grateful for the support I have enjoyed from members of the CEFE FUT, Minna for the over ten years of working together. I strongly believe that we have made our contributions here, but we have to do more to carry the CEFE message beyond Niger State. I am equally appreciative of the support of all members of the University Seminar and Colloquium Committee. The achievements recorded by the committee over the years are no doubt a result of cooperative teamwork. It gladdens my heart every time during seminars, when I see you guys moving up and down the venue coordinating events. I urge you to show the same support to whoever will be taking over from me in the nearest future as the Chairman of the committee. I also wish to use this opportunity to thank the past Chairmen of the committee (Prof. E. E. Udensi and Prof. (Mrs.) I.

Mogbo) under whom I served before I took up the mantle of leadership. I am particularly grateful to Prof. E. E. Udensi for the useful and helpful advices and tips I received from him when I assumed the Chairmanship of the committee.

I wish at this junction to acknowledge and appreciate the support, friendship and love I have enjoyed over the years from Dr. and Dr. (Mrs.) Tunde Akinremi, Mrs. Mary Lori, Dr. and Mrs. J. O. Oyero, Dr. and Mrs. O. Kemiki, Mr. and Mrs. Musa Yashim and Pastor and Mrs. Yakubu G. Ishaya.

I am grateful to Alhaji Hassan Nuhu, the Executive Director and all other members of the New Gate College of Health Technology, Minna for honouring me recently at their 1st Annual lecture Series in recognition of my modest contribution to the manpower development of the college. I am indeed proud to be associated with your college.

I wish to profoundly express my gratitude to the immediate past Vice-Chancellor of this great University Prof. M. S. Audu who appointed me as the Chairman of the University Seminar and Colloquium Committee. Sir, in my first outing which you chaired, you jokingly remarked that "you will tell everybody that the committee under my chairmanship succeeded in organizing only one Inaugural lecture". I am proud to notify you today Sir, that three years down the lane, we have successfully organized 17 Inaugural lectures and many public lectures.

I thank the current Vice-Chancellor Prof. M. A. Akanji and the other principal officers of the University for their unflinching support and encouragement all through. Mr. Vice-Chancellor Sir, you challenged us early in the year not to go below our achievement of six Inaugural lectures in 2014. I wish to proudly tell you Sir, that we have surpassed our own record. I also wish to assure you that the tempo will not slow down in the coming year, as we have to date over ten distinguished Professors who have indicated interest to deliver their Inaugural lecture in the year 2016.

I also wish to acknowledge with sincere gratitude the goodwill I have always enjoyed from the current Ethiopian Ambassador to the Federal Republic of Nigeria (Her Excellency, Mrs. Samia Zekaria Gutu), the Embassy staff and indeed the Ethiopian community in Abuja.

I am deeply appreciative of my in-laws all over the world, particularly my late father in-law, my aged mother in-law, my sisters and brothers in-law. I thank you all for the love and care you've shown me over the years and for taking me as one of you.

During my sojourn in life, I have resided for not less than five years in each of four different countries including Nigeria. During the course of my residency in these countries, I was able to adjust to life easily, eat their food, drink their water, speak their language, sing their song etc. All these have been made possible by the special Grace of God and the training I received from my late parents. They taught me to love and appreciate every human being without discrimination. Abba and Emma, may you continue to rest at the bosom of the Lord.

I wish to appreciate my late senior sister Manalebish, who was also my childhood friend and confidant. I thank you dear sister for all we shared together, for being always there for me in times of need and for your encouragements and advices whenever I was desperately in need of some. May you continue to rest at the bosom of the Lord. To my other sister and brothers and their families, I say a big thank you for the love and support you've always showed me and my family.

My special appreciation and gratitude goes to all my children (biological, physical and chemical) for being a blessing and source of joy to me. I thank you Nosa, Ame, Steve, Mulika, Dotun, Wusi, Kusin Ehis and Mercy for making me proud always. May God continue to strengthen the bond that ties us together. To my grand children, I am indeed blessed with you all. May God continue to bless and keep you all hail and healthy.

Finally, let me appreciate my one and only, the man who brought me to the western part of the African continent even though I was born and bred in the eastern part. My husband, my friend and my lover. Thank you for your love, care, support and guidance over the years. I thank you for standing by me all the time.

Mr. Chairman Sir, I am done!

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Profile of the Inaugural Lecturer

Engr. Professor (Mrs.) Zinash Delebo Osunde (née Dilebo-Gmebo) is an Ethiopian by birth and a Nigerian by marriage. She was born on August 18th 1957 in Ambo, Ethiopia. She attended Maerege Hiwot Primary and Secondary Schools in Ambo, Ethiopia and proceeded to the then Republic of Czechoslovakia (now Slovak Republic) for her University Education. Between 1976 and 1982 she was at the University of Agriculture Nitra, Czechoslovakia where she bagged an MSc degree in Agricultural Engineering. She also attended the Technical University of Vienna, Austria between 1986 and 1989 where she earned a diploma in Computer Science. In 2003 she bagged a PhD degree in Agricultural Engineering (Crop Processing and Storage) from the Federal University of Technology, Minna. Prof. Zinash Osunde joined the services of the Federal University of Technology, Minna in 1990 and rose to the rank of Professor of Agricultural Engineering on October 1st 2011.

Professor (Mrs.) Osunde attended a number of professional training in the subject matter area of *"processing and storage of agricultural products"* in various part of the world some of which include: I.I.T.A. Ibadan, Nigeria in 1991; International Agricultural Centre (IAC) Wageningen, the Netherlands in 2004; MASHAV course at Bet Dagan, Israel in 2006; MASHAV course at Maizube Farms, Niger State in 2008. She also attended a specialized *CEFE methodology* entrepreneurship training programme organized by GTZ and CEFE International in Abuja in 2008; and a Regional Workshop on *'local economic development'* in Pretoria, South Africa in 2012.

A distinguished academic, Professor (Mrs.) Osunde has served the University in various capacities and has held several positions of responsibility at various times in (i) the Department of Agricultural and Bioresources Engineering, which includes: Welfare officer; Departmental secretary; Post Graduate Programme coordinator and Head of Department. (ii) The School of Engineering and Engineering Technology, which includes: School Examination Officer; SWEP coordinator; SIWES coordinator; Chairperson, Staff welfare committee and Member, Editorial Board of the Nigerian Journal of Engineering and Applied Sciences. (iii) University responsibilities, which includes membership of the University ceremonies committee, students' disciplinary committee and University Senate. Others are Chairperson, University staff disciplinary adhoc committee, University CEFE coordinator; Chairperson, University Seminar and Colloquium Committee; Faculty adviser, Unilever Nigeria Ltd., and Hall adviser, for female hostels.

Outside the University community, Prof. (Mrs.) Osunde has served as the Editor, *Processing and Post Harvest Engineering*; Journal of Agricultural Engineering and Technology (JAET); Chairperson, LOC Maiden CEFE Nigeria conference in 2012; Consultant to Fadama II programme (Niger, Kaduna, Bauchi, Taraba, Adamawa, Sokoto and Kebbi States); Financial Secretary, National Association of Women in Academics (NAWACS), Minna Branch; Treasurer, Nigerian Society of Engineers, Minna Branch; Technical Secretary, Nigerian Society of Engineers, Minna Branch; Vice Chairperson, Nigerian Society of Engineers, Minna Branch; Assistant Secretary, Nigerian Institution of Agricultural Engineers (NIAE) and Chairperson, Association of Professional Women Engineers of Nigeria (APWEN), Minna Branch.

Professor (Mrs.) Osunde belongs to several professional bodies among which is the Nigerian Society of Engineers (NSE), Nigerian Institution of Agricultural Engineers (NIAE), Association of Professional Women Engineers in Nigeria (APWEN), International Network of Women Engineers and

Scientists (ICWES) and the National Association of Women in Academics (NAWACS). She is a registered engineer with COREN and a Certified National Senior Adviser of CEFE International. She has served as external examiner and Professorial assessor to several Higher Institutions in Nigeria at various times. She has supervised several undergraduate and postgraduate diploma students, 14 Master's and 4 Doctoral students to date. She has several journal publications, including chapters in books to her credit.

Professor (Mrs.) Osunde is also a keen sports woman and she has represented the University in table tennis at the Nigerian Universities Staff Games at ABU, Zaria in 2009 and at the University of Benin in 2013. She won a bronze medal for the University in the "mixed doubles" at the ABU, Zaria Games.

Engr. Prof. Zinash D. Osunde is married to Prof. Akim Osunde of the Department of Soil Science and Land Management, Federal University of Technology, Minna and they are blessed with children and grand children.