OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA.

Inaugural Lecture series 251

FOOD, WOMEN AND TECHNOLOGY: THAT WE MAY EAT AND BE SATISFIED

By

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PREAMBLE

Mr. Vice Chancellor Sir, distinguished ladies and gentlemen, it is with deep gratitude and thanks to God and indeed a great honour that I stand before you today to deliver the 251st Inaugural lecture of the Obafemi Awolowo University. This is the sixth inaugural lecture from the Department of Food Science and Technology.

Permit me to give a brief history of my choice of career into academics. I was admitted into the Department of Biochemistry (then Unife) in 1980 but my brother-in-law Dr Akinmusuru of the Department of Civil Engineering encouraged me to change my course of study as there were only a handful of female students in the Faculty of Technology at the time and he saw a future full of opportunities for women in Engineering. Hence, my transfer to the Department of Food Science and Technology in 1981. I had the best graduating result in my Class. Dr Akinmusuru also encouraged me to do my post graduate studies with Prof Ajibola in the Department of Agricultural Engineering. During this period, I registered for several undergraduate courses to make up for deficiencies in my engineering background so I could become a registered engineer. I sat for the professional examination in 1994 (while nursing a three week old baby) and became the first female registered engineer in Ile-Ife and environs. Today, I am one of the few Fellows of the Nigerian Society of Engineers in Ile-Ife and one of the three female engineering Professors in Nigeria as of today.

The idea to give this inaugural at this time was birthed by one of my sisters who suggested I give the lecture to celebrate my 50th birthday. This idea was given shortly after I was pronounced a professor in 2010 and thus began the process. Mr Vice Chancellor Sir, I turned 50 on the 3rd of Oct but today is the closest I could arrange to my birthday.

Before I go into the lecture, I would like to acknowledge the role of my mentor Prof Femi Ajibola. He successfully nurtured me through the early stages of my career in this University. Without his guidance I may not have been standing here before you today.

I will like to acknowledge my late brother Mr. Adebiyi Adeeko who came to Kano every weekend from Zaria (during his M.Sc program) to coach Taiwo and I for the National Common Entrance Examination. He believed in the equality of the sexes even when such ideas were unpopular in the 70s. With his tutoring, I gained admission into the prestigious Federal Government Girls College, Benin City on merit and there has been no looking back since then. I acknowledge with gratitude the financial, moral and emotional support of my older siblings who ensured that all their *aburos* (younger ones) were educated.

INTRODUCTION

" And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, in the which is the fruit of a tree yielding seed; to you it shall be for meat." Gen 1:29. In addition, God gave man dominion over the animals which means man is to exploit or decapitate animals in a responsible manner. What we have been given we are expected to enjoy but not waste. In the story of Jesus feeding 5,000 people, 12 baskets of leftover were collected. My work has been about how to enjoy what we eat and take care of the leftovers and surpluses.

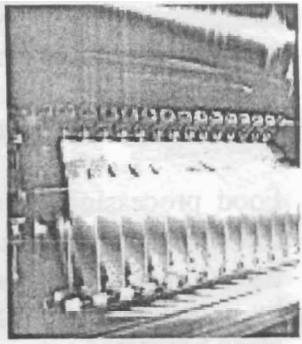
The right to food is a human right derived from the International Covenant on Economic, Social and Cultural Rights (ICESCR), recognizing the "right to an adequate standard of living, including adequate food", as well as the "fundamental right to be free from hunger". While many foods can be eaten raw, many also undergo some form of preparation for reasons of safety, palatability, texture, or flavor. Some preparation is done to enhance the taste or aesthetic appeal or help to preserve the food.

Cooking kills potentially harmful microorganisms that are present in the food supply. The amount of nutrient loss and changes caused by cooking is important as these affect the benefits derived from the meal. The thrust of my work is ensuring that processed food retains both its appeal and nutritional value as much as possible. Table 1 shows the amount of nutrient losses observed with different food processing techniques.

My main research focus has been in the general area of post harvest processing of agricultural materials. In this area, my research interests can be grouped as follows: i) Food Process Engineering, ii) Gender studies in post-harvest technology adoption and iii) Technology Management in the food industry.

Food

Women



Technology

POST-HARVEST FOOD HANDLING

One of the sources of food insecurity in Africa is post harvest crop loss. In African countries pre and post-harvest crop losses are higher than the global average and impact more severely on already endangered livelihoods. A high percent of the continent's crop productivity is lost on and off the farm. This is mainly because most subsistence farming communities do not have access to appropriate technologies. A wide range of existing food processing technologies is not accessible to and adapted by African countries and their communities. Overcoming the perishability of

the crops, enhancing nutritional value and adding economic value through processing are the main ways of enlarging food security in Africa. The critical role that food science and technology plays in national development cannot be overemphasized in West Africa where high postharvest food losses, arising largely from limited food preservation capacity, is a major factor constraining food and nutrition security.

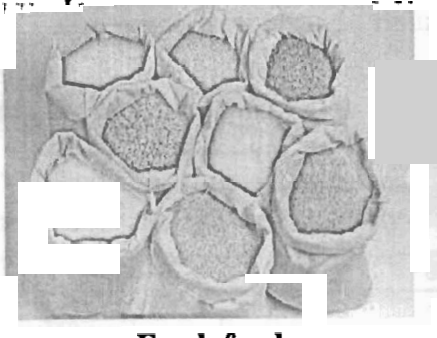
Agriculture is the mainstay of the West African economy and in Nigeria; over 70 % of the population derive their livelihood from agriculture. It is estimated that about 50 % of perishable food commodities including fruits, vegetables, roots and tubers and about 30 % of grains including maize, sorghum, millet, rice and cowpeas are lost after harvest in West Africa. Inefficient or inappropriate food processing technologies, inefficient postharvest handling practices and inadequate or complete lack of storage facilities, packinghouses and market infrastructures are some of the factors responsible for high postharvest food losses.

Food processing is the set of methods and techniques used to transform raw ingredients into food or to transform food into other forms for consumption by humans or animals either in the home or by the food processing industry. Food processing takes clean harvested crops or butchered animal products and uses these to produce attractive, marketable and often long shelf-life food products.

Food processing dates back to the prehistoric ages when crude processing incorporated slaughtering, fermenting, sun drying, preserving with salt, and various types of cooking (such as roasting, smoking, steaming, and oven baking). Salt-preservation was especially common for foods that constituted warrior and sailors' diets, up until the introduction of canning methods. Modern food processing technology in the 19th and 20th century was largely developed to serve military needs. Although initially

expensive and somewhat hazardous due to the lead used in cans, canned goods would later become a staple around the world.

Benefits of food processing include toxin removal, preservation, easing marketing and distribution tasks, and increasing food consistency. In addition, it increases seasonal availability of many foods, enables transportation of delicate perishable foods across long distances and makes many kinds of foods safe to eat by de-activating spoilage and pathogenic micro-organisms. Modern supermarkets would not be feasible without modern food processing techniques, long voyages would not be possible and military campaigns would be significantly more difficult and costly to execute.



Fresh food

Processed food

The extremely varied modern diet is only truly possible on a wide scale because of food processing which often improves the taste of food significantly. Transportation of more exotic foods, as well as the elimination of much hard labour gives the modern eater easy access to a wide variety of foods unimaginable to their ancestors. Mass production of food is much cheaper overall than individual production of meals from raw ingredients. Therefore, a large profit potential exists for the manufacturers and suppliers of processed food products. Individuals may see a benefit in convenience, but rarely see any direct financial cost benefit in using processed food as compared to home preparation. Processed food freed people from the large amount of time involved in preparing and cooking

"natural" unprocessed foods. The increase in free time allows people much more choice in life style than previously allowed. In many families the adults are working away from home and therefore there is little time for the preparation of food based on fresh ingredients. The food industry offers products that fulfill many different needs: From peeled potatoes that only have to be boiled at home to fully prepared ready meals that can be heated up in the microwave oven within a few minutes. Modern food processing also improves the quality of life for people with allergies, diabetics, and other people who cannot consume some common food elements. Food processing can also add extra nutrients such as vitamins.

Table 1- Typical Maximum Nutrient Losses (as compared to raw food)

Nutrient	Freeze	Dry	Cook	Cook+Drain	Reheat
Vitamin A	5%	50%	25%	35%	10%
Lycopene	5%	50%	25%	35%	10%
Vitamin C	30%	80%	50%	75%	50%
Thiamin	5%	30%	55%	70%	40%
Riboflavin	0%	10%	25%	45%	5%
Niacin	0%	10%	40%	55%	5%
Vitamin B6	0%	10%	50%	65%	45%
Folic Acid	5%	50%	70%	75%	30%
Vitamin B12	0%	0%	45%	50%	45%
Calcium	5%	0%	20%	25%	0%
Iron	0%	0%	35%	40%	0%
Magnesium	0%	0%	25%	40%	0%
Phosphorus	0%	0%	25%	35%	0%
Potassium	10%	0%	30%	70%	0%
Sodium	0%	0%	25%	55%	0%
Zinc	0%	0%	25%	25%	0%
Copper	10%	0%	40%	45%	0%

Source: Latham (1997).

In the area of Food Process Engineering, I have worked on the expression of oil from oilseeds, utilization of legumes, preservation and utilization of fruits, and designs of machines for food processing.

EXPRESSION OF OIL FROM OILSEEDS

Vegetable fats and oils are lipid materials derived from plants. Physically, oils are liquid at room temperature, and fats are solid. Although many plant parts may yield oil, in commercial practice, oil is extracted primarily from the seeds. Vegetable fats and oils may or may not be edible. Examples of inedible vegetable fats and oils include processed linseed oil, tung oil, and castor oil used in lubricants, paints, cosmetics, pharmaceuticals, and other industrial applications. Many vegetable oils are consumed directly, or indirectly as ingredients in food - a role that they share with some animal fats, including butter and ghee.

Vegetable oils are used as an ingredient or component in many manufactured products. Many vegetable oils are used to make soaps, skin products, candles, perfumes and other personal care and cosmetic products. Some oils are particularly suitable as drying oils, and are used in making paints and other wood treatment products. Vegetable-based oils, like castor oil, have been used as medicine and as lubricants for a long time. Castor oil has numerous industrial uses, primarily due to the presence of hydroxyl groups on the fatty acid chains. Vegetable oils are also used to make biodiesel, which can be used like conventional diesel. The vegetable oil economy is growing and the availability of biodiesel around the world is increasing.

Nigeria is rich in oilseeds (groundnut, sesame seeds, soybeans, melon seeds, cashew nuts, palm fruits, sunflower seeds, cotton seeds, rape seeds, coconut, etc.). These oilseeds have oil content in the range 20-55%. Groundnut is an economic crop of importance in Nigeria processed mainly into vegetable oil. Melon seeds (*Citrullus vulgaris*)- very rich in oil are used as popular

condiments in Nigerian local soup. The oil has potential in industrial manufacture of margarine, shortening, and cooking oils. Locally melon is extracted by squeezing the ground samples by hand or on a hard platform resulting in low yield having poor quality. Rubber seed oil has a high proportion of unsaturated fatty acids comparable to that of linseed oil which is useful as a semi-drying oil in the paint and varnish industry. Commercial expression of rubber seed oil could therefore lead to the replacement of linseed oil which is imported into Nigeria. Nigeria stands to net a substantial sum of income if the oils are made available and harnessed.

Extraction

The "modern" way of processing vegetable oil is by chemical extraction, using solvent extracts, which produces higher yields and is quicker but more expensive than other means of obtaining oil from oilseeds. The most common solvent is petroleum-derived hexane. This technique is used for most of the "newer" industrial oils such as soybean and corn oils. Supercritical carbon dioxide can be used as a non-toxic alternative to other solvents. Another method is physical expression, called "crushing", which does not use solvent extracts. It involves using several different types of mechanical extraction techniques (expeller-pressed, the screw press and the ram press). This method is typically used to produce the more traditional oils (e.g., olive, coconut etc.), and it is preferred by most "health-food" customers in the USA and in Europe. Oil seed presses are commonly used in developing countries, among people for whom other extraction methods would be prohibitively expensive. The amount of oil extracted using these methods vary widely ranging from 20% to 43% depending on the press used and other pre pressing operations employed.

Of the mechanical presses available, the hydraulic press has relatively low initial and operating costs, and it is easy to operate and maintain. Not all oilseed crops are suitable for processing at the small scale; the most common types that are suitable include

groundnut, sunflower, coconut, sesame, mustard seed, oil palm and shea nuts. In many cases the crude extracted oil is not suitable for human consumption until it has been refined to remove undesirable free fatty acids that taste rancid, have dark colours and waxes. Refining involves considerable extra equipment costs. The most suitable oils for small and medium scale extraction are those that need little or no refining e.g. mustard, sesame, groundnut, sunflower, palm and palm kernel.

Most small enterprises will find that small expellers are the best technology choice. Methods such as water extraction and manual pressing only produce small amounts of oil, the extraction efficiencies are low and labour requirements high. Solvent extraction while highly efficient involves very substantial capital cost and is only economicalat large scale. There are also health and safety risks from using inflammable solvents.

Efficient expression of oil from oilseeds using the mechanical press is dependent on several intrinsic and extrinsic factors. Most oil bearing seeds need to be separated from the outer husk or shell. This is referred to as shelling, hulling or decortication. Shelling increases the oil extraction efficiency and reduces wear in the expeller as the husks are abrasive. After decortication, the shell may have to be separated from the kernels by winnowing. At the small scale this can be done by throwing the material into the air and allowing the air to blow away the husk. At larger scale mechanical winnowers and seed cleaners are available. Pre-heating seeds prior to expelling speeds up the release of the oil. Pre-heating is generally carried out in a steam heated kettle mounted above the expeller. As the material passes through the expeller the oil is squeezed out, exits through the perforated cage and is collected in a trough under the machine. The solid residue, oil cake, exits from the end of the expeller shaft where it is bagged. The crude expelled oil contains solid particles. These can be removed by allowing the oil to stand and then filtering the clear oil

by gravity through fine cloth. A better but more expensive method is pumping the crude oil through a filter press.

Low yield and poor quality oils are obtained due to the inefficient technologies employed at the rural level. There was need therefore to upgrade the expression process in order to improve the yield and quality using affordable technology. My research works on expression of oil from oilseeds have focused on evaluating the processing factors affecting the yield and quality of mechanically expressed oil from groundnut, melon seeds, rubber seeds and sesame seeds. Generally, oil yields from coarsely ground groundnut were higher than those from finely ground samples, but the free fatty acids were lower. Oil yield increased with greater particle size, temperature, heating time and pressure. Increasing the temperature and time of pre heating of the groundnut materials prior to pressing increased the free fatty acids, peroxide value, and the colour intensity of the oil expressed (Adeeko and Ajibola, 1988). The post- harvest moisture content (PHMC) has been suggested to have greater influence on oil yield than the initial moisture content. One of our studies examined the influence of PHMC on the yield of mechanically expressed groundnut oil. The optimal PHMC of 3% resulted in higher yields. This gave an oil yield of 34% (corresponding to an expression efficiency of about 75%) (Ajibola *et al.*, 1997).

On melon seeds (*Citrullus vulgaris*) we (Ajibola *et al.*, 1989) showed that the efficient expression of oil using the local hydraulic press required size reduction of the oilseeds, followed by heat treatment and application of pressure. Coarsely ground melon samples gave consistently lower yield of oil than finely ground samples. Highest oil yield of about 41.6% (i.e. expression efficiency of 80%) was obtained when samples conditioned to 9-12% moisture content (wet basis) were pressed at 25Mpa. Characteristics of the oil such as colour, specific gravity, refractive index and viscosity were of acceptable quality requiring little or no refining.

The effects of some processing factors on oil yield of mechanically expressed rubber seeds were studied (Ajibola *et al.*, 1990). Higher oil yields were obtained from finely ground samples when expressed at 20MPa and oil yield increased with heating time up to 25min. Maximum oil yield of 33.2% (i.e. expression efficiency of 77%) was obtained from finely ground rubber seeds heated at 110°C for 15min. and expressed at 20MPa. The physical properties of the oil obtained fr[illegible]e above conditions were comparable to literature values for refined linseed oil. However, the colour of the expressed oil darkened progressively with increased heat treatment. For sesame seeds (*Sesamum indicum*) the oil yield increased with increase in heating temperature, heating time and pressure but decreased with moisture content of the sample. Highest oil yield of 33.5% (equal to an expression efficiency of 65.7%) was obtained when sesame seeds were conditioned to 6.1% moisture content, heated at 85°C for 20min., and expressed at a pressure of 20MPa (Ajibola *et al.*, 1993). The quality of expressed oil was not affected by the range of processing conditions studied.

In summary, on the optimization of oil expression from some oilseeds, I identified optimal processing conditions resulting in good oil yield of high quality for the different oilseeds. Characteristics of the oils such as colour, specific gravity, refractive index and viscosity were of acceptable quality requiring little or no refining. Cost of refining of the oil is greatly reduced; the cake is suitable for both human and animal consumption (unlike cake from chemically extracted oil). These studies were sponsored by the IFS Grant under the leadership of Prof. O. Ajibola.

COWPEA PROCESSING AND UTILIZATION

Legumes are rich and less expensive sources of dietary proteins and water soluble vitamins. Among the legumes, cowpea is the most widely grown and distributed within Nigeria. Africa produces

about 95% of the world crop while Nigeria accounts for more than 66-70% of the world production. However, the various methods of storing and preserving the crop locally are grossly inadequate. With the development of higher yielding varieties and the potential of cultivating the crop twice in the farming season (if the early crop is harvested at physiological maturity) there arose a need to consider other means of preserving cowpea. The consumption of cowpea is limited because of the long cooking time due to the development of the hard-to-cook (HTC) defect and the presence of anti nutritional factors. Long cooking times require the use of more fuel and cause loss of nutrients, constraining the use of dry beans as food. Legume proteins are of poor nutritional value unless subjected to heat treatment. The thermal process among other things tenderizes the cotyledons which increases product palatability. Cooking times of beans differ according to variety and processing treatments and may be quite long if the HTC condition has developed. The required cooking time for beans increases with the age of the beans and it is also a function of the storage conditions.

Numerous techniques have been employed to reduce the cooking period of legumes. Soaking prior to cooking has been reported to influence both the texture of cooked beans and the cooking time. Several authors have reported that soaking prior to cooking reduced the hardness of cooked beans of various species as well as the concentration of toxic factors and flatulence inducing sugars (stachyose and raffinose). Giami and Okwechime (1993) reported for some Nigerian cultivars that cooking time was reduced by 10-27% after soaking at room temperature for 12-16hrs. In order to reduce this long soaking time, I studied the soaking characteristics of two cowpea varieties at elevated temperatures. Water absorption and texture of two cowpea varieties IFE-BPC and ITA-2246 soaked at (25-90°C) were determined. Water absorption increased with soaking time up to 1hr for all temperatures considered and cowpea seeds soaked in water at 60 and 75°C had greater

penetration (softer texture) than those soaked at other temperatures. Prolonging soaking time beyond 1hr did not significantly increase water uptake at elevated temperatures while beans soaked at room temperature continued to absorb water gradually up to the sixth hour of soaking. Generally penetrometer readings increased with increase in temperature of soaking water with time. Dehulled cowpeas absorbed less water than whole seeds and varying soaking conditions had milder effects on the texture of dehulled cotyledon halves. The study concluded that soaking need not go beyond 1hr at between 45-75°C for optimal water absorption and softness (Taiwo *et al*, 1994). This result has significant industrial application in that it reduces the processing time, reduces large volume of material in process and minimizes the possibility of microbial growth during the overnight soaking hitherto practiced.

Soaking prior to cooking had an effect only on the cookability, while the amount of water absorbed and the penetration depth (a measure of texture) of a penetrometer head in the seeds increased with cooking time. Soaking at elevated temperature shortened water absorption equilibrium time to 1 hour instead of 6 hours at room temperature. Texture of soaked seeds was a function of soaking temperature and seed variety but independent of soaking time. Seed variety and cooking time influenced the final cooking rate, percent splits and time of achieving adequate tenderization in cooked seeds. Splitting in cooked beans increased with cooking time with a maximum of 92% split in ITA-2246 and 63% split in IFE-BPC. Soaking for 1hr, prior to cooking reduced bean hardness and time by as much as 40-50% and 12-14% for IITA-2246 and IFE-BPC seeds respectively (Taiwo *et al.* 1995).

Mathematical relations were established between product characteristics. Water absorption correlated positively with time but the goodness of fit was temperature and variety dependent. Poor correlation coefficients were obtained when the penetration

depth of the seeds was expressed as a sole (linear) function of soaking time and amount of water absorbed. However, equations involving both variables described the penetration depth of the soaked cowpea better. Cooking time correlated very well with drained weight ($0.883 \leq r \leq 0.979$), percent split ($0.797 \leq r \leq 0.9622$) and the penetration depth of cooked seeds ($0.895 \leq r \leq 0.982$). Equations involving drained weight and cooking time as variables were developed to predict the penetration depth of cooked cowpea. The degree of fit increased with the inclusion of the product or higher order terms ($0.841 \leq r \leq 0.996$). These equations are useful for process scale up if the hydration capacity of the beans is known. The reliability of these equations is quite high and may be used in engineering calculations.

The rate of heat transfer must be known for efficient equipment and process design to prevent overheating or under heating during processing. Under heating will cause problems such as unsafe food production while overheating will waste energy in addition to depleting the nutritional value of the food. Hence, the knowledge of the thermal properties such as thermal conductivity, specific heat, density, etc. is essential in the computation of thermal lethalities of canned food and in product development or formulation. The most important parameters that affect the thermal properties of food as applied to thermal processing are bulk density, moisture content and temperature. There was a dearth of information on the thermal properties of legumes hence a study was undertaken to determine the effect of temperature and moisture content on the specific heat, density and thermal conductivity of cowpea flour. For most of the samples, the specific heat was highest either at 60°C or 28.6% moisture content while further increase beyond these levels resulted in a decrease. Density decreased with moisture increase up to 23.1% and then increased at the higher moisture contents considered. Thermal conductivity was dependent on moisture content and density but independent of temperature (Taiwo *et al*, 1996). This study provided information

on the influence of processing variables on the thermal properties of cowpea flour which are needed in computing the heat process parameters.

Further work on legume utilization was undertaken to develop industrial products from cowpea. The imported "Canned Baked Beans" (CBB) is a ready to eat but expensive product and therefore of limited consumption in Nigeria. The work of Taiwo *et al*, (1997) sought to produce local cowpea in tomato sauce as an alternative to or substitute for the ready-to-eat CBB. Cowpea variety Ife-BPC was identified as having the best canning quality in terms of water absorption, percent split in grains and texture (Taiwo *et al.*, 1997). The thermal process time and sensory attributes of Ife-BPC cowpea seeds canned in tomato sauce were studied. Heat resistance of *Bacillus stearothermophilus* 1518 was determined by the plate count method at 114.5 and 120.6°C. Surviving spores were cultured and the thermal death time (TDT) curves were plotted from these data to obtain D values of 2.2 ± 0.2 min at 120.6°C and 7.5 ± 0.5 min at 114.5°C.

Heat penetration studies were conducted on two can sizes and at two operating temperatures. Thermal process parameters were determined using both the general and formula methods. There was no significant difference ($P < 0.05$) in the process times determined by the two methods although slightly higher values were obtained with the formula method. The medium can size required a longer process time to approach the retort temperature than the small can size. The lethal effect of sterilizing at 120.6°C resulted in a lower D-value, higher sterilizing value (F_0), and higher safety ratio (a/b) than at 114.5°C. The final F_0 (18.6 min) at the end of processing was greater than the targeted F_0 (11.0 min) from the 5D value, suggesting that the processing time was adequate for safe food production. Taste panel assessments were conducted to identify optimal processing conditions. The sensory attributes of dry and semi-dry Ife-BPC cowpeas canned in tomato

sauce were compared with those of imported CBB. Semi-dry processed cowpeas had high consumer preference over the dry seeds, and acceptable canning qualities similar to those of the imported baked beans. The production of commercially sterile cowpea in tomato sauce as a local substitute to imported baked beans will not only save the country some foreign exchange earnings, but will lead to industrial growth thereby generating employment for the populace.

Appropriate packaging in addition to its role of providing a mean of delivery of the product, maintains commercial sterilization of the product, and provides a barrier to several hazards. The establishment of new processing industries may be based on the less energy consuming packaging line. The economic feasibility of using the retort pouch as an alternative to the canning system for packaging and processing of cowpeas in tomato sauce was evaluated using the net present value (NPV) and Internal Rate of Return. Assuming a uniform cash flow over a 10-year plant life. Cost estimates for the alternative packaging systems were based on an equal mass flow rate of processed cowpea, i.e., 360 cans/min. The retort pouch system required larger fixed and working capital investments than the canning system. The cost of cans accounted for a larger percentage of the raw material cost than the cost of the food material. Increasing the number of shifts to two increased the economic performance of both systems at the same time reducing products cost. Results of the NPV and IRR indicated that capital investment on the canning line would be more profitable than the pouch system.

Seasonal supply, size, color and the level of insect damage of the grains cause price variability for the product and purchasers discount from the first *bruchid* hole observed (Langyintuo et al, 2003). Utilization of cowpea in the production of bean flour adds value to the product and hides evidence of insect infestation (Akanbi, 1992; Akanbi and Taiwo, 1999). Production of cowpea flour with good functional and reconstitution properties has the

potentials for a large market as it can be readily incorporated in various recipes. Akanbi (1992) developed a dry soup mix of *Gbegiri*. The advantage of the dry soup mix is the convenience that the consumer derives from rapid reconstitution and simmering of the required quantity of drum dried cowpea mix. Economic evaluation of the industrial production of *Gbegiri* bean soup mix was conducted using the NPV and IRR methods. The results indicated that the economic performance of the plant could absorb variation in operation and plant capacity. Flexibility in the plant capacity utilization in the range 70-100% yields a good economic performance. Nowadays, few consumers have time to prepare and grind cowpea into flour, an essential ingredient for traditional Nigerian dishes such as *akara* (fried cowpea paste), *danwake* (cowpea dumplings) and *moin-moin* (steamed cowpea paste). Instead, consumers are increasingly purchasing cowpea flour to make these dishes, just as they have begun to do with pounded yam flour and plantain *fufu*. By helping processors improve their mechanization processes, we help them to increase product shelf-life and better meet rising consumer demand for this quick and easy product.

In summarizing my work on cowpea appreciable research efforts has been devoted to optimizing the soaking and cooking of legumes. My work in this area provided engineering data on the soaking and cooking characteristics of two cowpea varieties and identified the variety best suited for canning. My results showed that soaking of beans at slightly elevated temperatures for short time achieved the same water absorption capacity as the overnight soaking at room temperature. The adoption of high temperature short time soaking will provide continuous flow, a more readily controlled schedule, at the same time reducing bacteriological problems associated with a long soaking period. Studies on the thermal properties of cowpea provide data useful in equipment and process design. These results were used as a basis in establishing the processing conditions for the production of commercially

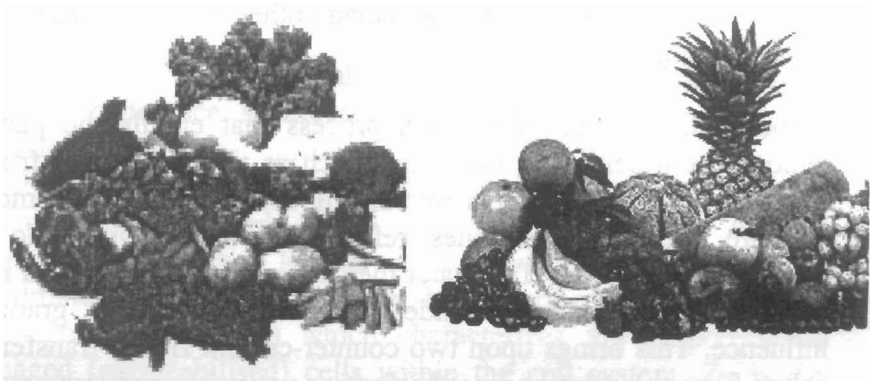
sterile whole Ife-BPC cowpea seeds in tomato sauce with acceptable canning and sensory attributes. Economic analysis of different packaging systems (i.e. the cans or the flexible retort pouch) were evaluated and appropriate policy recommendations made. I received a Postgraduate Research grant from the Obafemi Awolowo University, Ile-Ife during my doctoral program which supported the above studies.

PRESERVATION OF FRUITS

The term fruit normally means the fleshy seed-associated structures of certain plants that are sweet and edible in the raw state, such as apples, oranges, grapes, strawberries and bananas. Fruits are generally high in fiber, water, vitamin C and sugars, although this latter varies widely from traces as in lime, to 61% of the fresh weight of the fruit. Regular consumption of fruit is associated with reduced risks of many diseases and some of the functional declines associated with aging. Diets that include a sufficient amount of potassium from fruits and vegetables also help reduce the chance of developing kidney stones and may help reduce the effects of bone-loss. Fruits are also low in calories which would help lower one's calorie intake as part of a weight-loss diet.

Fruits in general contain more than 75% water and get spoiled very quickly, if not stored properly. Even proper storage fails to preserve the fruits for a long period unless they are dehydrated. The osmotic dehydration techniques not only enables the storage of the fruits for a longer period, but also preserves flavor, nutritional characteristics and prevents microbial spoilage. Apart from this, problems of marketing, handling and transport becomes much simpler and all types of fruits could be made available to the consumer throughout the year. Osmotic dehydration can remove 50% of the water from fresh ripe fruits e.g. bananas, mangoes, papayas, apples and other tropical fruits. The final drying of these osmotic dehydrated fruits by vacuum drying provides a product

which has good quality attributes with respect to appearance, taste, flavor and colour as compared to sun drying.



Assorted fruits and vegetables

Dried fruits are beneficial to human health because they are a rich source of vitamins, minerals, anti-oxidants, and especially fibre due to their concentration during processing. These products are also a rich source of energy, particularly if produced by osmo-convective dehydration using concentrated sucrose solutions. However, this may limit the attractiveness of such dried fruits to weight-conscious consumers. The process of dehydration consists of three steps i) Osmotic dehydration (OD), ii) Vacuum or air drying and iii) Packaging. In osmotic dehydration, the fruits are subjected to osmosis by dipping or spreading them in aqueous sugar syrup under specific conditions, so that the water from the fruits migrate to the sugar syrup. Major dehydration of the fruit takes place in this process step. The final drying of the fruits to make it suitable for marketing is carried out by vacuum or air drying depending on cost considerations.

There are many positive benefits to osmotic dehydration. Some of these benefits include being able to store fruits and vegetables for a longer period of time, maintaining nutritional values and flavors of fruits and vegetables and also preventing microbial spoilage from occurring. Also, transport and handling of fruits and vegetables that have undergone this process are much easier. Osmotic

dehydration is used in order to prevent spoilage in many different food products including kiwis, mangos, strawberries, carrots, pineapples, potatoes, bell peppers, tomatoes, bananas, grapefruits, oranges, lemons, guava fruits, and many other different varieties of fruits and vegetables.

Osmotic dehydration (OD) is a process that entails the partial removal of water from food items such as vegetables and fruits. Osmotic dehydration works by soaking food in a higher osmotic pressure solution, sometimes referred to as a hypertonic or concentrated solution. The water then passes through the food into the concentrated solution under the osmotic pressure gradient influence. This brings upon two counter-current flows: transfer of solute from the solution into the fruit or vegetable and large water flow out of the fruit or vegetable into the solution.

Mass transfer rates during OD depends on factors such as temperature, concentration of the osmotic medium, size and geometry of the sample, sample to solution ratio and the degree of agitation. Pretreatment has been reported to enhance the mass transfer kinetics during OD. During pretreatment, changes occur in the cell membranes which play a key role in the changes that occur within the tissue during further processing. The changes in the state of the cell may vary between partial and total permeabilization depending on the treatment. Further information on cellular integrity can be obtained by measuring the electrical conductivity of the solution in which the food is immersed. High conductivity is indicative of leakage of intra cellular ions and, therefore, damage to membranes.

Texture, color and vitamin C contents are common quality indices of fruits and vegetables and a major result of their processing is the loss of tissue firmness depending on the severity of the process. Enzymatic browning occurs in fruits and vegetables after bruising or cutting or during storage, leading to the development of unpleasant colors, flavors and loss of nutrients. Studies on different

apple cultivars have shown that susceptibility to browning may depend on polyphenol oxidase (PPO) activity or degradation of phenolic content or both (Goupy *et al.*, 1995).

The application of an external electrical field induces an electrical potential difference across the membrane leading to electrical breakdown and local structural change of the cell membrane thereby increasing its permeability. The application of high pressure was reported to increase the permeability of cell membranes resulting in loss of tissue firmness. The extent of cell membrane permeabilization can be described using the cell disintegration index Zp which characterizes the proportion of damaged (permeabilised) cells within the cell system. Zp is the impedance of cells with ruptured membranes and is determined on the basis of the changes in electrical conductivity of the cell system at different frequencies. For intact cells Zp = 0, and for total cell disintegration Zp = 1. The theory and determination of Zp are described by Angersbach *et al.*, (1999).

As a recipient of the Alexander von Humboldt Foundation fellowship award (1999-2001) I was a visiting scholar to the Department of Food Process Technology, Technische Universitat, Berlin Germany headed by Prof Knorr. In this laboratory, I collaborated with other scientists from various parts of the globe to study the Influence of osmotic agents, pre-treatment methods and osmotic conditions on the mass transfer and product characteristics of several fruits (apples, mango, paprika, strawberries, etc. – Tedjo *et al.*, 2002, Eshtaghi *et al.*, 2002, Angersbach *et al.*, 2001, Adeomowaye *et al.*, 2002, 2003 and Taiwo *et al.*, 2001, 2002, 2003).

Pretreatment has been reported to enhance the mass transfer kinetics during OD. During pretreatment, changes occur in the cell membranes which play a key role in the changes that occur within the tissue during further processing. Taiwo *et al.*, (2001) studied the effects of different pretreatments (blanching, freezing or

applying High-intensity Electric Field Pulses (HELP) or High Pressure (HP) on the diffusion kinetics and some quality factors of osmotically dehydrated apple slices. The results showed that application of HELP, HP and blanching facilitated more water loss during OD, but the influence of pretreatment was more distinct on rate and extent of sugar uptake during OD. Untreated and HELP treated apple samples had comparable solid gains which were lower than in other samples. The results indicated that HP and HELP as pretreatments may be considered in the production of dehydrated apple products as they yielded good quality products having firmer texture, brighter colour and better retention of vitamin C compared to samples that were either blanched or pre-frozen. Application of HELP is advantageous when moisture reduction and minimal alteration in product taste are desired due to minimal sugar uptake, whereas, HP may be considered when product formulation through sugar uptake is desired. Since these results indicated that HELP as a pretreatment enhanced mass transfer, further studies were conducted on identifying the optimal processing conditions for using HELP for different food materials. HELP - a low thermal short time process induces membrane permeabilization in various biological cell systems due to electrical break down of the membrane something on frequencies etc.

The use of HELP was applied on paprika (capsicum annum L) in juice production in place of enzyme use. The bell pepper contains health promoting carotenoids and vitamin C which encourages their exploitation in juice production. The primary objective of the juice processor is to obtain high yield while maintaining or improving the quality and stability of the final juice product. Advances in enzyme technology ensure that the fruit tissue is macerated and liquefied in order to extract additional soluble solids. This process involves strong agitation, high temperatures and lengthy treatment times. The use of HELP has been exploited to avoid the disadvantages associated with the use of enzymes. In our work, Adeomowaye *et al* (2001) investigated the impact of HELP treatment on yield and some quality parameters of juice

from paprika and the results compared favorably to the results of juice obtained from enzyme treated or untreated paprika mash. HELP treated paprika juice had comparable yield but better quality than the enzyme treated samples. The short treatment time involved in the application of HELP(<5min) is an advantage in reducing juice making process time compared to the traditional method of enzyme digestion of at least one hour.

Rehydration studies were also conducted on the osmotically dehydrated slices with the aim of investigating their water absorption characteristics as well as their quality attributes. Taiwo *et al* (2003) reported that the longer the OD time, the higher the rehydration capacity (RC) and the shorter the rehydration time required for optimal water uptake. Blanched and prefrozen samples had higher RC, firmer rehydrated samples and greater dry matter loss than the other pretreated samples. The data showed a good relationship between RC, OD time and the electrical conductivity of the rehydrating medium. These findings have important implications in the manufacture of breakfast cereals. Combined pretreatment of HELP and OD increased the RC (10-30%) of apples more than either treatment on its own. The application of HELP enhanced more solid retention during rehydration. Rehydration rate increased with temperature but higher RC values were obtained at low temperature (24-45°C) long time. The results of the study have shown that the combined pre-drying treatments yielded products having satisfactory rehydration characteristics thus highlighting their potentials in processing (Taiwo *et al.*, 2002).

Efforts are on to integrate dried fruits into food formulation – they can be used as concentrates, chopped up and used dry with breakfast cereals, granola, or cookies. Dried fruits can also be eaten after they have been soaked in water or used to make jam and other tasty snacks. I have explored the utilization potential of osmo-dehydrated pineapple slices in jam production. The research investigated the influence of different osmotic conditions on the

characteristics of dried pineapple slices as well as determined some physico-chemical and sensory characteristics of the jam produced. Panelists most preferred jam samples produced from pineapple osmotically dehydrated in sugar solution and rehydrated at 24 °C, followed by jam from samples dehydrated in sugar/salt medium and rehydrated at 90 °C for 15 min. The study concluded that there is a great utilization potential for osmotically dehydrated pineapple slices in jam production however, with a need for improvement in product colour. The implication of this is that surplus fruits can be preserved during market glut by osmotic dehydration followed by oven drying for later use.

My research efforts on fruit preservation has provided data on the impact of different pre-treatment methods on the kinetics of mass transfer during osmotic dehydration of fruits and on some selected quality indices. Mass transfer kinetics during osmotic dehydration (OD) can be enhanced by pretreatment and some quality indices of apple slices were reported improved when pretreated by either blanching, freezing or applying High-intensity Electric Field Pulses (HELP) or High Pressure (HP).

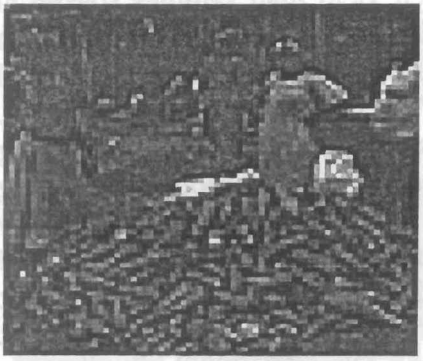
Studies on Other Food Products

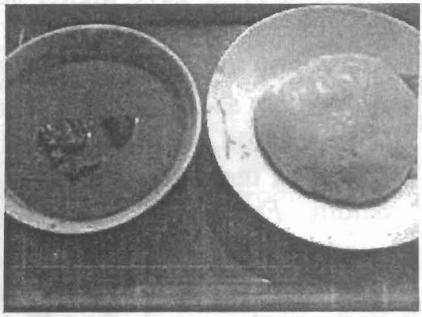
At various times in the course of my career, I have researched on the optimization of processing conditions that will enhance the quality and functional properties of some other food materials not covered above.

Emulsifiers - Taiwo *et al.*, (1997) studied the influence of temperature and additive substances on the absorption kinetics of food emulsifiers. Emulsifiers (e.g. proteins) are used to lower the interfacial tension (IT) between liquid interfaces. This study investigated the emulsifying properties of two proteins (egg yolk and whey protein concentrate-WPC) as influenced by the pH, ionic strength and temperature of the mixture. The presence of salt and higher temperatures reduced the absorption kinetics of egg yolk solutions, while that of WPC solutions increased with salt

additions. The presence of sugar and vinegar generally increased the IT of both emulsifiers while increased temperatures caused the equilibrium of IT of both emulsifiers to decrease and attain equilibrium more quickly. The stability and consistency of oil-in-water emulsions are important properties in the food industries.

Cassava utilization - Nigeria is the largest producer of cassava in the world with its production currently estimated at about 49 million tons a year. Cassava plays a vital role in the world food security because of its capacity to yield under marginal soil conditions and its tolerance to drought. Cassava, a valuable subsistence and cash crop in the tropics is consumed by humans in various forms. Taiwo (2005) discussed the major Nigerian domestic products as well as the potential industrial products of cassava that are yet to be exploited locally and the machines required for their production. In the study by Owolarafe *et al.*, (2000), we investigated the comparative performance of the hammer mill and the grater in pulverizing dewatered cassava mash in *gari* production. The results showed that the hammer mill had a higher throughput capacity, grinds finer than the grater and has a greater efficiency; however the grater produced *gari* with a greater swelling capacity and consumed less energy which makes it more suitable for industrial use.





Cassava processing/products

Cassava, *Manihot esculenta* (Crantz) spoils after 48 h of harvest (due to physiological changes and microbial activities) unless kept under special storage conditions or must be quickly processed (Abera and Rakshit, 2003; Kolawole and Agbetoye, 2007). So far, there is no economically feasible technique of storing harvested cassava root for long periods on a large scale except in the form of dry chips. Processing into dry cassava chips is an attempt to solve this problem. The surplus roots during peak harvest could be dried and stored. With improved technologies annual production is going to increase and there is a need to generate from this crop multiple economic benefits through improved post harvest handling and processing (Kolawole and Agbetoye, 2007; Tomlins *et al.*, 2007). In addition, the cassava crop is undergoing a transition from a mere subsistent crop to a commercial crop that will be grown in large quantities. Thus, there is a need to expand its utilization base. Chips are used in animal feed production but some studies have investigated its use as human food – *gari and lafun* (Famokunwa, 1994; Oluwole *et al.*, 2004). I have contributed to knowledge in the area of utilizing dried cassava chips in the production of widely consumed products (*fufu* and *gari*) in Nigeria.

Studies on *fufu* production from cassava chips showed that oven dried chips absorbed more water than sun dried chips while soaking at 35°C gave higher starch yield than samples soaked at room temperature. Dried chips did not ferment when soaked in water at any temperature. Oven dried chips gave about 84% yield of *fufu* when soaked at 35°C for 72 h in 4 day old liquor (4DOL). Drying method, sample size, and steeping temperature had varying impacts on the pH and titratable acidity of the roots and soaking medium. *Fufu* from oven dried chips had acceptable sensory attributes similar to those of fresh root. A good yield (78%) of *gari* was obtained from cassava chips but the colour was dark indicating the need for further work to make the product aesthetically acceptable (Taiwo and Okesola, 2009). Studies are ongoing to improve product yield and sensory properties by seeding dried chips with fresh cassava mash in order to facilitate

the fermentation process. This work is funded by the University Research Committee.

Deep fat frying of food - Improved public and media awareness on reducing the proportion of fat in the diet has prompted studies on lowering the oil content of many foods especially fried foods. Taiwo *et al.*, (2004) studied the deep fat frying of yam - a popular Nigerian snack. This work provided much needed engineering data on the kinetics of moisture loss and oil uptake during deep fat frying. Frying at higher temperatures for longer periods decreased yield and moisture content with concomitant increase in the fat content of the chips. Going from 100 to 160°C increased oil content from 85 to 235% depending on the type of pretreatment while increasing frying time from 5 to 20min resulted in 20-57% increase in oil content. Blanching prior to frying did not enhance moisture loss neither did the use of palm oil. The type of oil used significantly influenced the quality attributes of the chips.

With the ACU award of 2005, I visited the Department of Agricultural and Environmental Engineering, University of Saskatchewan, Saskatoon, Canada where I worked with Dr Oon Doo Baik on deep fat frying of sweet potatoes. Taiwo and Baik (2007) reported the effects of pre-treatments on the shrinkage and textural properties of fried sweet potatoes while the physic-chemical properties (kinetics of heat and mass transfer and color development) of the fried sweet potato were reported in Taiwo *et al.*, (2007). I have done some work on fried snacks in particular *puff-puff* and *chinchin* using composite flour. The chemical, nutritional and sensory properties of these products were investigated at different levels of substitution in replacing wheat flour with cassava flour. The aim is to expand cassava utilization while minimizing oil uptake. Results showed an optimal substitution level of 20% cassava and frying at 180°C for 10mins as best for these products.

Tomato and Pepper - Tomato and pepper have a wide range of culinary and medical uses but the cultivars differ greatly in physico-chemical characteristics. The design of appropriate machinery for mechanizing the processing of these fruits requires the knowledge of their physical properties. The physico-chemical characteristics and suitability for processing into puree of wild tomato (L. *pimpinelli folium*) was compared with the already known varieties Roma VF, Ife-1, and Ife Local. The results showed that the Local and wild varieties had higher fruit yield than Ife-1 and Roma-VF cultivars. The wild variety has a high skin and seed content. The shape of the fruit varied from spherical to pear-like. Physico-chemical properties such as specific gravity, pH, titratable acidity, ash, moisture content and refractive index did not vary significantly while total solids, longitudinal and cross-sectional diameters, vitamin C and reducing sugars were significantly different amongst the cultivars investigated (Adedeji *et al.*, 2005). Capsicum peppers are perishable crops with high water loss due to transpiration resulting in shrinkage. Preservation by sun-drying is beset with a myriad of problems and this has led to dehydration by alternative means. Pre-drying treatment and drying conditions however affect mass transfer dynamics as well as nutrient retention. This paper reported the drying and storage characteristics of two varieties of pepper. The oil/water blanched peppers required shorter drying time, had a brighter attractive product colour and higher vitamin C content compared to unblanched or steam blanched samples. Packaging in metal foils and their laminates preserved dry pepper with no significant alteration in colour and flavour. The powders rehydrated well into paste with no visible difference from the freshly ground paste. These results have great potentials for industrial applications of peppers in addition to their other uses (Akanbi *et al.*, 2003).

FOOD MACHINE DESIGNS

Mr. Vice Chancellor Sir, I transferred my service to the Department of Food Science & Technology in Sept 2001 from the then Technology Planning & Development Unit (TPDU) now

known as the African Institute of Science & Innovation Policy (AISIP). As a Food Engineer, I have supervised projects on machine design for various food products in collaboration with some staff in the Departments of Agricultural Engineering (Dr Owolarafe and Engr. Sanni) and Mechanical Engineering (Dr Koya, Dr Oladejo, Engrs Fasogbon, Obayopo and Adio). All the engineering technicalities have been omitted in this presentation but diagrams of the finished products are presented below. Some of these diagrams are the current versions of several editions i.e. modifications over the years. Some of the machines have been presented at National Exhibitions and Fairs.

A Plantain slicer

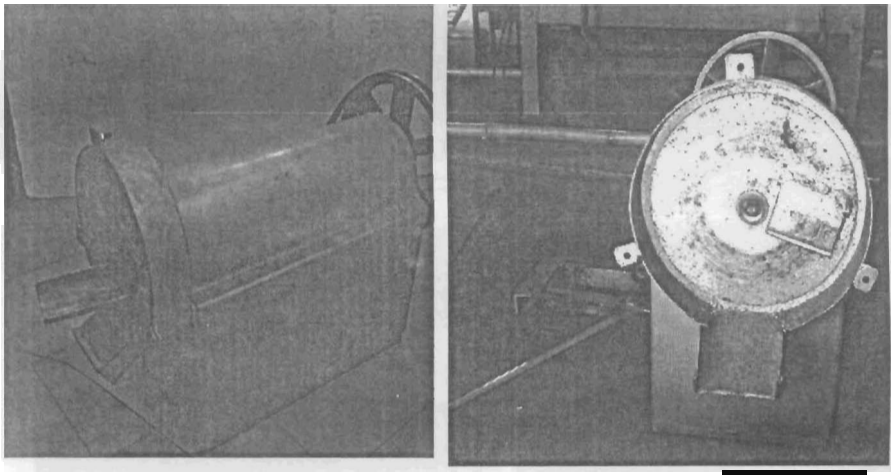


Fig. 1- A motorized plantain slicer for commercial use.

The device (Fig. 1) simulates the traditional method of cutting plantain pulp transversely and showed 90.7% - 92.6% efficiency when tested with moderately ripe and unripe matured plantain pulp to make a 5 mm thick slice. Feed rate. The speed of the cutting disc is 400 rpm = 6.667 rev/s. Matured ripe and unripe plantains were used with moisture content 75% and 64% respectively. Efficiency of the plantain slicer was determined based on the

average number of slices produced i.e. 90% for ripe plantain and 91% for the unripe plantain samples. This is a low-cost, machine fabricated from locally available materials, simple mechanism and simple to operate.

A Bread Slicer

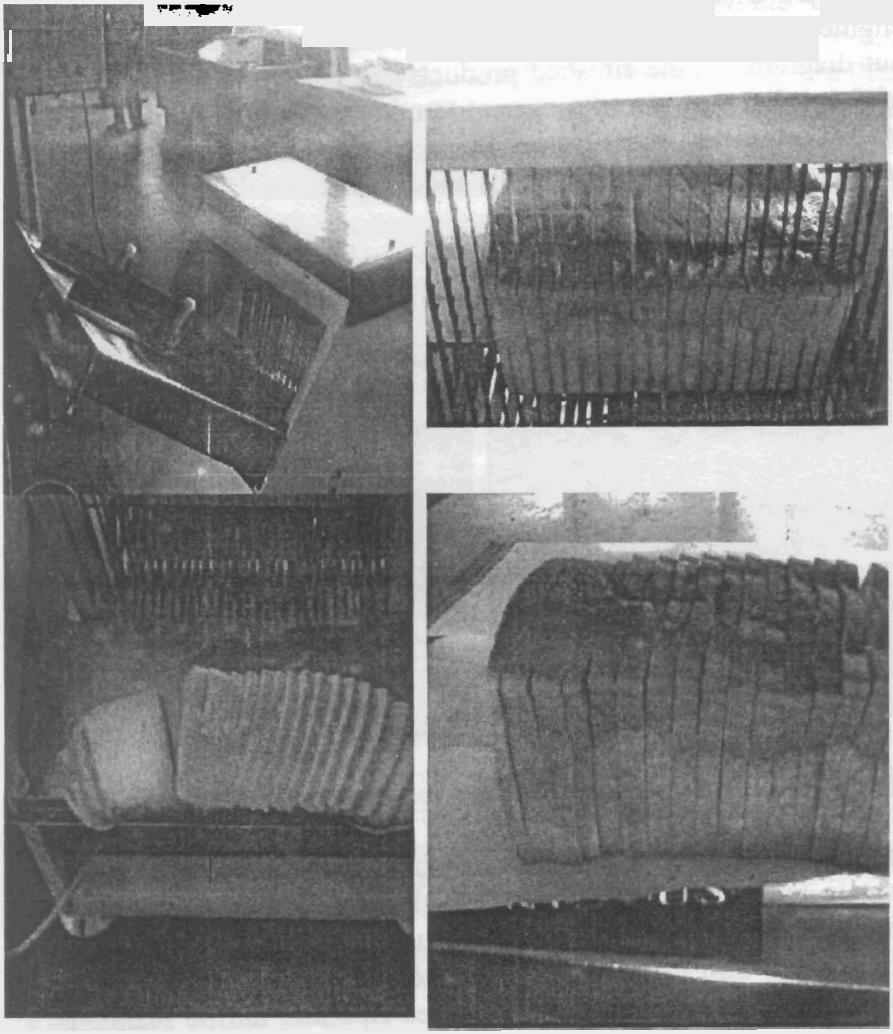


Fig.2 – Different views of the bread slicer with some sliced loaves.

Table 2 - Performance Evaluation of the Bread Slicer

Samples	Height (mm)	Width (mm)	Length (mm)	Weight of loaf (g)	Cutting time (min)	Moisture content (%)
A	85	120	240	570.24	2.2	35.31
B	92	121	243	590.14	2.8	38.00
C	81	124	233	626.15	2.9	40.01
D	85	115	229	584.24	3.1	40.05

Average cutting time = 2.9mins

Table 3 - Percentage weight loss or Percentage Crumbs generated by the slicer

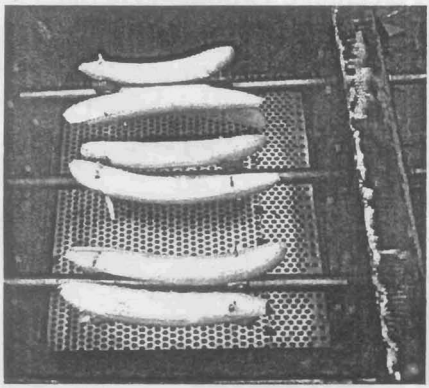
S/No	Sample	Initial Weight (g)	Final Weight (g)	Weight loss (g)	Percentage Weight Loss (%)
1	A	570.24	562.24	8.00	1.40
2	B	590.14	582.28	7.86	1.33
3	C	530.20	522.11	8.09	1.52
4	D	584.24	576.24	8.00	1.37

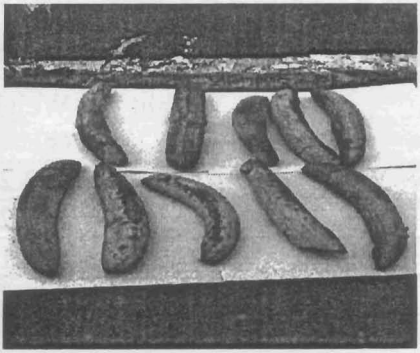
Slicing uniformity – 95%

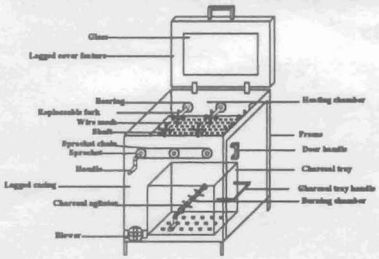
Efficiency of the Bread Slicer - 98.6%

Cutting time is 2.5 ± 0.5mins while that of an imported slicing machine at a commercial bakery = 3mins

Plantain Roasters







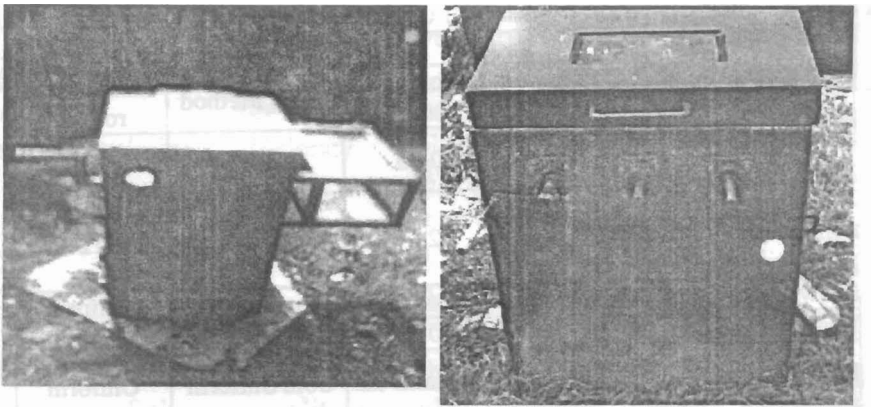


Fig. 3 – Traditional and laboratory plantain roasting devices

The roasting machine has been designed to correct the limitations of local devices:

- Ergonomic stability and low-weight for easy transportation and operation;
- Affordability;
- Adequate lagging to reduce the rate of heat transfer to the operator and the environment;
- Reliability and advanced functionality, as provision is made for adaptability for multiple food items.
- Incorporating a cover to the food item on the roaster to prevent exposure of the food item to dirt.
- Incorporates a chimney – minimal blackening of roaster

Table 4 – Performance evaluation of the roasters

Parameters	Yam		Plantain	
	Local Method	Laboratory roaster	Local Method	Laboratory roaster
Roasting Time (min)	30	20-25	20	12
Maximum number of pieces per batch	12	24	10	12
Browning	Severe	None or Light	Non-uniform	Uniform
Heat loss (kJ/s)	16	0. 0143	16	0. 0143
Product appearance	Burnt skin contaminates taste	Maintains its taste	Soft/Uniform dryness	Uniform dryness
Amount of charcoal used for a batch (kg)	0.908	0.454	0.590	0.318

The Groundnut Peeler

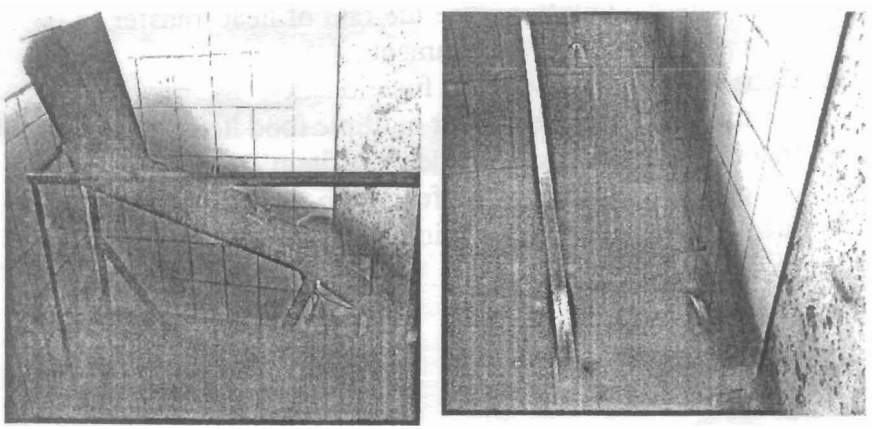


Fig. 4 – Views of the groundnut peeler

Table 5 - Effect of interaction between speeds of rotation on machine performance

Angular speed(rev/min)	Peeling efficiency %	Percentage split %	Partially peeled %	Unpeeled %
18	75	44	5	20
25	77	63	4	19
30	85	82	2	13

The higher the speed the higher the peeling efficiency however the amount of the nuts split open also increased. Percent efficiency increased with increase in the weight of the headstock.

Table 6 - Effect of weight of the headstock on machine performance

Weight of headstock kg	Peeling efficiency %	Percentage split %	Partially peeled %	Unpeeled %
1.5	65	35	5	30
1.8	88	50	2	10
2.0	91	63	1	8

WOMEN AND FOOD PRODUCTION

Women have always been active participants in agriculture in Sub-Saharan Africa. Women play a pivotal role in growing (60-80 percent of all food), processing, and preparing food (Boserup, 1970; and Susskind, 2008). The constraints facing women farmers include women's lack of access to: land (women beg for land rather than own it), capital or credit or cash (women don't usually raise cash crops which are in the male domain), fertilizer or manure, technological training and extension services, the political arena, and the non-farm labor markets (e.g. education) (Gladwin, 1997; Gladwin *et al.*, 2008). Today due to higher volume of labor migration of men and the greater likelihood that men have education and skills required for formal sector employment, the responsibilities, of women in agriculture are increasing.

In the rural areas of Nigeria, women's economic activities are to a large extent centered around the food chain. About 65-70% of rural women are actively engaged in physical cultivation of land, planting, harvesting, etc. while women are exclusively responsible for the later steps in the food chain, particularly food processing, preparation and distribution (UN. 1994; Ali, 1996). Economic development is closely related to the advancement of women. Poverty alleviation strategies must therefore take full account of rural women to ensure that productive resources and social services that flow to rural populations have a positive impact on food production for consumption by rural households and, by extension, surpluses to be consumed by the nation.

Does it really matter whether food is grown by a man or a woman? It does! if we are trying to fashion out new policies to resolve the food crisis. More and more policymakers now understand that boosting the capacity of small scale farmers to produce and sell food locally is a key part of the solution. What they haven't yet grasped is that as women, many small farmers face gender discrimination that undermines their capacity to feed people (Susskind, 2008). Women farmers are the least educated and the least connected to powerful people with non-farm jobs in town. African rural women will therefore have to rely on the more informal income-generating activities - the "small money" and "medium money" activities - to generate their cash income for a significant period of time (Thomson and Metz, 1997; Braun, 2008).

African policy planners need to look at ways of improving returns to women farmers' resources in a broader context than a narrow focus on their food production allows. They should instead look at opportunities to increase their cash cropping, agricultural labor, and off-farm income-earning activities. Africa, Haiti and other impoverished countries needs help to end the cycle of famine and emergency food aid, by helping the poorest farmers get started with fertilizer, improved seeds and small-scale irrigation

equipment where applicable (OECD, 2008). Africa could double its food production within five years. There's already one success story: the southern African country of Malawi, which has roughly doubled its food production since 2005. Doubling grain production in sub-Saharan Africa would mean roughly 100 million tons more of cereal grains, more than enough to replace its current imports of around 35 million tons. The cost to the rich countries would be around $10 per person per year, one of the great bargains on the planet. Food prices would ease worldwide (Sachs, 2008).

Wealth Creation Through Agro-Processing Enterprises.
Processing greatly increases the value of perishable food-stuffs by making them available for longer period of time and over a wider area. Micro enterprises involved in production and processing play a key role in the economies of less developed countries as a basic source of goods and services, income and employment. They are particularly important for poor people, especially women, who in many countries form the majority of micro-entrepreneurs. Sustainable improvements in the productivity and competitiveness of micro-enterprises are essential for their growth and for creation of new wealth and opportunities for the people involved. The search for technological innovation to reduce the burden of women as producers and housewives is therefore a compelling task (Jeans *et al.*, 1991, ODA, 1994).

A lot of problems still beset crop post-harvest handling and processing activities in Nigeria. A substantial proportion of the food harvested is lost through inadequate handling, storage and processing. Traditionally women have been the custodian of most primary on-farm processing operations. Tools used by food processors are characterized by their simple nature (mainly traditional and manual) with little use of mechanical devices. Chinsman and Fiangan (1987) observed that although traditional techniques give products of low yield. Poor quality and packaging often limits the market that micro-entrepreneurs can serve (Taiwo and Faborode, 2003).

Findings have shown that these improved devices are not popular with the women because of their high cost (Atala *et al*, 1991). Affordable mechanization of post harvest processes would increase productivity, save time and minimize losses (Eggleston *et al*, 1992). Thus, there is clearly a need to improve the traditional post-harvest practices to assist farmers, particularly women, in fighting the war against poverty. The introduction and adoption of appropriate technologies in the post harvest processing of agricultural produce in rural areas would achieve some of the following:

- Ensure an adequate and low-cost food supply for an increasing urban population.
- Prevent periodic rural food shortages (famine)
- Meet the rising demand of agro-industries.
- Reduce the workload of women and children and ensure a healthier working environment.
- Ensure a uniform high quality product such as starch cassava chips, pellets, etc.
- Reduce the amount of fuel used for processing
- Promote the establishment of economically visible small or medium-scale agro-based industries and create new opportunities for employment in rural areas.

Export opportunities provided by adding value to farm produce by post harvest processing should be an added economic and strategic incentive to spur the development of agro-based cottage industries. There are ventures today whose continued productivity is anchored on the export market, both in West African sub-region as well as in the wider world. Processed *fufu* amongst other tropical products, is in high demand in the United States and some Asian countries (Faborode, 1997). Upgrading technologies in women's traditional occupations would raise their productivity and reduce the drudgery of their work.

Gender Considerations In Post Harvesting Processing Technologies.

Technologies are the key to increasing the productivity of micro-enterprises while generating broad based sustainable economic growth. Home-based traditional methods of processing technologies impose a heavy burden on the families labor supply, especially the women. The upgrading of technologies can help to establish the growth of new types of manufacturing enterprises that allow more of value added during the processing of raw commodities to be captured in rural areas. Micro-enterprises can be strengthened through technological changes to become more self-reliant and thus less vulnerable in their links with their supplies and markets.

Technological change is recognized as a major factor in women's employment. In the past women workers tended to be displaced when cheap labor was replaced by technology. Agricultural development programs since the 1970s have attempted to respond to the production problems of women by providing appropriate technology. Satisfying the technology needs of women goes beyond merely providing access to technology, they must also be empowered to choose and control what is appropriate. Generally, village women are very enthusiastic about innovations that will lighten their daily workload.

The fact that technology is there to assist women in their work by reducing drudgery has not really enhanced the lot of women. The introduction of processing machines resulted in several adverse effects. Although technology may in theory lighten the women's workload, it may lead to men taking over a task traditionally performed by women, so depriving them of needed income. For example, is with the introduction of mechanical graters and presses (in cassava processing). Works traditionally done by women became work of men. This transfer of control resulted in a transfer of income. Women lost an important income source. The women become customers to local entrepreneurs (men) and they have no say in charges for the use of the machines. In such a case, women processors are only using community services without a real upgrading in their own professional operations.

The Post Harvest Technology Research Group (PHTRG) under the leadership of Prof Ajibola undertook a survey of "Capacity and agro-processing needs of women in Osun and Ondo States" a WID program NIR/A2 UNDP sponsored project in 1995. The survey focused on the agro processing technologies involved in the production of *gari* and palm oil. The various technologies available in the two states for each unit operation for the production of palm oil and *gari* were evaluated from the gender perspective. Although a female dominated enterprise, the study showed over dependence on male operators for the machines. A proportion of the unit operations are yet to be mechanized and the two activities (digestion and extraction of palm fruits) that have been mechanized have been taken over by male operators. Mechanization expected to reduce drudgery resulted in the displacement of labour. Cultural and psychological barriers hindering women from operating the machines were identified. Many operators have no formal training in the operation and maintenance of these machines. A technology profile (including modest and accessible changes) for each unit operation was proposed that is feasible in the existing cultural system and can readily be adopted by female processors. A well designed training

program for local artisans will provide the necessary bedrock of reliability and sustainability of rural agro-enterprises (Taiwo *et al.*, 2000).

Taiwo (1995) identified some factors (gender considerations) in the adoption of technologies by women as: availability of credit facilities, cost benefit of the new technology, possibility of the technology having multi-purpose or multi-crop use, cultural practices, supply of raw materials, source of technology and the capability to maintain it. Farinde and Taiwo (2003) in their work on 'Moving women from subsistence to commercialization: Issues and policy imperatives', discussed issues such as access and control of assets, women's education and agricultural production, technology development and transfer, role of government in agricultural commercialization moving women from subsistence farming to market oriented production. Taiwo and Faborode (2003) advocated the sustainable livelihood approach (SLA) which places people at the center of any intervention programme and aims to help people achieve lasting improvements against the indicators of poverty as defined by them. The SLA focuses on development activities that are people oriented, responsive and participatory, conducted in partnership, sustainable and dynamic. It is anticipated that this refocusing on the poor will make a significant difference to the achievement of poverty elimination goals.

Osunbitan *et al.*, (2000) provided information on micro-enterprises involved in cassava and palm oil processing in Osun and Ondo States of Nigeria. In this paper, we provided some general information on agro-allied micro-enterprises such as funding and managerial structure for the group or processing centers, relationship between processors and community based organizations, available infrastructural facilities (e.g. sources of water, housing structure, prime movers, etc.), inventory and sources of processing machines. The paper highlighted areas in which intervention is needed such as rural road network,

maintenance of equipment, training of women in machine operation. The participatory approach was used to analyze the problems of production from the gender perspective and preferred solutions which are acceptable to women. Information provided in this paper is of great benefit to project planners and donor assisting agencies as it prevents improvement of an aspect not perceived as problematic by the women.

Indigenous food technologies are generally rudimentary, easy to operate and low-cost. They usually give inconsistent product quality. The yield or output per unit weight of raw material is generally low. They are associated with drudgery with other attendant health hazards such as exposure of operators to smoke, heat and toxic gaseous emissions from certain product, e.g. roasting stage of *gari* production. The objective of upgrading an indigenous system should be to achieve a process control system, a sanitary and hygiene system as well as a system for achieving technical efficiency in terms of time, energy, labour and material use while focusing on improved product quality. An improved indigenous technology is the result of the combination of modern technological practices and traditional food processing practices. The traditional character of the final product may be maintained, modified or changed depending on the target market for the final product.

It is important to integrate transfer of technology with enterprise development concerns. Upgrading of the technology used by an enterprise requires investment in the improved technology. Willingness of entrepreneurs to invest in improved technology should be influenced by market expectations and external consumer demands. To improve the performance of rural based micro-scale enterprises engaged in food processing, the use of appropriate technology as an instrument for employment creation and income-generation should have a business approach (Adeyemi *et al.*, 2010).

It is important that participatory approach be used to ensure that vital local knowledge is recognized and tapped in development. Local people should be recognized as managers knowledgeable about local resources, the environment and their operations. There has to be constant forward and backward flow of information between key players in the process of technology development so as to achieve a balance between 'science-push and demand-pull'. There is need for close interaction between all persons concerned with decision making in technology development, extension and diffusion.

Appropriateness of the technology is very crucial for women to be able to adopt these new technologies. Some technological solutions (tools and methods) are indeed available. But they have not been widely applied, especially at the level of the small-scale women processors. Although a technology may be tested technically in a research laboratory and proven to be good, it may end up being inappropriate for its intended social setting. For example, a 1995 survey showed that women did not welcome the introduction of palm kernel cracker not because it is inefficient but because it denies them of something to do in the evening while telling tales (Olushina *et al.*, 1997). A UNIFEM (1989) report revealed that women rejected a bicycle operated rice dehuller because the sitting position exposed their thighs. An extreme case was reported of women who refused to fetch water from a bore hole in the village but preferred to go to a stream two miles away because the women recognized the trek to the stream as their time of socialization and relaxation. Ogwu *et al.*, (2001) reported that the use modern kitchen equipment enhanced the quality of food consumed and the frequency of eating plant protein based foods (in particular *moinmoin*) which are normally tedious to prepare. Thus improving the nutritional status of the household and ensuring the food security of the family.

New technologies focusing on an activity traditionally carried out by women may actually displace them. There is a growing

awareness of the subtle dis-empowerment engendered by this sort of transfer of control of traditional tasks and its negative implications to the overall economic development. Appropriate technologies for rural women should release them from back-breaking labor, be easily mastered and be simple to operate and maintain. Given the extremely limiting constraints under which low-income rural women earn income, it has been suggested that small changes that work within the existing system be proposed. This means modest but accessible changes that could be adopted by large numbers of women, without the requirement that other systems are in place before they can be adopted (Gordon and Swetman, 1994).

Concerted efforts must also be made to raise awareness of the gender implications of the food crisis among policymakers (Wahlberg, 2008). Decision makers should ensure adequate treatment of gender, from conceptualization to implementation. In the short term, gender analysis should be employed to ensure that women benefit from efforts to boost production during the growing season, and it should be used to strengthen information and knowledge to inform longer-term actions. In the medium term, women's access to productive resources should be improved, and resources should be budgeted for gender equality work and women's empowerment. Just as critically, women must participate in making decisions that affect their lives.

Women in Science and Technology Education and Practice in Nigeria

As a Fellow of the Nigerian Society of Engineers and one of the few female Professors of engineering in Nigeria, I am interested in the participation of women in science and engineering education. A diverse workforce is a more creative workforce capable of challenging old attitudes and practices bringing fresh thinking and greater innovation to product development. The talent of every worker is needed in order to compete and prosper. Furthermore, science and technology (S&T) will not be as good

as it could be when 'other' perspectives are missing. When there is a mass exclusion of a group of people whether intentional or coincidental — with a different set of perspectives and worldviews, the profession is the poorer. If women and other groups and cultures are excluded, other viewpoints of the world are being lost. Women need to have more input in how the world around them operates and unless they develop skills in the sciences that command the future, their voices will remain silent. Having only 50% of the nation's potential brainpower engaged in the solution of the problems that beset us all means the nation is limping along, sparking on just two out of four cylinders - half the insight, half the results, half the solutions. Family related reasons such as the demands of a spouse's job or the presence of children have been given for low participation in the S&T workforce, as well as cultural norms, or personal preferences (Colwell, 2001).

Scientific literacy promotes the development of a capable work force, economic and physical well-being, and the exercise of participatory democracy. This kind of literacy is necessary for the workforce required by modern industries, but it is also necessary for informed public involvement in public policies. The demand for scientists and engineers in the technology-driven global economy is ever increasing. S&T is often not considered an appropriate occupation for girls and women, for reasons ranging from lack of intellectual ability to expectations that women's work is inside the home. It has been recognized that women trained in S&T constitute an under recognized but important potential resource (Huyer and Westholm, 2000).

Technology is about the future and if women are not contributing, then half of the society is not represented (Armour, 2003). Women comprise less than a quarter of the total science and engineering labor force in many parts of the world but they have very distinct skills to offer science. They are pragmatic problem solvers - net workers who operate best in teams and are more socially aware

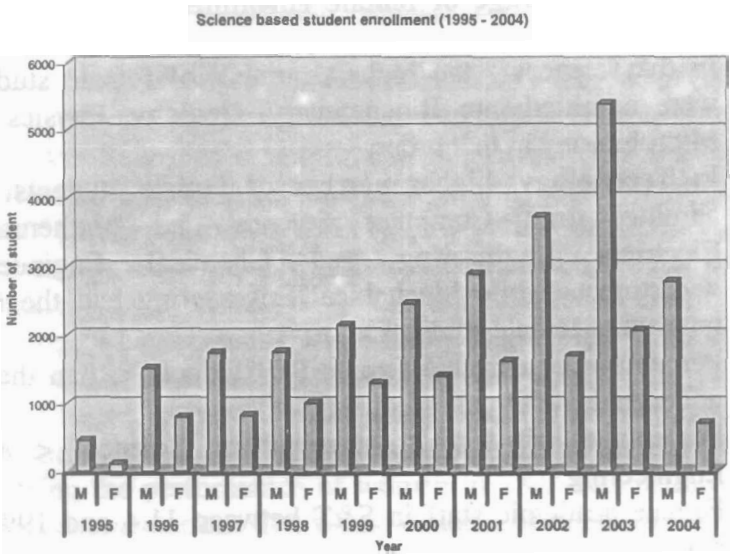
than men (Huyer and Westholm, 2000). In the developed nations, attempts are made to get more women into science and engineering careers for reasons related to economics, equality of access, relative employment stability and utilization of talent, as well as personal satisfaction and intellectual challenge for the women involved. Role models continue to be important especially on the campus. Mentors, benefit as much from mentoring as the mentees. In an effort to assist women undergraduates, several colleges and universities in the US have developed programs to promote research experiences and mentors that foster their consideration of engineering careers (Fox, 1998).

While there are common trends determining women's participation in science and technology, there are important variances from culture to culture and region to region. In Africa, while the overall enrollment of women in higher education is still much lower than men's, enrollment in science courses is lower still. Review of literature showed a dearth of information on women's participation in S&T in Nigeria both at the tertiary level and in the practice of the profession. A national survey was undertaken in collaboration with the National Centre for Technology Management (NACETEM) to study the enrollment, graduation and post graduation occupational activities of female S&T graduates in Nigeria with the aim to identifying types of employment female S&T graduates engage in; assess the factors influencing the performance of women in S&T occupations and make recommendations that would enhance women participation in S&T. The survey was conducted in July 2006 in the six geo-political zones of the country - Abuja (North Central), Bauchi (North East), Kano (North West), Port-Harcourt (South South), Lagos (South West) and Enugu (South East). The study covered universities, polytechnics, colleges of education and research institutes in the fields of engineering and the natural sciences excluding medical and pharmaceutical sciences and the financial institutions.

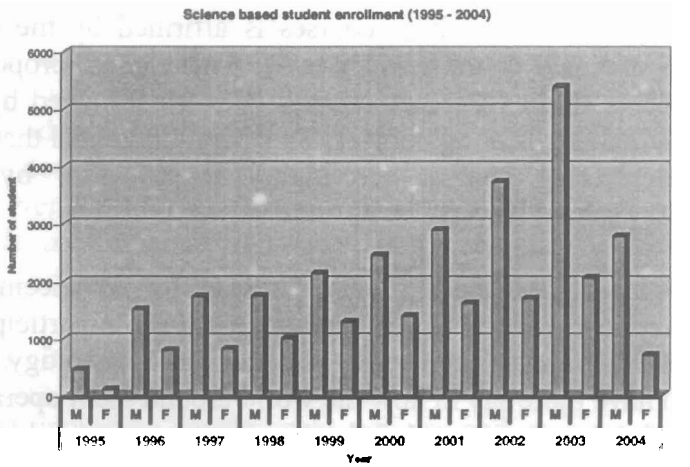
Highlights of the results are given below:

- 68.5% are graduates of universities
- 23.4% are graduates of Polytechnics
- 8% finished from Colleges of Education
- Enrollment increased over the ten-year period in S&T courses by
- 63-81% - male and 77-110% -female
- Enrollment varied across the regions
- Northwest zone had least female participation in S&T
- 15-40% in Sciences and 1-5% in Engineering
- Southwest has highest female enrollment in Science courses with 60-77%
- **National average of female enrollment in S&T is 32-40%**
- In the sciences - the highest number of female students were admitted into Biochemistry, Geology, Physics and Microbiology in that order.
- In Technology, higher number of female students was admitted into Computer Science and Mathematics, Electrical Engineering and Chemical Engineering departments while Mechanical Engineering had the least number of female students.
- Percentage of enrolled female PG students < than that of undergraduate female students
- Percentage of female students in Science < than Engineering
- Female academic staff in S&T between 11.4 and 19% of male
- **Among the University FSTG respondents about**
- 10.4% - First Class Honors degree,
  49% - Second Class Upper Division,
- 35.8% - Second Class Lower Division
- 4.8% - Third Class.
- **Amongst the FSTG of Polytechnics**
- 53.5% graduated with Upper Credit,
- 44.8% had Lower Credit and only

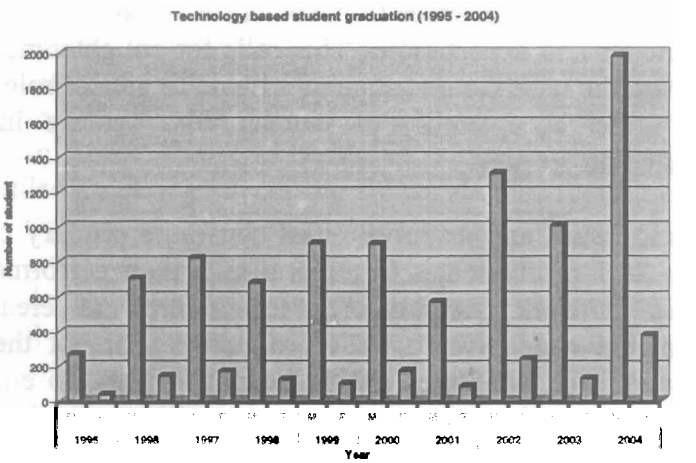
- 1.7% graduated with a Pass certificate.
- 61.4% Science courses
- 23.5% studied engineering courses.
- 6.2% - EDM - Environmental Design & Management
- 7.4% - Agriculture 7.4%
- 1.5% - Education
- **Postgraduation actions**
- 23% went for higher degrees on graduation
- 36.8% indicated there was lack of suitable positions where they lived.
- 15.5% - class of degree was a limiting factor
- 21.8% - got employment



- Fig. 5 Enrollment of female students in science courses



- Fig. 6 – Student enrollment pattern into the Science based courses



- Fig. 7 – Graduation pattern of students from the faculties of Engineering

The number of females studying S&T has increased tremendously over the years amongst the respondents with 70% of the respondents graduating between 1990 and 2000. The interest and

capability to excel in these courses is affirmed by the Class of degrees obtained at the tertiary level. The highest proportion of respondents studied Science courses (61.4%) followed by 23.5% who studied engineering courses. This result indicated that science and engineering courses are highly sought after by female secondary school leavers.

The right of women to equal access to advancement and empowerment is a reason to encourage women's participation in and contributions to engineering, science and technology. Women need to have more say in how the world around them operates. The result of the survey revealed that female secondary school pupils have the interest and capability to excel in S&T courses at the tertiary level. However, in the course of their study, female S&T students face more challenges as a result of gender discrimination from male colleagues than from the academic curriculum. The gender discrimination arises from social stereotyping which affects our attitudes and expectations. This calls for enlightenment of the society on the need for a change of attitude to gender roles, as this would affect acceptability of women who venture into male dominated professions.

Domestic issues and responsibilities constitute primary challenge women S&T professionals face that affects their performance and progress at work. Employers of labor need to create work environment conducive to the reproductive years of the female S&T workforce. Measures should be put in place to ensure that child bearing and rearing are seen as positive contributions the female make towards providing human resources and should therefore not be a limiting factor in the advancement of women. Many developed nations have low birthrates because women do not want their domestic responsibilities to hinder their professional progress and now the governments of some of these nations give monetary reward to the women who choose to give birth as a form of encouragement in order to boost their population growth. Working conditions have been improved to elongate maternity

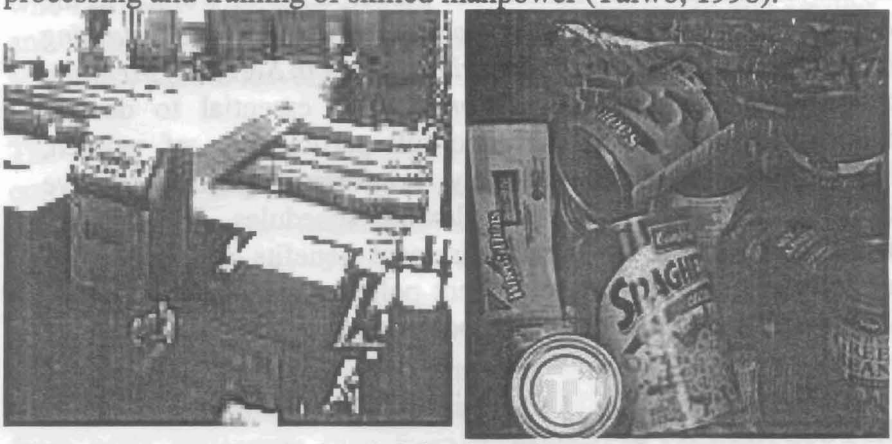
leave and also have flexible working hours to accommodate this period in a woman's life while contributing their potential to economic growth and development of the nation. Other measures that may be adopted to promote the participation of women in the S&T profession include: i) *Purposive recruitment and retaining policies,* ii) *Networks for women with careers in S&T;* iii) *Mentors, role models and internal networks.* It is essential to design, implement and monitor, with the full participation of women, effective, efficient and mutually reinforcing gender-sensitive policies and programmes (e.g. flexible schedules, job sharing, telecommuting, family leave, retirement benefits and help with family care), including development policies and programmes, at all levels that will foster the empowerment and advancement of women.

The Food Industry in Nigeria

Food processing helps to preserve food, reduce post-harvest losses and to extend the availability of food products over a longer period. The food industry creates jobs and income for about 60 percent of the Sub-Saharan African labour force, most of whom are women. In Africa, food processing accounts for 40 percent of the value-added by all manufacturing industries. The food industry in Nigeria consists of the large foreign-backed companies; the government owned or sponsored companies and the medium-scale, the small-scale and the very small scale (as small as one person) - mostly small or informal enterprises owned by indigenous operators (Ladipo *et al.*, 1986).

The large-scale food industries are located predominantly in urban areas where their impact is greatest. They are involved mainly in brewing and beverage production, flour milling, production of complementary foods, sugar refining and production of sugar confectionery, milk and dairy products processing, vegetable oil refining, production of biscuits and other bakery products, condiments and flavorings (Aworh, 1999). The large-scale food industries which are financed through joint ventures with equity

and loans from national and international financial institutions (the multinationals), have a unique role to play in promoting industrial development through employment generation, value-added processing and training of skilled manpower (Taiwo, 1998).



Industrial food products

Large-scale food industries have considerable export potentials through value added processing. Unfortunately, they are yet to realize their full potentials and there is the need to increase their contributions to overall value-added in West Africa. The major problems faced by large-scale food industries in West Africa relate to power supply, low capacity utilization, supply of raw materials, access to foreign exchange, maintenance of machinery and equipment, low local technology input and over-reliance on imported technology, as well as the need to improve the overall efficiency of their operations so as to reduce the unit costs of their products (Taiwo, 1998 and Aworh, 1999).

Small-scale food processing industries are mostly rural-based. They supply local markets with low-cost consumer goods, add value to the produce, contribute to its economic growth through diversification, contribute to import substitution, and to foreign exchange earnings (as non-traditional export products) and increase the technical and management skills of the rural

population. Rural development and agro-industrialisation are closely linked with the promotion of small-scale food industries that involve lower capital investment and that rely on locally produced raw materials and traditional technology (Ngoddy 1988, Igene 1992, Aworh 1994). By generating employment opportunities in the rural areas, small-scale food industries reduce rural-urban migration and the associated social problems. They are vital to solving the problem of imbalance between the rural and urban areas and are crucial to reducing postharvest food losses and increasing food availability.

Unfortunately, rapid growth and development of the small-scale food industries is hampered by the adoption of inefficient or inappropriate technologies, poor management, inadequate working capital, and limited access to banks and other financial institutions, high interest rates and low profit margins (Taiwo, 1998, Aworh 2005). In addition, small-scale food industries rely on locally fabricated equipment and non-standardization of equipment and lack of spare parts for equipment maintenance and repair are major problems constraining their growth (Taiwo *et al.* 2002).

Taiwo (1998) in an assessment of the Nigerian food industry discussed the various inputs such as raw materials supply, supporting infrastructural facilities, and access to capital, processing technologies and government policies necessary for a sustainable and vibrant industry. Although the number of food manufacturing companies (FMC) in Nigeria has increased over the years, the range of products is still small. More than 50% of the FMC's are located in the South West with Lagos as the major host. Information on ownership structure, academic and professional qualification of the managers of the FMC's, sourcing of raw materials, etc. was provided MORE. The study identified some technological changes within the small-scale food enterprises within the last ten years and the impact they have had. There has been improvement in personnel utilization efficiency in the industry with the elimination of repetitive jobs performed by non-

skilled workers while opening up numerous opportunities for specialized employees with greater skills, tasks and responsibilities. In addition, technology change has had impact on consumer preferences, cost reduction, reduction in energy consumption and increase in volume of output/economies of scale (Oladepo *et al.*, 2002). These changes have implications on the growth of the Nigerian food industry.

Adeyemi *et al.*, (2010) provided information on some nutritional indices for Nigeria and examined the contribution of the food industry in Nigeria to national development. The bulk of foods consumed are converted into edible forms using indigenous food technologies (IFTs) which are micro/small/medium-scale in capacity. The need for upgrading indigenous technology was stressed. Technology transfer as a vehicle for developing the post harvest processing sector was discussed.

Post-harvest technologies in critical areas such as food storage, processing, preparation, preservation and packaging play a significant role in the transfer of technology. There is no doubt that selective and intelligent borrowing of modern foreign technologies can help. But a viable and efficient strategy calls for careful consideration of traditional technologies that have been or can be upgraded for wide application and broad-based benefit to the local population. Indeed, many modern technologies are either hard to acquire for economic or financial reasons or unsuitable to the socio-cultural context. Foreign technologies may not exist for either solving some of the specific problems or meeting the whole spectrum of technological needs for producing indigenous foods. These technologies have to be developed locally.

Many locally fabricated food machines litter the laboratories of tertiary institutions awaiting commercial uptake. With the existence of centers such as the National Center For Agricultural Mechanization (NCAM) and Rural Agricultural And Industrial

Development Scheme (RAIDS), adoption of research designs should be an easy process.

Food Nutrition and Security

Food security implies access, at all times, to adequate, safe, nutritious and healthy food that meets dietary needs, including the various micronutrient requirements, and food preferences of every segment of the population. A well-nourished, healthy workforce is a pre-condition for sustainable development. Food technology is therefore, important to maintaining social stability and in ensuring national food security.

Over 70 % of the population in Nigeria derives their livelihood from agriculture. Regrettably, it is estimated that about 50 % of perishable food commodities including fruits, vegetables, roots and tubers and about 30 % of grains are lost after harvest. Inefficient or inappropriate food processing technologies, inefficient post harvest handling practices and inadequate or complete lack of storage facilities, packing houses and market infrastructures are some of the factors responsible for high post harvest food losses.

The management of agricultural post-production systems (marketing, storage, processing, and distribution) which influences agricultural performance and food security can help to solve the problem of food insecurity. Food processing and associated activities, in particular, are important factors in the promotion of food access and the production of safe and nutritious foods. The bulk of foods consumed in many African countries are converted into edible forms using indigenous food technologies (IFTs). Unfortunately, the role of these technologies in the attainment of food security has not been fully addressed by the many paradigms characterizing agricultural development in Africa. As a result, the underlying technologies have not received much attention from the scientific community.

To be food secure, rural women must have multiple livelihood strategies, and they recognize this fact. In Nigeria as in other parts of the world, they are farmers, petty traders, food processors, and engage in informal labor markets. The reason for this is that none of the strategies on their own are capable of sustaining them. Given the complexity of women's multiple livelihood systems, cash and food crop production by women farmers are so interdependent that it is almost impossible to separate them (DFID, 1999). The intensification of food production by women farmers requires them to also grow cash crops which traditionally have been in the male domain; while their ability to switch some land out of food crops into cash crops requires them to intensify their food production. Based on these interdependencies, rather than simply recommend an increased use of chemical fertilizer to expand the aggregate food supply (Larson and Frisvold, 1996), a more complex strategy with interrelated parts are recommended:
(1) Encourage women's income generating activities and multiple livelihood strategies, including cash cropping of very profitable cash crops, non-farm microenterprises, and agricultural labor that will bring in cash to women in the household.

(2) Promote agricultural research programs that aim to design technologies that women farmers can afford to adopt. Unfortunately, due to women's severe cash and credit constraints, they cannot adopt high-cost technologies using high amounts of chemical fertilizer, and are therefore bypassed - and further marginalized.

(3) Realize rural women are not a homogeneous group, and more than one recommendation may be needed to address the various needs of the members. Women in female headed household (FHHs) and male headed household (MHHs) should not be treated as a homogeneous group, especially in societies where cash is considered to be in the male domain. In these societies, women in FHHs might adopt cash crops and new income generating activities more easily than do women in MHHs, even though they

tend to have less land and less adult labor (Peterson, 1999; Sullivan, 2000).

Manpower Development And Commercialization Of Research Outputs

There has been a phenomenal increase in the number of institutions offering training in Food Science and Technology, Agricultural Engineering, Agricultural Extension and other related fields in Nigeria since the 1970s. There are a total of 20 Universities in Nigeria offering B.Sc. degree programs in Food Science and Technology or Engineering. The graduates are trained in the art, science and technology of food preservation to achieve national goals and objectives of industrialization and self reliance, reduce postharvest food losses and promote national food security. Then the questions arise: why are there no new products developed? Are there no research outputs from R&D from these various institutions? The ability of these institutions to impact quality knowledge has over the years been challenged by lack of sufficient funding. Thus, despite the rise in the number of educational institutions at the tertiary level, a commensurate rise in human capacity and products has not been experienced. The Technology Transfer Office (TTO) has a role to play here. This office should be saddled with the task of commercialization of research results and this enables the researcher to focus on other research interests.

The Technology Transfer Office (OTT) should be established to serve as the link between the commercial marketplace and the University faculty. TTO should offer researchers expertise and guidance regarding the protection of intellectual property, including patents and copyrights, and in seeking licensing agreements with commercial entities to take research developments into the marketplace for the public benefit. Research outputs are not readily adopted by local entrepreneurs. The communiqués of several professional conferences over the years have called for fostered/strengthened relationships between

academia and the industry but the governments have paid little or no heed to such calls.

CONCLUSION

My research findings have potential in contributing to reduction in post harvest losses through processing and utilisation of preserved foods such that we may eat and be satisfied. My research endeavours have been to ensure that both the final product characteristics and processing techniques are satisfactory to the end user. I have worked on the utilisation of different food crops and issues relating to food production.

In the area of Food Process Engineering, my results on the mechanical expression of oil identified optimal processing conditions resulting in good oil yield of high quality for the different oilseeds requiring little or no refining. Cost of refining the oil is greatly reduced and the cake is suitable for both human and animal consumption. On the utilization of cowpea my work provided engineering data on the soaking and cooking characteristics of two cowpea varieties and identified the variety best suited for canning as well as established the canning conditions. The results concluded that cowpea may be planted twice a year with the first crop canned at the physiological stage of maturity and the second crop left to dry thus increasing food security. The quality of dried fruits can be enhanced using osmotic dehydration and the potential uses of these dried fruits have been demonstrated in the production of breakfast cereal, jam, etc. Surplus cassava tubers can be dried and utilized as human food during scarcity. The engineering data provided on several food materials in the course of my career provide important information for engineering design and industrial product development.

Technology adoption at the rural level is a matter of concern, as its proper integration into the social system would result in improved product output and better quality of life. Appropriate technologies are particularly needed for processing food in rural areas of

developing countries. Traditional technologies need to be upgraded to enhance the shelf life and consumer acceptance of indigenous foods, as well as developing value added products with export potential. Indigenous technologies should assure the needs of the local people first in terms of acceptability and affordability before addressing the needs of international markets. It is pertinent to satisfy local needs before venturing into international markets.

It is important to integrate transfer of technology with enterprise development concerns. Upgrading of the technology used by an enterprise requires investment in the improved technology. To improve the performance of rural based micro-scale enterprises engaged in food processing, the use of appropriate technology as an instrument for employment creation and income-generation should have a business approach. It is important that the participatory approach be used to ensure that vital local knowledge is recognized and tapped in development. Local people should be recognized as managers knowledgeable about local resources, the environment and their operations. There has to be constant forward and backward flow of information between key players in the process of technology development so as to achieve a balance between 'science-push and demand-pull'. There is need for close interaction between all persons concerned with decision making in technology development, extension and diffusion. A participatory approach that requires the active involvement of all stakeholders, with the target group at the centre, facilitates the selection of appropriate choices and contributes to eventual success of the project.

Information on relevant technology products that are available locally and elsewhere should be accessed and compiled. Such information should include uses of the technology, technical specifications, summaries of cost-benefit analysis, and sources of the technology to guide entrepreneurs to make informed choices. Governments should provide adequate funding for research into indigenous (traditional, rural) food technology so as to provide

information on scientific principles upon which improvements could be made for upgrading of indigenous technologies. An effective mechanism should be established to assist micro and small-scale entrepreneurs to have access to sustainable technologies that would facilitate the upgrading of traditional food processing in Nigeria.

The skills of local equipment manufacturers need to be strengthened. A number of artisans are engaged in the production of tools and machinery. These artisans who are mostly in the informal sector, as well as equipment manufacturers in the formal sector need to be trained to upgrade the quality of their products which are of mostly sub-standard and inconsistent in quality in most cases. Intensive training of operators of indigenous technologies needs to be done as part of efforts to upgrade such technologies. Practitioners are lacking in technology management, entrepreneurial practices and business management. Training programmes which integrate technology acquisition with enterprise development need to be promoted to upgrade indigenous food processing to improve their viability and sustainability.

Hunger is a consequence of failed policies and fortunately, policies can be changed. Agricultural policies should be in line with the interests of small-scale women farmers instead of giant corporations. All government policies should respect human rights, including women's rights. But when it comes to fixing the broken food system, the kind of small-scale, sustainable farming that women traditionally do is exactly the mode of agriculture that should be expanded. There is need for the Nigerian government to formulate development policies and strategies to create enabling environment that focuses on enhancing technology-led, market-oriented enterprise and development of micro and small-scale food processing operations. Such policies should provide incentives which should include exemptions from payment of duty on imported equipment and machinery, tax holidays, low interest rates on loans through special savings and credit schemes and

strengthening of support institutions to provide effective assistance to the sub sector.

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MEMBERSHIP OF PROFESSIONAL BODIES

- Nigerian Society of Engineers (Fellow No. 07157).
  Nigerian Society of Agricultural Engineers (Corporate Member No. M 454)
- COREN Registered (No. R 7535)
- Third World Organisation of Women in Science (TWOWS) member
- Nigerian Institute of Food Scientist and Technologists (member)

Fellowships

- DAAD Fellowship award to attend the 28th International Seminar for Research and Teaching in Chemical Engineering and Physical Chemistry at the Institut fur Lebensmittelverfahrenstechnik, University of Karlsruhe, Germany, May 1992 to July 1993.
- Alexander von Humboldt Fellowship Sept –Dec 1999 German language course at the Goethe Institute, Berlin

and Jan 00 – April 01, Dept. of Food Biotechnology and Process Engineering, Technical University, Berlin.

George Weston Fellowship awarded by the Association of Commonwealth Universities (ACU) for the 2004/2005 Titular Fellowships, Department of Agricultural and Bio-resource Engineering, University of Saskatchewan, Saskatoon, Canada, May –Sept., 2005

Awards

i) Award by International Association for Management in Technology (IAMOT), Washington DC, April 2004

ii) Nigerian Society of Engineers' Award in honour of the meritorious service rendered as Vice Chairman, Nigerian Society of Engineers, Ile-Ife Branch (1997-2003).

iii) Carnegie Corporation of New York to attend HERS-SA ACADEMY 2004, Cape Town South Africa, Sept 26-Oct 2, 2004

iv) Carnegie Corporation of New York to attend Training on Institutional Advancement and Fundraising, held at Inyathelo Training Centre, Cape Town, South Africa, Oct 4-6, 2004

v) Carnegie Corporation of New York to attend Spring Institute in Educational Fundraising, organised by Council for Advancement and Support of Education CASE, March 26 to April 5, 2006

vi) The African Union award to attend - The Congress of African Scientists and Policy Makers, Alexandria, Egypt, 27-29 October 2006

vii) WFEO/FMOI award to attend the International Colloquium on "Empowering Women in Engineering and Technology: Global Efforts for Local Empowerment". Tunis, Tunisia, 6 – 8 June 2007.

viii) Carnegie Corporation of New York to participate in The Leadership Foundation Fellows Program of 2007-2008, organised by the International Women's Forum, Washington, DC

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ii) Formulation of an appropriate policy frame work for South Western Nigeria in selected food industries through studies of growth factors Project Code - 1425 UC
(iii) Studies on tomato processing and packaging, URC funded – not utilized
(iv) Studies on the Production of Dried Cassava Chips. **Code**: 11812AXM

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UN – United Nations (1994) Women in a Changing Global Economy – World survey on the role of women in development, New York, United Nations Department for Policy Cooperation and Sustainable Development.

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Wahlberg, K. (2008) Are We Approaching a Global Food Crisis? Between Soaring Food Prices and Food Aid Shortage. Global Policy Forum: World Economy & Development in Brief, March 3, 2008.

Wolf, M. (2004) "Food crisis is a chance to reform global agriculture" The Economists' Forum blog post, April 30, 2008.

Service within & outside OAU

Service within the Department

i) Coordinator of the TPDU Library and documentation services (1991-1999)
ii) Postgraduate Seminar Coordinator – TPDU (1991 – 1999)
iii) Chairperson, Departmental Consultancy Committee – FST 2002- to date
iv) Member, Examination Co-ordination Committee - FST 2001- to date
v) Departmental representative on the Industrial Training Committee - FST 2001- to date
vi) Departmental representative on Faculty Research Committee - FST 2006- to date
vii) Postgraduate Coordinator, FST - Jan 2009 to 2010
viii) Chairperson, Departmental Alumni Relations Committee
ix) Head, Department of Food Science & Technology (2012)

Service within the Faculty

i) Editorial Assistant to the Editorial Board of Ife Journal of Technology, 1987-1999
ii) Member, Faculty of Technology Public Relations Committee 1996-1999
iii) Dean's representative on the Board of Centre for Industrial Research and Development management Committee, 1996-1998
iv) Member, Faculty Board of Studies – (TPDU), 1997-1999
v) Member, Faculty Review Panel - 2001/2002, 2002/2003 sessions, 2010 todate
vi) Member, Faculty Consultancy Committee
vii) Dean's representative Faculty Board of Agriculture 2003/2004, 2007-to date
viii) Coordinator, Faculty Gender Focal Point Committee 2006 to 2010
ix) Member, Planning Committee for the Hall of Fame Award ceremony, Nov 2007

x) Member, Planning Committee for the Valedictory Lecture by Engr Olu Awoyinfa, May 2008
xi) Resource Person at Faculty Colloquium, 2008, to date
xii) Member, Faculty Research Committee, 2006 to date
xiii) Vice Dean, March 2011 to date
xiv) Chairperson, Faculty Post Graduate Committee, 2011

Service within the University

- Member, Disciplinary committee on examination malpractice, Apr 1998 – to date
- Hall Fellow, Akintola Hall of residence, 1998-1999, 2003 to 2008.
- Member, Sub – Technical Committee on University Strategic Planning committee for the next 5 years, 2002 – 2007
- Member, University Committee on Science Park
- Member, Directorate of Linkages Office
- Editor, Linkages News – a newsletter from the Linkages Office
- Research Associate, Centre for Gender and Social Studies, Obafemi Awolowo University, Ile-Ife, 1998 – to date
- Resource personnel and Associate of National Centre for Technology Management, Ile-Ife, 1997 – to date
- Member, Implementation Committee on African University Day for Center for Distance Learning, Sept – Nov, 2003-10-22
- Treasurer and member of Working Committee of Awovarsity Cooperative Investment and Credit Society, OAU, Ile-Ife, July 2002 – 2007.
- Coordinator and facilitator of course on fund raising and proposal writing, Linkages Office
- Coordinator of partnership between Obafemi Awolowo University and BAOBAB an NGO for women's human rights

- Facilitator of leadership training workshops for women, Linkages Office
- Facilitator of Proposal Writing Workshop, Linkages Office
- Member Editorial Board of Gender Equity Bulletin
- Chairperson, Gender Web Forum 2005-2010
- Member of gender policy formulating adhoc committee
- Member of the committee for the establishment of OAU Business School
- Chairman, Alumni Dinner Planning Committee, OAU Alumni Association, Home Branch, Dec 2006 and Dec 2007
- Chairperson, Electoral Committee for OAU Alumni Association, Home Branch, for election of National Secretary, Apr 2008
- Reviewer for International Foundation of Science Proposals for scientific equipment, May 2008
- Member, Board of Post Graduate College 2011 - todate
- Member, LOC for WARIMA Workshop In Honour Of Prof. Mike Faborode, (Vice-Chancellor, Obafemi Awolowo University, Ile – Ife), 25th – 27th May, 2011
- Member, Review team of OAU Research Policy Document, July 2011 and Marc 2012, Royal Palace Hotel, Iloko
- Member, OAU Institutional Accreditation Committee, Nov 2011
- Co-Editor in Chief Ife Journal of Science and Technology, 2011 to-date
- Chairman, Protocol Subcommittee for NUGA 2012
- Vice Chairman, 50th Anniversary Local Organising Committee for OAU
- Chairperson, Program & Registration Sub Committee for the 50th Anniversary Celebrations
- Member, LOC for 24th NUGA Games
- Chairperson, Logistics Committee for the 6th WARIMA Conference, 21-26th Oct 2012

- Member, Research & Innovation Task Committee (Aug 2012)
- Member, Committee for Institutionalizing Mentoring in OAU (Aug 2012)

Co-curricular Activities

- Vice - Chairman of the Nigerian Society of Engineers, Ile-Ife Branch, Nov. 1997 to Jan, 2004
- Assistant Secretary, Nigerian Institution of Agricultural Engineers, South West Regional Chapter, 2001 – 2005.
- Financial secretary and member of Council, All Souls Chapel, OAU, Ile-Ife, Jan
  2002-to-2006
- Vice Chair- Person PTA OAU International School July 2006 to 2012

  Vice Chairperson, Great Ife Alumni Association, Home Branch, Sept 2006 to 2008
- Sunday School Teacher, All Souls Chapel, OAU, 1981 to date
- Sunday School Superintendent and member of Council, All Souls Chapel, OAU, 2008 to date
- Chairperson, the Nigerian Society of Engineers, Ile- Ife Branch, March 2007 to May 2009
- Volunteer Member of the NGO Women Against Rape, Sexual Harassment and Sexual Exploitation (WARSHE), Nigeria, 2002 to date.
- Member, Women for Women's' Development (WOFWOD) a community based organization, OAU, Ile-Ife 2008 –
- President, Nigerian Christian Graduate Fellowship, Ile-Ife, June 2008 to June 2012
- Senate representative on the Interview panel for appointing the University Librarian, Jan 2011
- Financial Secretary, West African Research Institutions and management Association (WARIMA), Dec 2010 to 2012

- Chairperson, Consultancy Committee, NSE, Ile-Ife Branch, 2012
- Member, Prevention, Investigation & Fault Accccccccc Committee (PIFAC) of NSE Ile-Ife Branch, 2012

Staff Adviser/ Patron of

- Ijebu Students Association, OAU Chapter, Ile-Ife
- Life Channel Incorporated, OAU, Ile-Ife.
- National Association of Food Science and Technology Students, OAU Chapter, Ile-Ife
- Nigerian Society of Engineers, OAU Students' Chapter, Ile-Ife
- APWEN, OAU Students' Chapter, Ile-Ife
- Peace and You Movement, OAU, Ile-Ife, 2008 to date
- D Word, 2012