UNIVERSITY OF PORT HARCOURT

FOOD, NUTRITION AND TOXICOLOGY: IS YOUR LIFE IN YOUR HANDS?

An Inaugural Lecture

By

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DEDICATION

For their foresight in sending my wife and I to school, and commitment to seeing us through, this Inaugural Lecture is dedicated to the blessed and evergreen memory of my late parents

Ezinna Paul Nwaogwugwu Onyeike-Nwokolekwu
Ezinne (Mrs) Sussana Onuawuchi Onyeike

and late parent in-laws

Chief Louis Ejekwurumadu Nwosu
Chief (Mrs) Annasthesia Anuchuka Nwosu.

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Professor E.N. Onyeike.

TABLE OF CONTENT

Introduction

In one of the seven second-generation Universities in Nigeria in which 98 Professors had delivered their Inaugural Lectures and more than 150 others are awaiting for the opportunity to perform this academic and intellectual ritual, I consider myself privileged to have been granted the request to deliver the 99th Inaugural Lecture of this Unique and Entrepreneurial University.

An Inaugural Lecture is one delivered by a University Professor in which the Professor is expected to make public pronouncements on his/her contributions to knowledge through research findings and new ideas in the area of specialization before a multi-disciplinary audience. It affords the Lecturer the opportunity to share with the public his academic achievements, and the area he wishes to make impact in the future. Realizing that an Inaugural Lecture may not be delivered more than once in a period of academic career, the Inaugural Lecturer tries to show what he professes, and the extent to which his work over many years have imparted positively on the lives of people in the society.

Vice-Chancellor Sir, in preparing and delivering this lecture, the greatest challenge which I have faced, is how to simplify the language and depth of instruction to the level that may make sense to, and facilitate comprehension by non-experts without compromising quality and standard. For instance, how do I, as a Nutritional Biochemist and Toxicologist explain to non-experts in Biochemistry that the reaction of an enzyme trypsin (a biological catalyst) with a synthetic substrate α-N-benzoyl-DL-arginine-paranitroanilide hydrochloride (BAPNA) would produce para nitroaniline, which absorbance is measured spectrophotometrically at 410nm as a function of trypsin inhibitor activity in the widely consumed African yam bean seeds (Sphenostylis stenocarpa)? It is also a challenge to reduce the volume of information emanating from my many years of teaching, research, publications and community service which form the basis for my new ideas for the sole aim of not making this scientific discourse boring to the distinguished audience here present. I will try the best I can to explain in simple and

understandable terms, the concepts associated with the lecture topic, and I invite you to please relax and listen to the lecture.

When Should a Professor Deliver an Inaugural Lecture?

There appears to be divergent views on when a Professor should deliver an Inaugural Lecture. According to Akinpelu (1987) as reported by Eheazu (1998), Inaugural Lectures should be made to assume their true essence of introducing new Professors to mark a fresh beginning of a deeply and mature scholarship and productivity rather than a termination of same. Four months after he was appointed to the Chair of Regius Professor of Modern History in February 1895 by the University of Cambridge, the new Professor Lord Acton delivered his Inaugural Lecture (Figgis and Laurence, 1960). In Nigeria, it may take some Professors between two and ten years before they can deliver their Inaugural Lectures.

Vice-Chancellors Sir, it may be that

(i) Some Professors do not show interest because of absence of cash price award for preparing and delivering such a lecture.

(ii) A number of Professors may feel that they do not need to deliver an Inaugural Lecture for promotion having attained the status of "Academic Generals".

(iii) There is the uncertainty of a candidate being promoted to the rank of Professor by the University especially when a particular Vice-Chancellor is on seat. It is today common knowledge that the Vice-Chancellor sends out a candidate's publications for external assessment for Professorship after the candidate has scaled through the internal assessments at the Department, Faculty and Central University Appointments and Promotions Committee (Academic). The Vice-Chancellor alone also knows when the external assessment reports have been received and whether they are positive or negative. If there is the unfortunate problem of abuse of position, it may affect a candidate for promotion who is listed either for reasons known or unknown to him in the Vice-Chancellor's black book, as it did happen in 2008 and 2009 in one of the Universities in the South-South geopolitical zone of Nigeria (not Uniport). This uncertainty

affects one's desire to start early enough to prepare a lecture he/she is not sure to deliver.

(iv) Some Professors may be too busy with research activities, academic and administrative work, politics as well as other engagements within and outside the University that they do not find time to prepare and deliver an Inaugural Lecture.

In the analysis of Uniport Professors and Inaugural Lectures, and defining the time interval between becoming a Professor and delivering Inaugural Lecture as the waiting time, Nduka (2007) reported an average waiting time before Inaugural Lectures of 8, 4, 3, 5, 6 and 6 years for Professors in the Faculties of Education, Engineering, Health Sciences, Humanities, Science and Social Sciences respectively. My five years and nine months (approximately 6 years) waiting time as Professor before this Inaugural Lecture is consistent with the report of Nduka (2007) for the average waiting time of 6years before Inaugural Lectures for Professors in the Faculty of Science.

Rationale for the Choice of the Lecture Topic

Hardly would you find a Professor of Computer Science delivering an Inaugural Lecture in Religious and Cultural Studies which is not his area of specialization. The topic of this lecture is indeed a logical outcome of my teaching, research and publications from 1991 to date, for which I was elevated to the rank of Professor of Biochemistry with effect from 19th March, 2007.

Vice-Chancellor Sir, I have for many years of my research in Biochemistry been associated with foods, their nutrient composition and the toxicants that occur in natural and synthetic association with such food materials. Due to the current global food crisis, part of our challenge today in Nutritional Biochemistry and Toxicology is how to ensure adequate food production and supply, food processing, food security/safety, consumption and utilization for appropriate nutrients needed for healthy living. As the food we eat contain nutrients and toxicants, there is therefore food in health and in disease. In a hunger-prone Nigerian society where many households are managing but pretend that all is well, people tend to eat anything they see as food.

The dilemma faced by Nigerian food consumers and the need for information-knowledge-awareness on foods informed my choice of the topic for this lecture thus "Food, Nutrition and Toxicology: Is Your Life in Your Hands?"

The Subject Matter of Biochemistry

Biochemistry is a discipline that deals with the application of Chemistry to the study of biological processes at the cellular and molecular level. It is derived from the Greek word Bioxnueia biochemeia, which means "the chemistry of life". It studies the structures and functions of cellular components (carbohydrates, lipids, proteins and nucleic acids). Biochemistry explores the chemistry of living systems, and the molecular basis for the changes that take place in living cells, and it is hence both a life science and a chemical science. Biochemistry is not a combination of Biology and Chemistry, but a discipline that applies the methods of Chemistry, Biology, Mathematics, Physics, Microbiology, Immunology, Thermodynamics and Genetics to study the structure and behaviour of the complex molecules found in biological systems and the manner in which these molecules interact to form biological cells, tissues and whole organisms. This subject has become the foundation for understanding all biological reactions, and has provided explanations for the aetiology of many diseases in animals, plants and microbes. It also frequently suggests the ways by which such diseases may be treated or cured, and can therefore be regarded as an "essential science".

Biochemistry is also considered as a practical science since it unravels the complex chemical reactions in many living systems and provides the basis for practical advances in Agriculture, Biotechnology, Molecular Genetics, Genetic Engineering and Medicine.

Brief History of Biochemistry

Compared to other sciences, Biochemistry is a relatively young discipline which emerged about the 19^{th} Century when scientists used Chemistry, Physiology and Biology to study the Chemistry of living organisms. Lomonosov (1748) was the Russian who discovered the Law of Conservation of Matter and its applicability to both living and non-living things. Hitherto, it was believed that only living things could produce the molecules of life from already existing biological molecules. The

discovery of oxygen needed for respiration in plants and animals by Scheel and Priestly, led to the discovery of the process by which plants manufacture food (photosynthesis) from water and carbon(IV)oxide

$$6CO_2 + 6H_2O \xrightarrow{\text{chlorophyll, light}} C_6H_{12}O_6 + 6O_2.$$

Between 1748 and 1828, many organic molecules such as urea, acids, alcohols, fatty acids and amino acids were isolated from living things. To establish for instance that organic compounds can be made artificially, the German Chemist Friedrich Wohler published a paper on the laboratory synthesis of urea (Wohler, 1828), a major product of nitrogen metabolism in many living systems including man. The synthesis of urea was an accomplishment of great importance, and the year 1828 was regarded as a turning point in the establishment of Biochemistry as a science (Ekeke, 2000). The dawn of Biochemistry may have been

(i) the discovery of the first enzyme amylase or diastase by Anselme Paven in 1833
(ii) the discovery of DNA (the genetic material of most plants and animals) by the Swiss Biochemist, Miescher in 1869)
(iii) the first demonstration of a complex biochemical process outside the cell (alcoholic fermentation in cell extracts of yeast) by Eduard Buchner in 1896.

Although the history of Biochemistry spans nearly 405 years, the term "biochemistry" which was formerly referred to as or called Physiological Chemistry was first used in 1882 while the formal coinage was by a German Chemist Carl Neuberg in 1903.

Among the major landmarks in Biochemistry since 1903 were
(i) The establishment of the secondary structure of deoxyribonucleic acid or DNA (the molecule that carries heredity) by the British Biochemists, Watson and Crick in 1953.
(ii) The ability of yeast extracts to ferment sucrose in the absence of living yeast cells was studied by Eduard Buchner as from 1897 at

the University of Berlin. He found that sucrose was fermented even without living yeast cells in the extract mixture and named the enzyme that caused the fermentation zymase, for which he was awarded a Nobel Prize in Chemistry in 1907 for his biochemical research and discovery of cell-free fermentation.

(iii) In 1926, James B. Summer crystallized urease as a pure protein and also catalase in 1937. The conclusion that pure proteins can be enzymes was demonstrated by Northrop and Stanley (1930) who worked on the digestive enzymes pepsin, trypsin and chymotrypsin. The three scientists (Summer, Northrop and Stanley) were awarded the 1946 Nobel Prize in Chemistry. One can at this point see the basis for the strong relationship that exists between Chemistry and Biochemistry, and why the founding fathers of this University established the former School of Chemical Sciences that comprised the disciplines – Pure Chemistry, Biochemistry and Applied Chemistry, and which lasted from 1977 to the end of 1982.

(iv) The first controlled experiments in human metabolism was published by Santorio Sanctorius in 1614 in his book Ars de Statica Medecina in which he described how he weighed himself before and after eating, sleeping, working, sex, fasting, drinking and excreting and found that most of the food he took in was lost through what he referred to as "insensible perspiration".

Since 1903, Biochemistry has till date, advanced with the development of new techniques which have facilitated the discovery and analysis of biomolecules and metabolic pathways of the cellular systems. It is therefore evident that like other sciences, Biochemistry is rapidly evolving, and the future of this discipline will continue to be assured so long as life on earth persists.

Vice-Chancellor Sir, the findings in Biochemistry are today applied in many disciplines from Genetics to Molecular Biology and from Agriculture to Medicine and Industry.

Branches of Biochemistry

Among the basic sciences, Biochemistry is one of the broadest disciplines and is therefore a varied science. The sub-specialities of Biochemistry include Enzymology, Nutritional Biochemistry and Toxicology, Medical and Clinical Biochemistry, Environmental Biochemistry, Pharmacological Biochemistry, Industrial Biochemistry, Food Science and Technology, Neurochemistry, Physical Biochemistry, Immunochemistry, Molecular Genetics, Genetic Engineering, and Bioinformatics.

Vice-Chancellor Sir, having studied the various areas of Biochemistry, I decided to narrow down to Nutritional Biochemistry and Toxicology where most of my contributions in teaching, research and publications are domiciled.

Food

In the olden days, food was simply considered as anything people ate or took in, in response to hunger or illness. When one got up from sleep, he ate, and when he travelled from one place to another, he simply ate. No one really understood what was good or bad to eat. The Physicians then attempted to prescribe diets as remedies for illness, but the process was more of astrology than medicine (Mckenny, 2009).

The tenet "let food be thy medicine and medicine be thy food" was exposed by Hippocrates about 2500 years ago, to predict the relationship between foods for health and their therapeutic uses (Hasler, 1998 a,b; Bagchi, 2006; Ikewuchi, 2012)

Today, food can be defined as any edible substance that is of plant, animal or microbial origin, which is a source of nutrients and which when consumed, absorbed and oxidized (broken down) provides energy which the body uses to do all forms of biological work, maintain and repair damaged tissues, enhance growth and development, aid mental development and proper functioning of the brain as well as giving well being or nourishment to the food consumer.

When we say that an animal food such as meat contains protein, it simply means that it contains the nutrient protein in the highest amount relative to other nutrients (carbohydrate, fats, ash, vitamins, minerals and water). Hence, a plant food such as yam contains other nutrients but with the highest carbohydrate content.

Classification of Foods According to Nutrient Levels

i. **Proteinous Foods:** These contain mainly protein in relation to other nutrients. Examples are meat from poultry (chicken), pig (pork), cow (beef), sheep (mutton). There are snake, rabbit, weevil, grasshopper, dog and goat meat. Other proteinous foods are egg, milk, microbes (processed yeast powder and edible cultured microbes such as single cell protein), fishes, legume seeds (soy bean, cow pea, lima bean etc).

ii. **Energy-giving Foods:** They contain more of proteins, carbohydrates and fats/oils. Carbohydrate foods include yams, cassava, sweet potato, cereals (maize, rice, and millet) while fat-containing foods include oil seeds (coconut, groundnut, melon, dikanut), red palm oil etc. Proteinous foods are also energy-giving foods.

iii. **Vitamin and mineral foods:** They are required in minute amounts for the proper functioning of the body. They include fruits (oranges, pineapples, bananas etc), edible leafy vegetables (pumpkin leaf, bitter leaf, hard leaf, water leaf etc). Apart from providing vitamins A, D, E, K, B and C and the minerals Mg, Na, Fe, Zn, Cu, etc, they are good sources of fibre (roughages) which aid digestion of food and the removal of bulk stool from the alimentary canal, thereby preventing cancer of the colon.

Classification of Foods According to Sources

i. Plant Sources: they include
   (a) Cereal grains (rye, oat, maize, rice, sorghum) which can be processed into flours, biscuits, beer, bread, beverages etc.
   (b) Roots and stem tubers such as yams, carrots, cassava, potatoes
   (c) Fruits (apples, oranges, bananas, paw-paw, mangoes, pear etc)
   (d) Vegetables of all kinds (water leaf, spinach, tomatoes, hard leaf, green, okra, fluted pumpkin etc)
   (e) Legumes (Cowpea, African yam bean, Bambara groundnut and Soyabean.

(f) Nuts (Coconut, Pea, Palm, Walnut etc).

ii. Animal Sources – meat, egg, fish, milk etc.

iii. Microbial Sources: Example is single cell protein (SCP) obtained from edible cultured micro organisms (bacteria, mould, yeast). It is used mainly as animal feed to improve carcass quality, animal growth and for better meat.

Single cell protein is not directly consumed by most humans despite its high protein due to the problem of production and acceptability. By enhancing animal production, SCP is indirectly beneficial to human nutrition. There are also mushrooms which are cultivated, harvested and processed into foods or used in preparing soup and stew.

Food Science

Food science deals with the scientific and technological aspects of foods and related products beginning with harvesting (slaughtering) and ending with cooking and consumption. It is concerned with the study of the composition and properties of food. In the October 2006 issue of Food Technology, the 2006/2007 President of the Institute of Food Technology (IFT) Dennis R. Heldman noted that the IFT Committee on Higher Education currently defined food science as a discipline in which the engineering, biological and physical sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods for the consuming public (Heldman, 2006; Wanucha, 2009). Food science is a highly interdisciplinary applied science that embodies concepts from fields of chemistry, biochemistry, nutrition, microbiology and chemical engineering which are studied to provide nutritious, safe and wholesome food supply to food consumers. Two major options in food science are

(i) Food Science and Technology

(ii) Food Health and the Environment.

Food scientists are involved in the development of new food products, design of processes to produce these foods, choice of packaging materials, shelf-life studies, sensory evaluation of the products with trained expert panels or potential consumers as well as microbiological and chemical testing (Food Science-Wikipedia)

The food scientist is concerned with the determination of the biological, chemical and physical nature of food in terms of composition, quality, safety and consumption with the application of science and engineering to the processing, preservation, storage and use of food and its related products.

Subdisciplines of Food Science

Some of the subdisciplines of food science (Wikipedia, 2009) include

(i) **Food Safety:** This is concerned with the causes, prevention and communication dealing with food-borne illness. It also tells us about methods of ensuring that foods may not lead to harmful effects when consumed.

(ii) **Food Microbiology:** It is concerned with the positive and negative interactions between microorganisms and foods

(iii) **Food Preservation**: This deals with the causes and prevention of quality degradation in food samples.

(iv) **Food Engineering**: It is concerned with the industrial processes used to manufacture food.

(v) **Product Development**: Here, we learn about the invention of new food products from existing food materials.

(vi) **Sensory analysis/evaluation**: This is the study of how food is perceived by the consumers' senses in terms of the organoleptic properties such as colour, texture, taste, aroma, consistency and overall acceptability.

(vii) **Food Chemistry**: This deals with the molecular composition of food and the involvement of these molecules in chemical reactions. It also gives information about the quality, concentration and value of nutrients in foods.

(viii) **Food packaging**: This is the study of how packaging is used to preserve food after it has been processed.

(ix) **Molecular gastronomy**: This is the scientific investigation of processes in cooking, social and artistic gastronomical phenomena

(x) **Food Technology**: This deals with the technological aspects of food

(xi) **Food Physics**: This deals with the physical aspects of foods such as viscosity, creaminess and texture.

Among the subdisciplines of food science, food technology assumes prominence that we now talk more of the Department of Food Science and Technology. Food technology is the application of food science to the selection, preservation, processing, packaging, distribution and use of safe, nutritious and wholesome food. Food Scientists and Technologists study biological, chemical and physical composition of foods and develop ways to process, preserve, package or store foods to meet government and industry specifications and regulations.

Early history of food technology dates back to 1810 when Nicholas Appert developed the canning process which has had a major impact on food preservation techniques, without knowing the principle on which the process worked. Louis Pasteur's (1864) researches on the spoilage of wine, production of alcohol, vinegar, beer and the souring of milk were early attempts to put food technology on a scientific basis. Pasteur developed the process of heating milk and milk products to destroy food-spoilage and disease-producing micorganisms (pasteurization), and in his research into food technology, he became the pioneer in bacteriology and of modern preventive medicine. Among the landmarks in food technology are

- The development of instant milk powder (instantized milk powder) which has become the basis of a variety of new products for which D.D Peebles received a Patent (U.S Patent 2,835,586). These new products are rehydratable in cold water or milk- a process that increases the surface area of the powdered product by partial rehydration of spray-dried milk powder.
- The development of continuous freeze-drying of coffee.
- Decaffeination of coffee and tea which was first developed on a commercial basis in Europe around 1900 and described in U.S. Patent 897, 763. Green coffee beans are treated with steam or water around 20% moisture. The added water and heat separate caffeine (an alkaloid) from the bean to its surface. Solvents are then used to remove the caffeine from the beans.
- Food technology now allows production of foods to be more efficient i.e. there is process optimization. Methods of food production are now more sophisticated.

Presently, food technology is considered under

(i) Commercial Products- These include vegetable oil, margarine, beer, baked products, marshed yams and alcoholic beverages. These are produced in the industries for commercial purposes.

(ii) Removal of harmful ingredients and toxicants to make the food fit for consumption.

(iii) Food stability in which meals are made more palatable and presentable by the addition of emulsifiers and food stabilizers during food processing. When food containers (cans, bottles, polyethylene bags) are opened for a long time, there is microbial deterioration and spoilage. For example, oil becomes rancid, beer develops haze (polyphenolic compounds) and milk becomes sour.

(iv) Supplementation with ingredients such as vitamins and protein which are added to enrich the food. Spices are added to enhance flavour

(v) Production of new foods such as semovita, cocoa butter, semolina and soy-ogi which in Nigeria are products of the Federal Institute of Industrial Research at Oshodi, Lagos.

Through food technology, food is produced faster and in a commercial quantity at low cost. It saves labour but results in unemployment.

Food Processing

Food processing covers a field of study from simple cooking, drying and heating to the use of irradiation. It is the set of methods and techniques employed in the transformation of raw food materials into commercially sterile food products of highly extended shelf-life and stability. Food processing is also the act of converting foods into forms that can enhance their utilization or consumption by humans or animals either in the home or by the food processing industry. In food processing, harvested crop plant and animal food products are used to produce attractive, taste-appealing, marketable, long shelf-life food products.

The food processing methods often used in the homes include

(i) cooking, boiling, steaming, autoclaving, frying, roasting and baking. These are all forms of heat treatment/processing

(ii) Grinding into flour as in the case of legume seeds, cereal grains and crayfish etc.

(iii) Mashing as in barley used in the brewing industry during the manufacture of beer.

(iv) pounding as in the production of fufu from cooked yam/cocoyam/cassava.

(v) Sun-drying and oven-drying of foods to reduce the moisture content and prevent microbial spoilage thereby increasing the shelf-life and keepability (keeping quality) of such foods. High moisture promotes deterioration and spoilage by microorganisms.

(vi) Soaking and dehulling as in cowpea seeds used to make akara.

(vii) Canning: Canned foods such as tomatoes, beer, jollof rice, milk, beverages (bournvita, milk, nescafe) are processed from their various raw materials

(viii) Fermentation: This is a food processing method that effectively removes toxicants from cereals and legumes and improves their digestibility and sensory characteristics (Reddy and Pierson, 1994). During fermentation, enzymes produced by microbes breakdown proteins and starches to produce amino acids and sugars. Levels of riboflavin, niacin and methionine are increased, vitamin B_{12} is synthesized and there is increase in the amount of available iron (Ackroyd and Doughty, 1964).

Most foods especially roots and tubers are usually consumed after processing since the latter may increase their safety, keepability, palatability, digestibility and utilization. One's life is in his hands if he decides to consume foods that are not processed and the quality not evaluated, not palatable, cannot keep for a long time without spoilage by microbes, cannot easily be digested and utilized by the body for growth and energy, and whose safety is not guaranteed. Yam tubers are peeled, washed, boiled and pounded in a wooden mortar to produce a dough called pounded yam. Yams are also eaten boiled, fried, baked or roasted and may be processed into flour used to prepare composite flour with cereal (wheat) used in baking. The yam flour can also be used as soup thickener.

Cassava is a good source of carbohydrate for human and livestock. For the red species, the root may be boiled and eaten with oil. The roots may be peeled, sliced, sun-dried, ground into flour and used to prepare various local diets. To process into garri, the roots are peeled, washed, grated, fermented and fried into white garri flour. Red garri is produced by the addition of red palm oil prior to frying. I recommend red garri to the white one because red garri contains little or no cyanide and the latter is detoxified by red palm oil.

Like other edible leaves, cassava leaves are processed into leaf protein concentrate (LPC) which is one of the ways of addressing the world protein needs. Many other foods are processed into various products – the processing methods of which vary with the types of food materials being processed. At the industrial or commercial level, many food industries are involved in the processing of food materials into various products. Some examples are

(i) the processing of malted barley or cassava, cereal adjuncts and hops used in the manufacture of lager beer in the brewing industry

(ii) the degumming of fats and vegetable oils with dilute sodium chloride solution (brine) to remove gum particles, resins and proteins which are nutrient sources for microganisms and the hydrogenation of the oil in the presence of nickel catalyst at 160-220°C to manufacture margarine.

$$\underset{\text{unsaturated fat}}{-CH=CH-} \xrightarrow[160-220^{0}C]{H_2,\ \text{nickel catalyst}} \underset{\text{saturated fat (margarine)}}{-CH_2-CH_2-}$$

(iii) The processing of cassava to produce industrial starch used in laundry services

(iv) The processing of wheat into flour used in baking of bread, biscuits etc by the baking industry.

(v) The processing of palm oil or palm kernel oil into vegetable oils.

Merits of Food Processing

(i) The manufacturers and suppliers of processed foods enjoy higher profit since mass production of food is much cheaper than individual production of meals from raw materials.

(ii) Food processing increases seasonal availability of foods and enables transportation of delicate and perishable foods such as tomatoes across long distances.

(iii) Processing results in better food preservation, reduces the tasks of marketing and distribution and increases food consistency.

(iv) Through processing, toxic factors in foods as well as spoilage and pathogenic microbes are removed thereby making such foods safe to eat.

(v) Without modern food processing techniques, supermarkets and long voyages would not be feasible.

(vi) Processed foods are less susceptible to spoilage than fresh foods, and are suited for long distance transportation from the producer to the consumer. Fresh plant and animal foods are more likely to harbour pathogenic microbes such as *Salmonella typhii* and *Clostridium botulina* capable of causing illnesses.

Demerits of Food Processing:

(i) Generally, unprocessed foods contain higher percentage of naturally-occurring vitamins, minerals and dietary fibre than processed foods. Heat processing for instance, destroys vitamins A and C and hence, canned fruits have a lower content of these vitamins than fresh fruits. It is advisable to consume more of natural foods with low level of toxicants.

(ii) Food processing can lower the nutritional value of foods, and introduce contaminants not naturally associated with the food materials.

(iii) Processed foods contain some additives (stabilizers, flavouring and texture-enhancing agents) which have little or no nutritive value, or preservatives (nitrites etc) added to extend the shelf-life of commercially available food products which may affect the health of the consumers.

(iv) Processed foods usually have a higher ratio of energy to other essential nutrients than unprocessed foods – a phenomenon

called “empty calories”. Most often, mass produced processed food products are the so called junk foods to satisfy consumer demand for convenience.

Effect of Processing on the Nutrient Composition of Foods

Processing increases food digestibility, palatability, keepability and safety. Cooking causes food sterilization, starch solubilization, food availability and reduces soluble nutrients (sugars, minerals, vitamins and amino acids of proteins) which are lost to the cooking water when discarded.

Boiling or cooking of yam results in the removal of free amino acids, a reduction in the mineral (P, Mg, Fe, Na, Ca, etc) levels, but increases the availability of proteins and carbohydrates in cocoyam tubers. Moisture content of roots and tubers generally increase with boiling (98 ± 2^{o}C), but baking which occurs at a higher temperature of about 205^{o}C decreases moisture level in foods. Ash content of foods is decreased by boiling due to loss of water-soluble minerals (Na, K, P, S) when the boiling water is discarded.

There is inevitable losses due to processing and cooking and both have positive and negative effects on the nutritional value of foods. For instance, cooking improves the digestibility of proteins and starches and destroys the toxicants in foods, but there is inevitable leaching of nutrients into the cooking water that is sometimes discarded.

Nutrients can be lost from food intentionally as occur when cereals are milled, vegetables are peeled or individual nutrients are extracted from raw materials, and also by inevitable processing methods such as blanching, sterilizing, cooking and drying of foods (Henry and Massey, 2001). They also reported accidental or avoidable losses due to inefficient processing or storage systems and that milling (mechanical separation of the endosperm from the germ, seed coat and pericarp) results in losses in B-vitamins, iron and calcium in cereals. For nutrient losses, Henry and Massey (2001), further reported that

(i) Commercial milling removes 68% thiamine (Vit. B_1), 58-65% riboflavin (Vit. B_2) and 85% pyridoxine (Vit. B_6) from whole wheat, and also reduces the levels of zinc and iron.

(ii) Milling results in beneficial loss of phytic acid (Kent, 1974). The phytic acid forms insoluble complexes with calcium and iron, thereby reducing the bioavailablity of these minerals. The reduction in phytic acid level through milling may improve the bioavailability of the remaining nutrients.

(iii) Milling and polishing of rice results in nutrient losses.

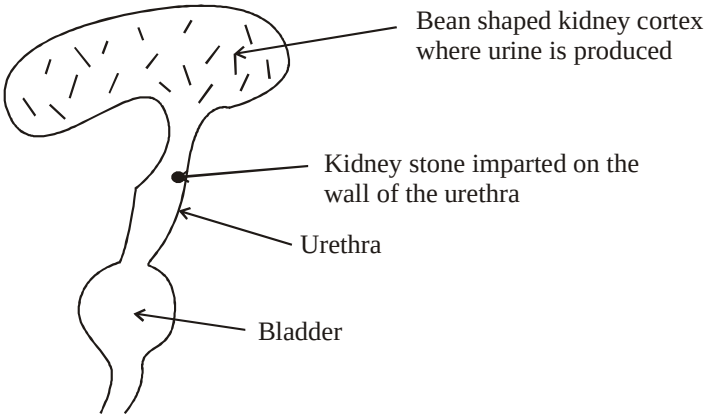
(iv) Washing and peeling of fruits and vegetables result in loss of water-soluble vitamins B and C since these vitamins are more concentrated in the peel and outer layers. To reduce losses of vitamins and minerals, peeling of roots and tubers should be minimized without affecting palatability.

(v) Blanching which is used to inactivate enzymes before vegetables are preserved is carried out by immersion in boiling water or treatment with hot air or steam results in loss of water-soluble nutrients such as mineral salts, proteins, sugars and vitamins. Higher losses occur on foods with large surface to volume ratio.

Effect of Processing on Toxicants in Foods

Processing, by whatever method, generally reduces to physiologically tolerable levels, the concentrations of toxicants found in natural or synthetic association with foods thereby making the foods safe for utilization by humans. For instance, calcium oxalate causes acridity and scratchiness that is irritating to the digestive tract, and can result in death when raw or not well cooked cocoyam is eaten. When ingested in high concentration by the consumer whose life is in his hands, the calcium oxalate crystals can cause the deposition of kidney (renal) stones/calculi. Oxalate binds minerals especially divalent cations (Mg^{2+}, Ca^{2+}, Zn^{2+}) making them unavailable for utilization by the body for growth.

Today, all roads lead to India, Germany and the United States of America for the use of laser to crush kidney stones instead of the delicate surgery that one is not sure of in Nigeria. In addition to avoiding foods that contain high levels of oxalic acid, water therapy is also recommended from time to time.



Simple processing methods that remove antinutrients in foods have significant impact on nutrient bioavaidability, and should be encouraged as part of the routine processing of food samples. The cyanogenic glycosides (linamarin, lotaustralin and amygdalin) in cassava, when hydrolysed by the enzyme linamarase, produce toxic hydrogen cyanide (HCN). Cyanide blocks oxidative phosphorylation (Osuntokun, 1973) by inhibiting cytochrome C oxidase responsible for electron transport from NAD^+ to molecular oxygen to form water thereby hindering respiration and resulting in death. The lethal dose of HCN when taken by mouth is 0.50-3.30 mg/kg body weight and the concentrations of HCN (mg/kg) in cassava and their consequences are shown in Table 1.

Table 1: Concentrations of hydrogen cyanide (HCN) in cassava and implication

Concentration of HCN (mg/kg cassava)	Consequence
0 – 50	Harmless
51-80	Slightly toxic
81 – 100	Toxic
Above 100	Fatal

Source: Montgomery (1980).

The level of HCN in cassava and similar food products can be reduced by post harvest processing involving peeling, washing, soaking, fermentation, boiling, frying and roasting which result in the production of various cassava products such as loi-loi, garri, tapioca etc.

Most legume seeds provide a valuable source of proteins in the diet of the world's poor as they contain 20-40% protein on dry matter compared to cereals which contain 7.0 – 15% protein. Processing, to remove antinutrients in legumes is an important step in the preparation of most legume diets.

When foods are exposed to heat (high temperature) and light, the nutrient fats and vitamins B_1, D and E are easily oxidized and destroyed. Vitamin A is very heat labile and is easily destroyed and oxidized by heat. When exposed to heat and light, carotene oxidizes, isomerizes and get destroyed. Folic acid is destroyed by the use of copper utensils and its level in foods decreases with storage/prolonged heating and is lost in cooking water when discarded. Vitamin C level decreases during storage, heating, drying, oxidation and cell damage such as chopping or slicing of food. The denaturation of proteins by heat treatment improves protein digestibility and retains amino acid composition because of heat inactivation of antinutrients such as trypsin inhibitors (Onyeike et al., 1991). Riboflavin (vitamin B_2) and niacin (vitamin B_3) are stable to heat. Reducing sugars (glucose, mannose, galactose and lactose) in foods react with some amino acids such as lysine during non-enzymatic browning (Maillard reaction) to form an indigestible complex, and thus reduce the protein quality of the food. Heat processing causes the dehydration of food samples thereby decreasing the moisture content and increasing the concentration of other nutrients.

Salting of meat and fish prior to smoking causes the exudation of liquid containing water soluble protein, vitamins and minerals from the flesh, and the salt denatures the proteins resulting in increased protein digestibility.

Smoking of meat and fish to make them dry is bacteriocidal and reduces oxidative changes in fats (rancidity), proteins and vitamins, but

causes nutrient losses due to heat involved; flow of gases and interaction of the components of smoke with proteins.

Food Preservation

Food preservation is the process of treating and handling food in order to stop or greatly slow down its spoilage (loss of quality, edibility or nutritive value) caused or accelerated by microbes. Preservation usually involves preventing the growth of bacteria, fungi and other microorganisms, as well as retarding the oxidation of fats which cause the fats and oils to become rancid (Wikipedia, 2009). It also includes processes to inhibit natural ageing and discolouration that occurs during food preparation such as the enzymatic browning when yams, cocoyams and apples are cut open.

Common methods of preservation include drying, spray drying, freeze drying, vacuum packing, canning, preserving in syrup, food irradiation and adding preservatives or inert gases such as CO_2. Pickling, salting, smoking, preserving in alcohol, curing and sugar crystallization are other methods that add flavour to food in addition to preserving it.

The principles of food preservation are based on the knowledge of agents that cause food spoilage and how to prevent deterioration, and how biological and chemical reactions, physical agents and attack by insects, rodents and microbes bring about reduction in food quality.

Methods of Food Preservation

There are two main methods of food preservation namely physical and chemical.

Physical Methods

i) **Cold preservation:** Here, changes which occur in food and affect palatability and result in spoilage are slowed down. In preservation by freezing, the temperatures used freeze or kill the cells leading to greater keepability since enzymes no longer have aqueous environment for activity that lead to food decay. Frozen cells (foods) retain their enzymes but activity that lead to decomposition is retarded. Freezing methods include slow

freezing of packaged and unpackaged foods in still cold air; quick freezing in rapidly moving air of high relative humidity; contact freezing in cold brine where temperature is close to the freezing point of the salt solution; indirect freezing in cans dipped in freezing liquids such as propylene glycol at -52^{o}C etc.

ii) **Heat preservation:** This involves adequate heating at high temperatures (100^{o}C and above) in hot water, steam or autoclaves to destroy microbes and prevent food decay. Sterilization occurs at 100-130^{o}C and is suitable for foods whose structure and consistency are not affected by high temperature. Such foods include meat, fruits and vegetables. Pasteurization occurs at temperatures below 100^{o}C and is used for juices, milk and fish whose protein and vitamins would be destroyed by higher temperatures used for sterilization.

iii) **Vacuum packing:** This method stores food in a vacuum environment in air-tight canisters, plastic bags or bottle or pack and presenting it for sale. The vacuum environment removes atmospheric oxygen, protecting the food from spoilage by aerobic bacteria, fungi and preventing evaporation of volatile components. Vacuum packing is used for long term storage of dry foods (nuts, cereals, coffee, smoked fish, cured meat, cheese) and fresh foods (meat, vegetables, soups). Here, the food is stored in an airless environment and bacteria are stripped of oxygen needed for survival. This method is used to store nuts to reduce loss of flavour.

iv) **Drying:** The aim of drying is to withdraw water from food (dehydration) to significantly reduce water activity in order to inhibit chemical and enzymatic reactions and delay/stop growth of microorganisms. Drying reduces weight and makes food more portable and ensures the retention of other nutrients. Foods that can be dried include fish, meat, cereal, grains, legume seeds, fruits (apples, pears, paw-paw, mangoes, banana, coconut, grapes, etc). In vapourization drying, water is removed from food to produce dry product at low temperature and pressure, while evaporation drying occurs at temperature and pressure close to the boiling point of water. Vacuum drying is an evaporation

drying under vacuum. In contact drying, liquid foods are converted into powdered food using warmed rollers or driers. Freeze drying is mainly an industrial method in which water in food is frozen and passed directly from solid to gaseous state and here, sensitive substances and aroma are preserved. Freeze-dried foods include meat, fish, milk, eggs, fruit juices, greens, onions, soup, coffee, potatoes, etc.

v) **Irradiation of food:** This is the exposure of food to ionizing radiation, either high energy electrons or x-rays, from Van der Waal accelerators or by gamma rays emitted from radioactive sources such as Cobalt-60 or Caesium-137 to destroy microorganisms (bacteria, virus) or insects that might be present in the food. Other effects of this treatment include inhibition of sprouting as in yams, delay of ripening, increase of the yield of juice, destruction of bacteria, moulds, insect pests and at higher doses causing sterility. It is also called cold pasteurization as the food is not heated. Because ionizing radiation is hazardous to life, irradiation facilities have a heavily shielded irradiation room where the process takes place. Scientists are protected from receiving radiation dose from the facility. Irradiated foods do not become radioactive and national and international expert bodies (FAO and WHO) have declared food irradiation as wholesome, but the wholesomeness of consuming such food is disputed by opponents (Hauther and Worth, 2008) and consumer organizations (Consumer International, 2009). However, it is estimated that in more than 40 countries, about 500,000 tons of food items are irradiated per year world-wide, and these are mainly spices and condiments with an increasing segment of fresh fruit irradiated for fruit fly quarantine (American Diet Association, 2000; Deeley et al., 2006 and Kume, 2009).

Radiation Absorbed Dose

Dose is the physical quantity governing the radiation processing of food, relating to the beneficial effects to be achieved (Wikipedia, 2009). The dose of radiation is measured in the S.I. unit known as Gray (Gy), and one Gy dose of radiation is one joule of energy absorbed per kilogram of

food material. In radiation processing of foods, the doses are generally measured in kilo Gray (K Gy) or 1000 Gy. Dosimetry is the measurement of radiation dose.

Table 2. Radiation dose and applications in foods

	Radiation	Application
i.	Low dose up to 1 KGy	- sprout inhibition in bulbs and tubers 0.03-0.15 K Gy. - Delay in fruit ripening 0.25-0.75 K Gy - Insect disinfestations 0.07-1.00 K Gy.
ii.	Medium Dose 1 KGy to 10 KGy	- Reduction of spoilage microorganisms to prolong shelf-life of meat, poultry and seafoods under refrigeration 1.50-3.00 KGy. - Reduction of pathogenic microbes in fresh and frozen meat, poultry and sea foods 3.00-7.00 KGy - Reducing the microbial population in spices to improve the quality of hygiene 10.0KGy.
iii.	High Dose Above 10KGy	- Sterilization of packaged meat, poultry and their products which are shelf stable without refrigeration 25.0-70.0KGy. - Sterilization of hospital diets 25.0-70.0 KGy.

Source: Wikipedia (2009)

Chemical Methods of Food Preservation

i. **Salting or curing:** A food sample such as meat is treated with salt which removes water from it by osmosis thereby preserving the food. Nitrates and nitrites (also used as additives) are used to

cure meat and inhibit the action of *Clostridium botulinum* that causes spoilage.

ii. **Pickling:** Here, food is preserved in an edible anti-microbial liquid that inhibits or kills bacteria and other microbes. Examples of pickling agents are alcohol, vegetable oil, brine and vinegar while chemically pickled foods include eggs, corned beef, cucumbers, pepper, etc.

iii. **Sugaring:** In this method, sugar is used to preserve fruits such as apples, citrus fruits, pears either in syrup with the fruit or in crystallized form where the preserved food is cooked in sugar to the point of crystallization.

iv. **Use of lye or sodium hydroxide:** This makes food alkaline for microbial growth and the alkali saponifies fats and oils in the food resulting in flavour and texture changes.

v. **Jugging:** This is the process of stewing food such as meat or fish cut into pieces in a covered earthen-ware or tightly-sealed jug with brine and stewed. Red wine and/or the animal's own blood may be added to the cooking liquid.

vi. **Jellying:** This is the preservation of food by cooking in a material (gelatin, agar or maize flour) that solidifies to form a gel. Some foods such as meat form protein gel. Fruit preserved by jellying is known as jelly, marmalade or fruit preserves, and the jellying agent is usually pectin added during cooking or arising naturally from the fruit.

vii. **Potting:** In this method, the food is set in a pot and sealed with a layer of fat. Potted foods include meat, liver, chicken, shrimp and other sea foods etc.

Reasons for which Foods are Preserved

i. To prevent spoilage and production of toxins.

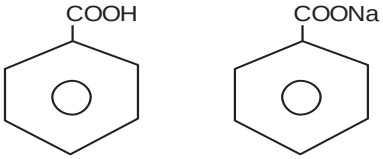
ii. To prevent nutrient losses. Milk exposed for a long time turns turbid and sour due to action of lactic acid bacteria while edible oil undergoes rancid if not preserved.

iii. To make food available all the year round to feed the hungry people of the world and reduce starvation and acute food shortage.

Commonly used Preservatives

i. Sorbic acid: $CH_3CH = CH - CH = CHCOOH$
it inhibits yeasts and moulds in bread without affecting smell, flavour and structure of foods and is physiologically safe.

ii. Benzoic acid and sodium benzoate



They preserve acid foods such as fruits, jams, fruit drinks, vegetables, fish and egg products.

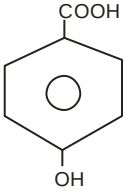
iii. Propionic acid, CH_3CH_2COOH
it is effective against microbes and prevents mouldiness in bread.

iv. Sulphur(IV)oxide SO_2 inhibits enzymic processes and browning reactions. It is used to preserve meat, wine and fruits.

v. Pyrocarbonic acid diethylether preserves wine, beer, fruit drinks and is effective against lactic acid bacteria, yeast and mould.

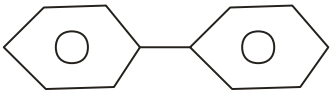
vi. Nitrite inhibits the action of *Clostridium botulina* (bacteria) and contributes to the flavour of cured meat.

vii. Parahydroxybenzoic acid



It has antimicrobial effect on foods.

viii. Biphenyl



This preserves citrus fruits.

Effects of Preservatives on Foods

Preservatives affect food colour. H_2SO_3 and SO_2 cause bleaching. Sometimes the taste and smell of the preservative may be transferred to the food to be preserved. Gases used to preserve foods can be absorbed by the latter bringing about secondary reactions between the food and the preservative resulting in changes in food flavour. Oxidizing preservative such as H_2O_2 may destroy vitamins A and C in foods which are sensitive to oxidation. However, these effects of preservatives on foods are negligible unless excessive or uncontrolled concentrations/amounts of preservatives are used.

Genetically Modified Organisms (GMOs)

Any organism (animal, plant or microbe) whose genetic material has been altered by means of genetic engineering techniques is referred to as a genetically modified organism (GMO). The GMOs include animals, plants/crops and microorganisms and are the source of genetically modified foods and are widely used in scientific research and to produce goods other than food (Wikipedia, 2012).

Genetic Modification: This involves the insertion or deletion of genes. When genes are inserted, they usually come from a different species (horizontal gene transfer). Transfer of gene occurs by (i) Penetration of the cell membrane by DNA for any reason (ii) Artificial attachment of the genes to a virus (iii) Physical insertion of the extra DNA into the nucleus of the intended host with a very small syringe or with very small particles fired from a gene gun (Johnston and Tang, 1994).

The general principle of producing a genetically modified organism (GMO) is to add new genetic material into an organism's genome. This is called genetic engineering, and was made possible through the discovery of DNA and the synthesis of the first recombinant DNA molecules by Paul Berg in 1972 (Jackson *et al*., 1972).

History of Genetically Modified (GM) Plants/ Crops

It was first discovered that DNA can transfer between organisms (Lederberg and Tatum, 1946), and the first genetically modified plant was produced in 1983 using an antibiotic-resistant tobacco plant. In 1994, the transgenic Flavr Savr tomato was approved by the Food and Drug Administration (FDA) for marketing in the US – the modification

allowed the tomato to delay ripening after picking. Hence, it was in 1994 that the commercial sale of GM foods began when Calgene first marketed its Flavr Savr delayed ripening tomato (James, 1996). The transgenic crops in the US which received approval for marketing in 1995 were

(i) Canola with modified oil composition (Calgene)
(ii) *Bacillus thuringiensis* (Bt) corn/maize (Ciba-Geigy)
(iii) Cotton resistant to the herbicide, bromoxynil (Calgene)
(iv) Bt cotton (Monsanto)
(v) Bt potatoes (Monsanto)
(vi) Soybeans resistant to the herbicide, glyphosate (Monsanto)
(vii) Additional delayed ripening tomatoes (DNAP, Zeneca/Peto, and Monsanto) (James, 1996).

By 2011, the United States leads the list of countries in the production of GM crops and foods and 25 GM crops had been granted regulatory approval to be grown for commercial purpose (James, 2011).

Method of Production of GM Plants/Crops

GM crops or biotech crops are plants, the DNA of which has been modified using genetic engineering techniques which are then used in agriculture. Methods of producing GM plants are

(i) **Transgenesis:** Transgenic plants have genes obtained from another species inserted into them. These plants have been engineered for research to form new colours in plants and to make different crops.
(ii) **Cisgenesis:** Cisgenic plants are made using genes from the same species or a closely related gene where conventional plant breeding can occur. Cisgenesis is useful for plants such as potatoes that are not easy to crossbreed by conventional means, and these plants should not require the same level of legislation as other GMOs (Mackenzie, 2008).

When plants are produced and seeds obtained, the seed producer (Company/Industry) will apply for regulatory approval to field-test the seeds. If field test is successful, the Company will then seek regulatory

approval for the crop to be marketed. Once approval is given, the seeds are mass produced and sold to farmers. The farmers will produce GM crops which contain the inserted gene and its protein product. The farmers then sell their crops as commodities into the food supply market in countries where such sales are permitted.

Genetically Modified (GM) Animals

The process of genetically engineering animals is slow, tedious and expensive. Many animals have been genetically engineered for various purposes. For example

(i) Green Fluorescent Protein (GFP) for medical research purposes for which Chalfie, Shimoura and Tsien (2008) were awarded the Nobel Prize in Chemistry.

(ii) A Japanese-American Team produced green-flourescent cats inorder to find therapies for HIV/AIDS and other diseases (Wongsrikeao et al., 2011).

(iii) Targeting Parkinson's disease, scientists in Japan successfully transferred a gene into a primate species (Marmosets), and produced a stable line of breeding transgenic primates for the first time (Sasaki et al., 2009; Schatten and Mitalipov, 2009).

(iv) Pigs have been engineered to produce omega-3 fatty acids through the expression of a roundworm gene (Lai et al, 2006), and goats have been genetically engineered to produce milk with strong spiderweb-like silk proteins (Zyga, 2010).

(v) In China, scientists have produced dairy cows genetically modified with genes for human beings to produce milk that would be the same as human breast milk (Stevenson, 2011), and this is of benefit to mothers who cannot produce breast milk which they want their babies to have rather than the use of infant formula.

(vi) Transgenic animals have been developed that produce human therapeutics or biotherapeutics (Houdebine, 2009).

(vii) GM fishes are used for research in genetics and as pets. They are being considered as food and as aquatic pollution sensors.

Genetically Modified (GM) Mammals

GM mammals are a category of GMO (EFSA, 2012) and include GM pigs, rats, mice, rabbits, sheep and these were the first GM Models of human disease including the first carcinoma caused by a transgene.

Genetically Modified Microorganisms

Bacteria have been genetically engineered (Melo et al., 2007) and are important in producing large amounts of pure human protein for medicinal purposes (Leader et al., 2008). Also genetically modified bacteria are used to produce insulin used to treat diabetes mellitus (Walsh, 2005). The enzyme alpha-amylase from GM bacteria is used to convert starch to simple sugars and fungal pectinesterase has been engineered to improve the clarification of fruit juice (Panesar et al., 2010).

Genetically Modified Foods

Genetically modified foods also known as GM foods or biotech foods are foods obtained from GMOs such as GM crops or GM fish. The GMOs have their DNAs altered by genetic engineering techniques which are much more precise (King, 2003) than mutagenesis (mutation breeding) where an organism is exposed to radiation or chemicals to create a non-specific but stable change. Humans can also modify food organisms by selective breeding, plant breeding or animal breeding other than by genetic engineering.

Typically, GM foods are genetically modified (transgenic) plant products such as soybean, corn, cotton seed oil, and golden rice which contains beta carotene – a precursor of vitamin A. Golden rice was the first GM crop in which an entire biosynthetic pathway was engineered, for faster growth, resistance to pathogens, increase in nutrient value or any other beneficial purpose. Although GM livestock have been developed experimentally, as at July 2010, none are currently on the market (http://www.fda.gov/animalveterinary/developmentapprovalprocess/geneticengineering/geneticallyengineeredanimals/ucm113672.htm).

Foods Made From GM Crops/Plants (Wikipedia, 2012)

(i) Paw-paw has been engineered to resist the deadly ringspot virus, and save the Hawaiian Papaya Industry from collapse in 1990. Today, 80% of Hawaiian *Carica papaya* is genetically engineered,

and there is still no conventional or organic method to control ringspot virus (Ronald and McWilliams, 2010).

(ii) Most vegetable oils used in prepared foods in the U.S are produced from GM crops (corn, soybeans, canola) and are sold to consumers as cooking oil, margarine and shortening (Michelle, 2011).

(iii) Canola, of which 93% of the U.S crop is genetically engineered to resist the herbicides glyphosate and glufosinate and for improved oil composition is used to produce vegetable oil (approximately 43% of the canola seed is oil) (Soyatech.com).

(iv) About 95% of the U.S soybeans is GM and approximately 85% of the world's soybean crop is processed into soybean meal and vegetable oil (Soyatech.com).

(v) In U.S, maize is known as corn. Maize is a staple food in many parts of the world, and 86% of U.S maize was GM in 2010 (NASS, 2010). In 2011, 32% of maize crop world-wide was GM, 49% was used for livestock feed, 27% went to ethanol production, 13% was exported while 4.1% of the U.S corn harvest was made into high fructose corn syrup, and the rest was used for other sweetners, corn starch, alcoholic beverages.

(vi) Cotton crop: About 93% of the U.S cotton crop is GM and the cottonseed oil produced is used as a salad and cooking oil, both for industrial and domestic purposes (National Cottonseed Producers Association, n.d.)

(vii) About 95% of the sugar beet acres in the U.S. were planted with glyphosate herbicide – resistant seeds (James, 2011). Sugar beets that are herbicide-resistant have been approved for the production of refined sugar (sucrose) in countries like USA, Mexico, Singapore, Korea, Japan, Canada and Colombia.

Foods from GM Animals

As of September 2012, no genetically modified animals had been approved for use as food, but a GM Salmon was near U.S Food and Drug Administration approval at that time (Andrew, 2012).

Controversies around Genetically Modified Foods

Criticisms around GM foods have centered on

(a) The issue of the safety of the food produced from GM crops (National Research Council, 2004) for consumption, ecological concerns and economic concerns raised by the fact that GM plants (and potentially animals) that are food sources are subject to intellectual property law and market dynamics.

(b) Whether

(i) The food should be labeled and if so, how.

(ii) Agricultural biotechnology (GM crops) are needed to address the world food crisis and hunger now or in the future.

(iii) Environmental effects of GM food crops have been adequately considered to permit the consumption of such foods.

(iv) It is ethical to make GM organisms and GM foods.

(c) Some critics argue that GM crops which have been used mainly to produce animal feed do not address the problem of hunger and poverty. The report of the recent International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) showed that there were no conclusive evidence that GM crops have increased yields, and that GM soyabeans for example, suffer from "yield drag" resulting in a 5-10% reduction in yield (Friends of the Earth, 2008). It was further argued that as yet, no GM crops modified to increase yield or resist drought are on, or even close to the market; instead crops have been modified to be resistant to insect pests and tolerant to herbicides resulting in increased use of chemicals to deal with the weeds that develop resistance to the chemicals over time.

Plate 1. GM Honeysweet plum. These transgenic plums contain a gene that makes them highly resistant to plum pox virus

Source: http://www.ars.usda.gov/is/br/plumpox/12/11/2012

Nutrition

Nutrition is the provision of food to living organisms in order to support life. The condition or health of the body depends on nutrition, and hence the latter is not merely food nor that which nourishes. Food is the substance of nourishment, while nutrition is the act of using food in a series of coordinated processes whereby the nourishment/aliment of the body is effected. Nutrition is the science of food values or the study of food, its properties and the ways the body utilizes it to produce energy used to do all forms of biological work and for growth and maintenance of tissues and mental development. Nutrition can be looked at in the context of the types of atoms and molecules present in foods, their reactions and effects on human and animal subjects consuming such foods.

A primary purpose of the function of nutrition is to establish and sustain the structure and function of all organs and parts of the body, to keep the mechanism of the body in order and prevent disease.

History of Nutrition Science

This dates back to about 400 B.C, when food was just considered as food. You got hungry; you ate. Hippocrates, the "Father of Medicine" said to his students, "Let food be thy medicine, and medicine thy food", and that "a wise man should consider that health is the greatest of human blessings". Foods were often used as cosmetics or as medicines in the treatment of wounds. One story described the treatment of eye disease, now known to be due to a vitamin A deficiency, by squeezing the juice of liver unto the eye. Vitamin A is stored in large amounts in the liver. No one really understood what was good for you or why, at least not in a physiological, scientific way, and Physicians attempted to prescribe diets as remedies for illness, (McKenney, 2009).

Foods which may be in solid or liquid state were then classified as hot, cold, wet or dry based on an association with one of the four classical Greek elements namely fire, air, water, earth. It was believed that these qualities of food interacted to create "humors" within the body. For example, cold and dry interact to create "black bile" (a humor), which was blamed for liver problems and would be treated with a diet of

hot and wet foods. Nutrition science continued in this way for many centuries, but today, we understand our diet as the source of six major nutrients namely carbohydrates, fats, proteins, water, vitamins and minerals.

Nutrients

These are constituents of food that allow the organism to grow, maintain itself and function normally. A nutrient is a chemical substance required by an organism to live and grow, and is used in an organism's metabolism. Nutrients enrich the body, build and repair worn out tissues, give heat and provide energy to enable the body function efficiently and regulate body processes. Methods for nutrient intake vary with animals consuming foods that are digested by enzymes, but most plants ingest nutrients directly from the soil via their roots or from the atmosphere.

Nutrients needed in relatively large amounts are called macronutrients. Examples are carbohydrates, proteins and fats which are organic nutrients. Water is also consumed in large quantity but is not always considered as nutrient when consumed in isolation. Salt (sodium chloride), calcium (Ca), potassium (K), Magnesium (Mg), Phosphorous (P) and Sulphur (S) are usually added to the list of macronutrients because they are required in large quantities compared to other minerals.

Nutrients required in relatively small quantities are called micronutrients and they include the remaining minerals and then vitamins (both water-soluble and fat soluble).

Classes of Nutrients in Foods, Sources and their Functions

There are six major classes of nutrients, namely carbohydrate, fats, proteins, water, vitamins and minerals.

Table 3a: Energy-giving nutrients, their sources and functions

	Nutrient	Sources	Functions
1.	Carbohydrates – the two components are nitrogen-free extractive (soluble sugars, starches)	Tubers (yam, cocoyam), grains (wheat, rice, maize), bread,	(a) Source of energy (4.20 Kcal/g) to do biological work (b) Building block for other nutrients and dietary excess stored

	and crude fibre (mainly cellulose)	potatoes, spaghetti, candy, pastries.	as glycogen.
2.	Fats (Lipids) – they are composed of fatty acids bonded to glycerol. Mono- or poly unsaturated fats are liquid fats which are healthier (e.g. olive oil) than saturated fats or solid fat such as butter, lard, at room temperature	Oils from fish, soybean, castor, lard or tallow from livestock.	(a) Keep cell membranes functioning. (b) Rich and cheap source of energy (9.10 Kcal/g) which is twice the energy content of 1.0g of carbohydrate or protein. (c) Source of heat to the body (d) Insulate body organs against shock thus protecting them (e) Helps to keep body temperature constant and maintain healthy skin and hair.
3.	Proteins: True protein is made up of amino acids. Crude protein contains true protein and other nitrogenous products or non-protein nitrogen (N-PN), while N-PN can be converted to true protein by rumen bacteria for ruminants.	Fish, eggs, meat, legume seeds, soy products, microorganisms (single cell protein), dairy products (milk, cheese, etc).	(a) Source of energy (4.10 Kcal/g) and essential amino acids. (b) Basic structural unit required in metabolism and in production of DNA, antibody and hormones. Hormones are secretions of ductless glands important in metabolic regulation.

Table 3b: Non energy-giving nutrients, their sources and functions

1.	Water (a chemical compound made up of hydrogen and oxygen in the ratio of 2:1, and whose molecules are held together by hydrogen bonds.	Rain, borehole/ ground water, rivers, seas and oceans.	(a) Functions in transport, chemical reactions, lubrication and the maintenance of body temperature. (b) A cell deprived of water gets dehydrated resulting in electrolyte imbalance and death. (c) H_2O is an essential nutrient, and the solvent in which all the chemical reactions of life take place. (d) Water is also a coolant
2.	Vitamins There are two classes namely: (i) Fat-soluble vitamins A,D,E and K called ADEK. (ii) Water soluble vitamins B (B_1, B_2, B_3, B_5, B_6, B_{12} and C).	Sources include vegetables, fruits, etc.	(a) Metabolic functions and as coenzymes in enzyme reactions. (b) They regulate metabolic reactions and help to ensure healthy living.
3.	Minerals – these are inorganic substances that originate from rocks and ores which enter the food chain through the soil. There are two classes namely (i) Major minerals (Na, Mg, Ca, P, Cl, K, S) (ii) Minor (trace) minerals such as Co, Cu, F, I, Fe, Mn, Mo, Se, Zn Humans get minerals by consuming plants grown on mineral-rich soils or by eating animals that	Sources are fruits, vegetables, nuts and seeds.	(a) Involved in protein synthesis, as component of skeleton, oxygen transport, fluid and acid-base balance in the body and as cofactor for enzymes. (b) Ca, Mg and P are the major constituents of bone and teeth. (c) Other minerals are needed for various biochemical processes occurring in the body.

	feed on these plants.		

Note: Each of carbohydrate and protein contains 4 kcal/g of energy, fat contains 9 kcal/g while ethanol (an alcohol) has an energy content of 7.0 kcal/g. This may in part, account for why some individuals who wish to engage in strenuous physical activity may like to drink a big bottle of an alcoholic beverage (stout).

Essential Nutrients

An essential nutrient is one required for the normal functioning of the body that either cannot be synthesized by the body at all, or cannot be synthesized in amounts adequate for good health, and thus must be obtained from an external dietary source (Wikpedia, 2010). Water and oxygen are essential for human health and life, because oxygen cannot be synthesized by the body and water is not formed in sufficient amounts. Water is used as a solvent, carrier, coolant and integral polar structural member, but both oxygen and water are not often included as nutrients or food when consumed in isolation (Wikipedia, 2010). Most mammals make their own vitamin C, and the latter is hence not considered an essential nutrient for such species, but ascorbic acid is an essential nutrient for human beings who cannot synthesize it and thus require external source of the ascorbic acid. Types of essential nutrients are those of amino acids, fatty acids, vitamins and dietary minerals.

The essential amino acids are very important for the body to function. They are eight of them for adults and ten for children. The eight essential amino acids for adults can be recognized by the statement "very important men lose their pride to ladies" for the amino acids valine, isoleucine, methionine, leucine, tryptophan, phenylalanine, threonine and lysine. Additional two for children are arginine and histidine. If a single essential amino acid is missing in a diet, there will be retardation of growth. They are required by the body during early development and maturation, pregnancy, lactation and injury.

Note: A complete protein contains all the essential amino acids, while an incomplete protein source is deficient in one or more of the essential amino acids.

The amino acid which the body does not recognize its absence and which it can synthesize is known as non-essential amino acid. The

absence of non-essential amino acid in a diet does not affect growth. Examples of non-essential amino acids are glycine, asparagine, serine, proline, alanine, cysteine, tyrosine and glutamic acid. Non-essential substances in foods can have beneficial or toxic effects on health. Dietary fibre for instance is not absorbed by the human digestive tract, but is important in digestion and absorption of otherwise harmful substances. Interest has recently increased in plant chemicals which include many non-essential substances that may have health benefits (Whitney and Sharon, 2005).

There are three essential fatty acids which the body cannot synthesize from other precursors and are important for cardiovascular health. They are

(i) α-linolenic acid or the shortest chain omega-3 fatty acid (LNA) which is taken in through marine food sources and serves as a building block for series 3 prostaglandins (e.g. weakly inflammatory PGE 3).

(ii) Arachidonic acid (AA) – a building block for series 2 prostaglandins e.g. pro-inflammatory PGE 2.

(iii) Linoleic acid or the shortest chain omega-6 fatty acid (Omega – 6 dihomo-gamma-linolenic acid, DGLA) which serves as the building block for series 1 prostaglandins e.g. the anti-inflammatory PGE 1, the shortest chain omega-6 fatty acid. Both AA and DGLA can be made from omega-6 linoleic acid (LA) in the human body or can be taken in directly through food.

Very good food sources of essential fatty acids are marine oils, vegetables, fish and fish oils, soybeans, nuts, walnuts, sunflower seeds, pumpkin seeds and cotton seed. Both omega-3 and omega-6 long chain polyunsaturated fatty acids are substrates for a class of eicosanoids called prostaglandins.

A diet high in saturated fat is harmful to the body, but a diet that is high in mono- and polyunsaturated fat is less harmful and more beneficial to health. One's life is therefore in his hands if he decides to consume diets high in saturated fat which is not recommendable.

By 2005, about 12 out of the 14 vitamins and 12 out of 18 minerals were recognized as essential nutrients, because the body cannot

synthesize them, and they have to be consumed and absorbed from diets/external sources. Vitamin D though present in salmon fish, cod liver oil, eggs, and steroid-containing foods irradiated with ultra violet (UV) light, is an example of a non-essential vitamin, because it is synthesized by the body when ultra violet light strikes the human skin. You are advised not to keep your new-born baby under the sun for vitamin D, but only in mild sunlight. Vitamin K is synthesized by intestinal bacteria, and is hence non-essential.

In large amounts, many essential nutrients are toxic while some can be taken in amounts larger than required without toxic effects as reported by Pauling (1986). He reported with regard to vitamin B_3, "what astonished me was the very low toxicity of a substance that has such very great physiological power; a little pinch, 5mg every day, is enough to keep a person from dying of pellagra, but it is so lacking in toxicity that ten thousand times as much can (sometimes) be taken without harm" (Pauling, 1986).

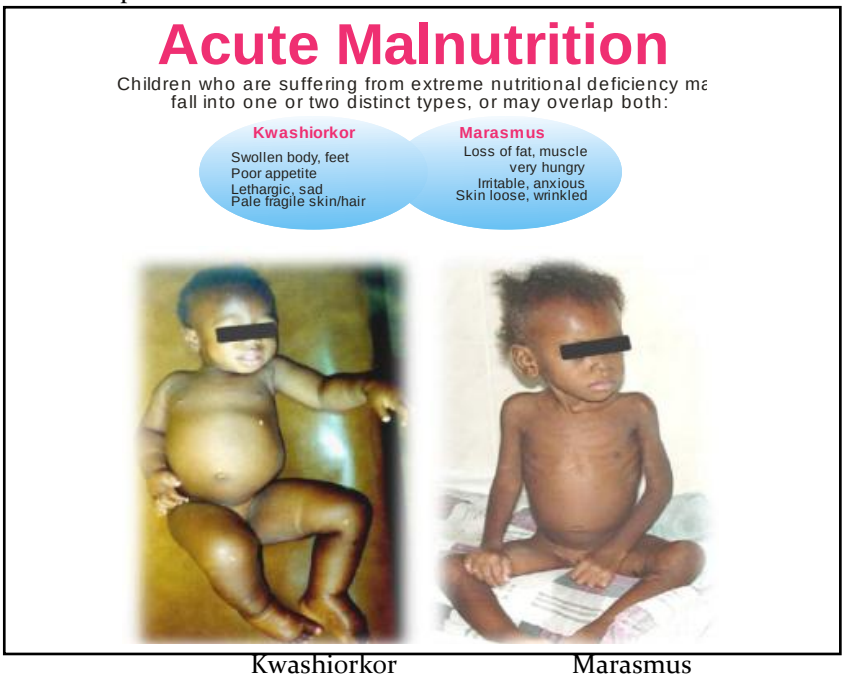
Nutritional Disorders

Nutritional disorders are nutrient-deficient diseases in humans that are caused by the consumption of diets that do not meet quantitative requirements of essential nutrients that ensure good health. These disorders are associated with chronic malnutrition and may also be caused by over-eating as in obesity. Excessive consumption of some nutrients can cause acute poisoning resulting in serious health problems. For the attainment of good health, since one's life is in his hands, appropriate diets which provide adequate amounts of nutrients to meet physiological requirements and prevent the development of nutritional disorders are highly recommendable.

Nutritional Disorders: Aetiology, Features, Prevention and Food Sources of Deficient Nutrients that should be Consumed

ii) **Protein-Energy Malnutrition (PEM):** This is nutrient deficiency disorder caused by inadequate intake of protein and energy-giving foods. It can also be caused by poverty, maternal malnutrition, infections, ignorance and wrong child feeding practices. PEM is common in African countries particularly

among infants/children under the age of five years. To prevent PEM, foods containing protein and energy (beans, meat, fish, maize) should be consumed and the use of pap, banana and plantain as main food for children should be discouraged. Nutrition education is important and there should be dietary modification, surveillance on infant/child growth monitoring, improvement in income and balanced diets should be consumed.



Kwashiorkor Marasmus

Plate 2. Patients Suffering from Kwashiorkor and Marasmus
Source: www.MAMAProject.org

iii) **Kwashiorkor:** This is the acute form of childhood PEM caused by insufficient protein consumption due to low level of protein in diet, but with sufficient calorie intake. In severe cases it may lead to death.

Features include growth failure, pedal oedema, severe anaemia poor apetite, wasting of muscle, dull hair with lack of luster,

irritability and anorexia, swollen scrotum, moon-face which appears oedemacious, skin changes such as peeling off and pigmentation, distended abdomen (stomach protrudes) with small buttocks, enlarged liver with fatty infiltrates, diarrhea, loose and offensive stool and mental changes. For prevention and treatment, dietary protein content of foods consumed should be increased. Dried skim milk, soy ogi, leaf protein concentrate (LPC) and all forms of animal and plant food proteins should be used therapeutically to reverse the conditions that characterize kwashiorkor.

Plate 3. Kwashiorkor sufferers show signs of thinning hair, edema, inadequate growth, and weight loss. The stomatitis on the pictured infants indicates an accompanying Vitamin B deficiency.
Sources:
A=http://upload.wikimedia.org/wikipedia/commons/thumb/4/4d/Kwashiorkor_6180.jpg/230px-Kwashiorkor_6180.jpg ;
B=http://bio.illinoisstate.edu/jearmst/syllabi/cassava/cassava8.jpg;
C=http://drugline.org/img/ail/150_151_3.GIF

One of many kwashiorkor cases in relief camps during the Nigerian–Biafran War
Source:
http://upload.wikimedia.org/wikipedia/commons/thumb/4/47/Starved_girl.jpg/200px-Starved_girl.jpg

iv) **Marasmus:** This is a severe form of PEM that results from energy deficiency and starvation due to lack of proteins, fats and carbohydrates that give calorie in diets. It is characterized by emanciation, reduced body weight, growth failure but no oedema, severe muscle wasting, less common hair and skin changes, no mental changes and no fatty infiltration of the liver.

Anaemia is present but less severe. Ribs are prominent and the face looks like that of old-world monkey; there is diarrhea and stool is loose but with consistent feature and not offensive. Patient has good appetite, voraciously hungry, wild awake, less miserable and irritable. To prevent marasmus, there should be adequate calorie in the diet of susceptible individuals.

Marasmic patients
Source:http://en.wikipedia.org/wiki/Marasmus

A marasmic patient
Source:http://malnutrition911.webs.com/reality%205.jpg

A child suffering the effects of severe hunger and malnutrition during the Nigerian blockade
Source:http://www.glahaiti.org/comingsoon/user_files/Before%20and%20AFter%20photos/Myrlene.JPG

Plate 4: Patients Suffering from Marasmus

v) **Marasmic-Kwashiorkor:** This is caused by deficiency of both energy and protein in diets consumed. It is in the middle of PEM spectrum in which there are both features of kwashiorkor and marasmus. This disorder can be prevented by consuming diets that give adequate energy and protein.

vi) **Goitre:** Goitre is an enlarged or swollen thyroid gland caused by lack/insufficient iodine in diet and water, and intake of foods which contain goitrogenic agents. Such foods include cabbages, turnips and groundnuts.

The thyroid gland produces the hormones thyroxine T_4 and triiodothyronine T_3 which are found in the bloodstream. If T_4 accumulates instead of being released, the thyroid gland swells resulting

in a condition known as goitre. To prevent goitre that is due to lack of iodine in the diet, iodine replacement is done using iodized salt and onions in diets. Prevention can also be by eating foods such as fruits, vegetables, meat, sea foods but avoiding foods containing goitrogenic agents e.g. cabbage. Nutrition education is important and so, the public should be enlightened to create awareness that goitre is not an inherited trait, but a nutrient-deficient disease.

For a small goitre that is not due to a cancerous nodule and the thyroid gland produces normal amount of T_4 and T_3, then no treatment is desired, but if there is cancer of the thyroid, surgery to remove the cancer and some of the thyroid gland is required (Mulinda, 2007).



A **B** **C**

Sources:
A=http://3.bp.blogspot.com/NeyiMYSRsQY/T4rLjmP5KI/AAAAAAAAAmc/hjFo_P7T_kE/s1600/DSC_0245.JPG
B = http://medicscientist.com/wp-content/uploads/2012/07/GOITERandTHYROIDITIS_thumb.jpg
C = http://goiterpictures.com/images/Goiter-Pic.jpg

Plate 5 Individual s suffering from goitre.

vii) **Obesity:** This is a medical condition in which excess body fat accumulates to the extent that it may affect health resulting in reduced life expectancy (http://en.wikipedia.org/wiki/obesity, 2011). It is one of the leading preventable causes of death in adults and children world-wide and was sometime in history perceived in the Western world as a symbol of wealth and fertility. The less activity one does, the fewer calories he burns and the higher the risk of becoming obese. Obesity is caused by excessive intake of fatty foods, carbohydrate, sweetened

beverages and drinks, potato chips and fast foods. It also results from increased use of medications that can cause weight gain e.g. antipsychotics and antidepressants, and lack of physical activity as well as genetic susceptibility. Smoking suppresses appetite and lowered rate of smoking can make people become obese. About 12% of people who stop smoking gain a large amount of weight. In obesity, it is difficult to move about, and there is arthritis.

The status of individuals susceptible to obesity is determined by the body mass index (BMI), which is a statistical measurement derived from the weight and height of the individual. BMI is calculated by dividing the weight of an individual in kilogram by his height in metre squared.

$$\text{BMI} = \frac{\text{weight of the individual in kilogram}}{\text{height of the individual in metre squared}} = kg/m^2$$

Table 4. Classification of obesity

Classification	BMI (kg/m^2)
Underweight	Less than 18.5
Normal weight	18.5-24.9
Overweight (pre-obese)	25.0-29.9
Class 1 obesity	30.0-34.9 (reduces life expectancy by 4 years)
Class 2 obesity	35.0-39.9
Class 3 obesity	Greater than or equal to 40.0
Severe obesity	Greater than or equal to 35 or 40 (reduces life expectancy by 10 years)
Morbid obesity	Greater than or equal to 35 or 40-44.9 or 49.9
Super obesity	Greater than or equal to 45 or 50

Source: http://en.wikipedia.org/wiki/obesity

The surgical literature breaks down Class 3 obesity into severe, morbid and super categories whose exact values are still disputed.

Obesity results in mortality and is a risk factor for cardiovascular diseases, type 2 diabetes mellitus, obstructive sleep, cancer, osteoarthritis (degeneration of bones and cartilages), stroke, hypertension, high cholesterol, gall bladder disease and respiratory problems (Wikipedia, 2010).

An obese woman
Source:http://www.chilloutpoint.com/images/2009/april/fat/funny-fat-gigantic01.jpg

An obese man
Source:http://www.topnews.in/health/files/obesity2_0.jpg

Obese children
Source:http://www.topnews.in/health/files/obesity2_0.jpg

Plate 6: Patients suffering from Obesity

Prevention and treatment of obesity can be achieved through

(a) Regular exercise: This helps to burn off excess calories consumed. Walking a kilometer daily for 15 days in a month is recommended to enhance one's mood, reduce anxiety, make the bones stronger, reduce hypertension and the chance of a heart attack or stroke.

(b) Diet consumed should be healthier (lower food energy diet). Eat more fruits, whole grains and vegetables and reduce intake of carbohydrate and fatty foods.

(c) Treatment can be by use of over-the-counter diet products or prescription medications for losing weight such as herbal remedies like Orlistat (Xenical) and Phentermine (Lonamin, Adipex-P, Fastin) prescribed by the Healthcare Provider. These drugs are taken indefinitely because as soon as their intake is stopped, overweight comes back.

(d) Weight Loss Surgery (WLS) or Bariatric surgery can be done for Class 3 obese individuals with severe, morbid or super obesity to lose weight. The two most common weight loss surgeries are Laparaoscope gastric binding and Gastric bypass surgery.

Note that heart disease, cancer, obesity and diabetes are commonly called "Western" diseases because these maladies were once rarely seen in developing countries. People whose diets are rich in vegetables, fruits and whole grains do not suffer from "Western" diseases and diseases of

affluence like heart disease and cancer. The United Healthcare/Pacificare Nutrition Guideline recommends a whole plant food diet and the use of protein only as a condiment with meals. A National Georgraphic cover article from November, 2005, entitled "The Secrets of Living Longer" also recommends for longevity, whole plant food diet.

viii) Hypertension: Blood pressure results from the force of the heart as it contracts and the resistance of the arteries to blood flow. Blood pressure is hence the force exerted by the blood against the walls of the arteries (Leikin and Lipsky, 2003). Hypertension or high blood pressure (an opposite of hypotension) is a heart, chronic medical condition in which the systemic arterial blood pressure is elevated. That is, a sustained systolic pressure above 140mmHg and/or diastolic pressure above 90mmHg (Wardlaw, 1999). Systolic blood pressure is blood pressure in the vessels during a heart beat, while diastolic blood pressure is the pressure between heart beats. A prevalence of 36.6% among the 167 million Nigerians has been reported, and the rate increases with age and is high among Nigerians with diabetes mellitus (Adedoyin et al., 2008).

Types of hypertension:

a) Primary (essential) hypertension is high blood pressure with no obvious medical cause and it occurs in 90-95% of the cases (Carretero and Oparil, 2000).

b) Secondary hypertension (5-10% of the cases) is caused by other conditions that affect the kidneys, heart, arteries or endocrine system (Mayo Foundation for Medical Education and Research, 2008).

c) Persistent Hypertension: This is one of the risk factors for stroke, myocardial infarction, heart failure, arterial aneurysm, and is a leading cause of chronic kidney failure (Pierdomenico et al., 2009). Changes in diet and lifestyle can improve blood pressure control and decrease risk of health complications although drug treatment is important in patients for whom lifestyle changes are ineffective or insufficient (Nelson, 2010).

d) Resistant hypertension occurs when medications fail to reduce blood pressure to normal levels (Chobanian et al., 2003).

e) Exercise hypertension is high blood pressure during exercise and its normal range for systolic values is 200-230mmHg (Klaus, 1987; Jette et al., 1987).

f) Accelerated hypertension: This is associated with headache, drowsiness, confusion, disorder of vision, nausea, vomiting. These symptoms are collectively referred to as hypertensive encephalopathy (Oppenheimer and Fishberg, 1928). It is caused by severe blood vessel congestion and brain swelling which can be reversed if blood pressure is lowered (Papadakis and McPhee, 2008). Symptoms in new borns and infants are failure to thrive, irritability, lack of energy, seizures and difficulty in breathing, while in children, there is headache, fatigue, blurred vision, nose bleeds and facial paralysis (Rodriguez-Cruz and Ettinger, 2010).

g) Diet-related hypertension is caused by high intake of sodium salt (more than 4g table salt daily). Other causes are high intake of alcohol, cadmium, lead, saturated fats and a deficiency of magnesium in diet.

Table 5. Sub-classification of hypertension

Sub-class	Range of Systolic pressure (mmHg)	Range of Diastolic pressure (mmHg)
Normal	90-119	60-79
Prehypertension	120-139	80-89
Stage 1 hypertension	140-159	90-99
Stage 2 hypertension	≥ 160	≥ 100
Isolated systolic hypertension*	≥ 140	< 90

Source: Chobanian et al. (2003)

* This is common in the elderly in which systolic pressure is elevated with normal diastolic pressure as measured using a sphygmomanometer.

Risk Factors of Hypertension

These are age, diabetes, obesity, heredity, stress, anxiety, high salt diet, low potassium (potassium balances sodium concentration in the body), excessive consumption of alcohol which damages the heart by causing the release of hormones that increase heart rate (Leiken and Lipsky,

2003). Smoking is another risk factor because the chemicals in tobacco can damage the lining of arterial walls and cause the arteries to narrow thereby elevating the blood pressure

Plate 7. Individuals with diet – related hypertension.
Source: http://www.webmd.com/hypertension-high-blood-pressure/guide/high-blood-pressure-diet

To prevent or treat diet-related hypertension, avoid high intake of foods rich in salt, alcohol, cadmium, lead, saturated fats. Ensure high intake of foods rich in potassium, calcium, phosphorous, magnesium, fibre and polyunsaturated fatty acids. Nutrition education is important.

ix) **Diabetes Mellitus:** This is a metabolic disorder of carbohydrate metabolism which as yet, has no cure, in which glucose is underutilized. Diabetics either do not produce insulin or produce very little or their body cells are unable to respond to insulin (insulin resistance) or recognize and utilize insulin, leading to hyperglycaemia (high blood glucose). Diabetes is a major cause of heart disease, erectile dysfunction in men, blindness, high blood pressure and kidney failure. Diabetics are 25 times more likely to undergo foot and other "lower extremity" amputations due to circulatory problems. In insulin-dependent diabetes mellitus (IDDM) or juvenile onset diabetes (Type 1 diabetes), diet is not implicated in the aetiology. In non insulin-dependent diabetes mellitus (NIDDM) or adult onset diabetes (Type 2 diabetes), diet is implicated in its aetiology. Gestational

diabetes is a temporary and less common one that occurs during pregnancy.

Diabetes is caused by lack of insulin due to the destruction of beta cells of Islets of Langerhans in the pancreas where insulin is produced. The beta cells can be destroyed by drugs (alloxan or streptozotocin) used to induce diabetes or by the immune system (a combination of genetic predisposition and other factors provoke the immune system into attacking and destroying the cells that produce insulin in the pancreas). Diabetes occurs when the blood glucose level is 126mg/dl or more after an overnight fasting (not eating any food). Another cause is defect in the utilization of insulin by the liver and other tissues, and is aggravated by high carbohydrate food intake (resulting in chronic hyperglycaemia) and obesity.

Prevention of Type 1 diabetes requires insulin injections. Type 2 diabetes can be prevented by eating small meals at a time, restricting total carbohydrate intake, eating liberal amounts of fibre-containing foods to minimize postprandial rise in blood glucose, consuming foods with low glycemic index (legumes, unripe plantain), exercising regularly, and if treated with insulin, synchronizing food intake with insulin action.

Delivering the Diabetes Association of Nigeria (DAN) Annual Lecture on the theme "Diabetes Education and Prevention" in collaboration with the College of Health Sciences and University of Port Harcourt Teaching Hospital (UPTH) on Wednesday, 7th December, 2011 at the Conference Room of the Hospital, during the celebration of World Diabetes Day, the National President of DAN, Dr. Sunny Chinenye revealed that "a contributing factor to the epidemic of diabetes is ignorance, which is due to lifestyle which is a factor because obesity is on the increase, and the more obese we are, the more diabetic we become" (Chinenye, 2011). To avoid being diabetic and obese, he advised that people should monitor their blood glucose level regularly, be physically active, avoid excessive intake of calories, reduce food intake when confirmed over-weight as measured by body mass index of 25.0-29.9 kg/m^2, consume balanced diet – a little carbohydrate, some protein, herbs, vitamins and minerals in every meal.

Presenting a paper earlier titled "What can I do to prevent diabetes mellitus?" the Guest Lecturer Dr. Olubi Adesina (Consultant at

the Federal Medical Centre, Abeokuta) advised early diagnosis, regular testing of blood sugar to reduce the risk of long term complications from diabetes (Adesina, 2011). According to him, anyone can come down with diabetes pointing out that high risk of diabetes includes one's race which is common among blacks; listing age, ethnic group, heredity, hypertension, sedentary lifestyle and obesity as risk factors. Adesina (2011) outlined signs of diabetes as fatigue, slow healing of wound, impaired vision, skin infection, itching sensation, infertility and miscarriages in women, increased thirst, unusual weight loss, stroke and poor sexual performance; stating that for prevention, patients should exercise regularly to burn enough calories, maintain a healthy weight, consume a healthy diet with lots of vegetables, fruits and take a lot of water instead of sweet drinks.

In people with Type 1 diabetes, the pancreas cannot make insulin. They often present with unusual weight losses.

Source:http://www.medicinenet.com/type_1_diabetes_pictures_slideshow/article.htm

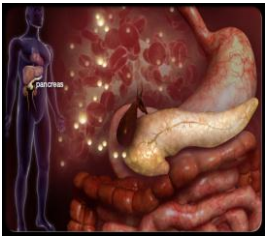


Plate 8a. Cases of diabetes

Foot ulcers. A=leg, B=toe. In Type 2 diabetes, cuts or sores that are slow to heal.
Sources: A:http://dermnetnz.org/site-age-specific/img/ulcer-ven1-s.jpg
B:http://www.woundcarespray.com/wpcontent/uploads/2010/04/diabetic_foot_ulcer_before.jpg

A B

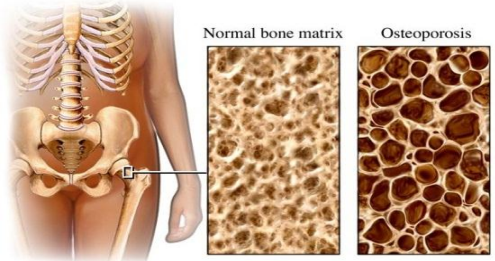
Plate 8b. Cases of diabetes

x) **Night blindness:** (Nyctalopia) is a disorder caused by low dietary intake of vitamin A. Vitamin A helps one to adapt to dim light in man thereby increasing visual sharpness because in the

presence of vitamin A, rhodopsin (the light-sensitive pigment in the rod cells of the retina) is formed. In vitamin A deficiency, there is (i) hyperkeratosis (excessive deposition of keratin of the epithelium of the eye cornea leading to eye irritation and dryness of the eye cornea resulting in blindness) (ii) Reproductive failure in male rats and foetal resorption in females (iii) Poor resistance to infection and stunted growth. Food sources are red palm oil, whole milk, butter fat, egg yolk fat, liver, fish, cod liver oil, tomatoes, pumpkin, spinach, paw-paw, carrots, peas, β-carotene which the body converts to retinol (vitamin A_1).

xi) **Rickets and Osteomalacia:** This is caused by the deficiency of vitamin D (calciferol) in diets consumed. Vitamin D increases the absorption of calcium and phosphorous from the intestine, and helps to transport intestinal calcium and phosphorous to parts of the body where they are used to build up strong teeth and bones. Vitamin D prevents rickets and osteomalacia, enhances normal growth, is needed for normal bone formation by increasing mineral uptake by the bone (mineralization).

In vitamin D deficiency (i) bones are not well formed and are softened (poor development of bones) due to poor calcium absorption and incorporation into bone tissues – a condition called rickets in children and osteomalacia in adults. (ii) Capillaries and bone-forming cells (osteoblasts) are not formed (iii) there is resorption of bone minerals (Ca and P), enlargement of wrists, knee, ankle joints, bowed legs and delay in teeth eruption in infants.



Rickets
Source:http://www.thachers.org/images/Rickets_family_1.jpg

Plate 9. Rickets in children and osteomalacia in adults. (Vitamin D deficiency) shown by poor development of bones.

Osteoporosis is characterized by low bone mass and structural deterioration. Normal homeostatic bone remodeling is altered – the rate of bone resorption is greater than the rate of bone formation
Source:http://www.austincc.edu/nursmods/evc/evc_lev3/rnsg_1247/musculoskeletal/documents/OsteomalaciaOsteoporosis.ppt

To prevent rickets/osteomalacia, eat food sources for vitamin D_3 (cholecalciferol) such as fish and cod liver oil, cheese, egg yolk, milk, butter and liver. Obtain vitamin D_2 (ergocalciferol) by irradiation of sterols in vegetables and grains (ergosterol) using UV light.

xii) **Red Blood Cell Hemolysis:** This is due to deficiency of vitamin E (α-tocopherol). There is no true disorder in humans due to daily dietary intake of vitamin E sources. In male rats and rabbits, deficiency causes nutritional muscular dystrophy (wasting of muscle fibres) and liver necrosis. In female rats, there is resorption of the foetus 9-12 days after conception. The tocopherols are good antioxidants and prevent oxidation of unsaturated fatty acids (oleic, linoleic, linolenic and arachidonic acids), protect vitamin A in foods from undergoing oxidation and enhance growth in rats. Unlike synthetic antioxidants butylated hydroxy anisole (BHA) and butylated hydroxytoluene (BHT), α-tocopherol is a natural antioxidant which prevents fats and oils from undergoing rancid. Vitamin E functions in reproduction and its administration during early gestation results in the birth of normal young. Plant food sources that prevent disorder are cereals (wheat germ, rice, maize), legumes (soy bean, African yam bean, cowpea), vegetable oils from (coconut, palm, groundnut, castor seed, fluted pumkin). Animal sources include liver, fish oils, butter, milk, egg.

xiii) **Hemorrhage:** This is caused by low dietary intake of vitamin K or its deficiency in diet, and occurs mainly in chicks and birds. Vitamin K_1, K_2 and K_3 are phylloquinone, menaquinone and menadione respectively. Hemorrhage is characterized by internal bleeding which may lead to death, delayed blood clotting time such that the removal of a few feathers from vitamin K deficient

chicks may cause them to bleed to death. Deficiency of vitamin K may also be due to prolonged intake of antibiotics that inhibit the growth of gut or intestinal bacteria that synthesize vitamin K to make its deficiency in humans and rats rare. In hemorrhage, there is decrease in the production of blood coagulation factors. Animal sources of vitamin K include fish meal, pig liver, cow milk, egg yolk while plant sources include alfalfa and cereals. Vitamin K is involved in liver synthesis of blood coagulation factors which prevent hemorrhage. Vitamin K reverses the action of anticoagulants such as dicoumarol and warfarin sodium (vitamin K antagonists which in animals produce hypoprothrombinemia) which prevent the normal functioning of vitamin K in the liver synthesis of prothrombin.

xiv) **Beriberi:** This may be dry/wet/infantile and is due to dietary deficiency in man of vitamin B_1 (Thiamine) and high carbohydrate intake in which only about 0.10-0.16 mg vitamin B_1 is supplied daily. In animals, beriberi is known as polyneuritis. In thiamine deficiency, there is impaired carbohydrate metabolism. Symptoms characteristic of beriberi are headache, muscle ache, constipation, anorexia (loss of appetite), loss of weight, tiredness, general body weakness (fatigue), degeneration of the blood pumping capacity of the heart, nausea, gastrointestinal upset and vomiting. Vitamin B_1 abolishes the symptoms of beriberi resulting in the normal functioning of the body. In the form of its coenzyme thiaminepyrophosphate (TPP), thiamine functions in carbohydrate metabolism.

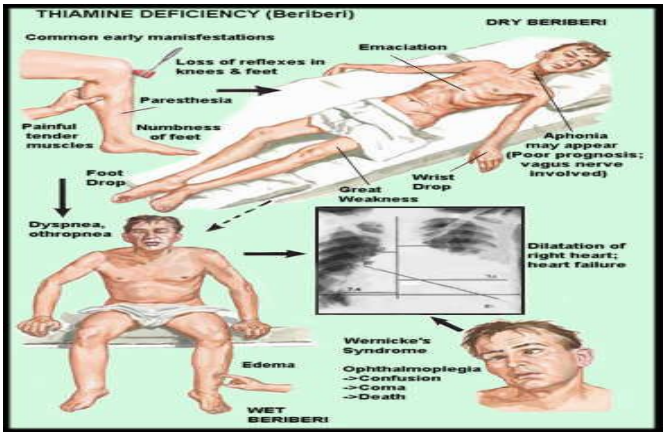


Plate 10. Patients suffering from Beriberi (vitamin B_1 deficiency).
Source: http://brain.otremba.org/images/beriberi1.jpg

Beriberi can be reversed by dietary intake of vitamin B_1 containing plant foods such as soy beans, orange juice, rice polishings, whole wheat bread flour, peanuts, potatoes and white/brown rice. Animal food sources of vitamin B_1 are cow milk, organs of beef and pork, cheese and eggs.

xiv) **Abnormal external (ectodermal) maintenance of tissues:** This results from deficiency of vitamin B_2 (Riboflavin), and is characterized by glossitis (inflammation of the tongue making its colour that of magenta), angular stomatitis (lesions of the lips and mouth) and scrotal and nose dermatitis in man. Vitamin B_2 promotes growth in man and animals; helps in keeping the lips, eyes, mouth and skin healthy; activates vitamin B_6 to convert tryptophan to niacin and helps in energy release in the cell because it is a component of flavinmononucleotide (FMN) and flavinadenine dinucleotide, FAD^+ (prosthetic groups of enzymes that are hydrogen transport carriers). The nutritional disorder can be prevented by intake of milk, liver, kidney, meat, eggs, yeast, polished rice, muscle, potatoes and wheat germ.

xv) **Pellagra (Rough skin):** This nutritional disorder in humans is caused by lack of vitamin B_3 (Niacin) in diets. Pellagra is characterized by diarrhoea, discolouration and scaling of the skin (dermatitis), pigmentation, dementia (disorder of the brain and nervous lesions). In dogs, deficiency results in black tongue syndrome which characteristics are similar to human pellagra. Niacin protects against pellagra in humans and black tongue in dogs and via its coenzyme forms (NAD^+, $NADP^+$), helps in energy generation in intermediary metabolism. Pellagra, which is common among humans who feed on maize or corn-based diets can be prevented or treated by intake of protein rich in the essential amino acid tryptophan which concentration is low in corn. Food sources that contain niacin that can be eaten to abolish pellagra are fresh fish, egg, milk, lean meat, crustaceae, organs (liver, heart, kidneys) as well as rice polishings, whole grains, legume seeds, green leafy vegetables and fruits.

Plate 11. Patients suffering from Pellagra (Rough skin or vitamin B_3 deficiency).
Sources: A&B:www.medicalook.com/Nutritional_supplement/Pellagra.html.
C:http://www.nutriweb.org.br/n0201/pelagra.gif

xvi) **Poor Conditional Reflex:** This occurs in man and dogs due to lack of vitamin B_5 (Panthothenic acid) in the diet. However, in man this disorder is rare because vitamin B_5 is widely distributed in plant and animal foods. In rats, there is poor growth and inability of implantation to occur (reproductive failure). In dogs, there is loss of conditional reflex, hypoglycemia, respiratory problems leading to convulsion, coma and eventual death. Vitamin B_5 helps to maintain normal conditional reflex thus ensuring good mental health. Excellent food sources among others are yeast, liver, eggs, skim milk, sweet potatoes, meat, fruits and vegetables.

xvii) **Variable Nutritional Specie-dependent Disorders:** This is caused by deficiency of vitamin B_6 (pyridoxine). In man, disorder is rare but in infants there is convulsion due to loss of the vitamin of infant formula during processing. In rats, there is dermatitis, oedema, convulsion and abnormal growth. Deficiency results in anaemia in dogs and dermatitis especially in new world monkeys. Vitamin B_6 prevents microcytic hypochromic anaemia and dermatitis and in infants, protects against convulsive seizures and promotes growth. Food sources that prevent the disorder include rice bran or polishings, yeast, egg yolk, liver, vegetables, whole grains, meat and kidney.

xviii) **Pernicious Anaemia:** In humans, dietary deficiency of vitamin B_{12} (cyanocobalamine) is rare, but individuals consuming diets

that lack this vitamin and animal products develop pernicious anaemia which is characterized by decreased red blood cells, impairment of nervous system and poor gastric secretion. In rats and chicken, deficiency of vitamin B_{12} results in poor growth and eventual death. Vitamin B_{12} is required for normal growth and protects against pernicious anaemia since it aids the formation of mature red blood cells. Animal food sources that prevent pernicious anaemia include liver, kidney and fish. Plant foods lack vitamin B_{12}.

xix) **Scurvy:** This nutritional disorder is due to lack of vitamin C (Ascorbic acid) in diets consumed by man, guinea pigs and other primates. Scurvy is characterized by the rupture of blood capillaries, hemorrhage, oedema, inability of collagen to form and wounds to heal, loss of weight, bleeding and inflammation of the gums, painful swelling of the joints and low blood tension as well as poor tooth development. There is failure of osteoblasts of the bone to form osteoid needed for the deposition of bone salts to prevent the formation of weak bone that fractures easily. Scurvy can be prevented by intake of foods containing ascorbic acid such as tomatoes, potatoes, spinach, beans, mango, fresh green pepper, guava, juices of citrus fruits (oranges, limes, lemons). **Note:** Animal products contain little amount of ascorbic acid due to losses during heat processing.

Scorbutic gums (Gingival haemorrhage)
Source:http://www.monzy.com/s

Periungual hemorrhage
Source:http://www.nlm.nih.gov/medlineplus/ency/imagepages/2344.htm

Corkscrew hairs
Source:http://www.nlm.nih.gov/medlineplus/ency/imagepages/3036.htm

Plate 12. Patients suffering from scurvy (vitamin C deficiency)

xx) **Poor growth, dermatitis and muscle pains:** These occur in humans, rats, chickens and monkeys that consume diets deficient in vitamin H (Biotin). In biotin deficiency, there is weight loss, irritability, swollen mouth and hair loss in hamsters. The practice of drinking raw egg should be discouraged because it could result in severe biotin deficiency. Avidin in raw egg white binds to biotin to form biotin-avidin complex making the biotin unavailable for cell utilization. Prevention of the disorder due to biotin deficiency can be achieved through dietary intake of egg yolk, liver, kidney, yeast, milk, nuts, grains and vegetables.

An advantage in man is that bacteria in the large intestine synthesize large amount of biotin thereby lowering dietary intake.

xxi) **Macrocytic/Megaloblastic Anaemia:** Deficiency in diet of folic acid (folacin) causes the disorder. Folic acid was formerly called vitamin M (a hematopoietic factor for monkeys), vitamin BC (chick growth factor), vitamins B_{10} and B_{11} as well as factor R (bacterial growth factor). The deficiency of folic acid results in the formation of megaloblastic cells containing abnormal levels of DNA, and which in the bone marrow, matures leading to anaemia due to decrease in red blood cell synthesis.

Folic acid is involved in normal red blood cell formation and prevents anaemia. Food sources of folic acid are liver, kidney, fresh fish, yeast, grains and green leafy vegetables.

Malnutrition

Malnutrition is a condition that develops when the body does not obtain the right amount of nutrients. It refers to insufficient, excessive or imbalance in the consumption of nutrients. People who suffer from malnutrition are said to be malnourished. Malnourished individuals consume enough calories, but not enough specific essential nutrients. Poverty affects at least 1 billion people (16.7% of the world's population) and is the main cause of undernourishment and malnourishment. Although poverty is a problem in developed nations, it is in the

developing countries of Asia, Africa and Latin America where hunger is common, that you find the world's most poorest people who do not own land on which to grow food and have no money to purchase food. According to the United States Report, as at 31st October, 2011, the world's population was 7.0 billion and Nigeria was ranked the 6th most populous nation with a population of 167 million people. It was reported by the Africa Independent Television News of Monday, 27th February, 2012 that 112 Million Nigerians are poor. Based on this report, 67.1% Nigerians are poor.

In developed nations (Europe, North and South America), malnutritional disorders are most often associated with nutritional imbalances or excessive consumption rather than insufficiency of nutrients in diets. Corn provides carbohydrate and protein and this does not mean that a diet heavy in corn is a healthy one, because corn lacks two essential amino acids, lysine and tryptophan required for normal growth and development. Quantity of food refers to producing enough calories while quality involves producing food with the appropriate nutrients. Malnutrition occurs in people who are either undernourished or overnourished.

Some Terminologies Associated with Malnutrition

i) **Undernourishment:** This results from consuming too few essential nutrients or using/excreting them more rapidly than they can be replaced, bringing about nutrient deficiency disorders such as kwashiorkor, marasmus, avitaminosis and mineral deficiency diseases. Underconsumption refers to the long term consumption of insufficient sustenance in relation to the energy that an organism expends, resulting in poor health. In developing nations, you mainly find individuals who consume fewer calories in their diets than they need, and are hence said to be undernourished.

The main cause of undernourishment and malnourishment which affects at least one billion people in the world is poverty. In 2008, the Food and Agriculture Organization (FAO) of the United Nations estimated that 850 million people (about 13% of the world's population) suffer from undernutrition.

ii) **Overnourishment:** Overnutrition or overnourishment is the most prevalent form of malnutrition in America, and results from eating too much of wrong foods. Over consumption is the long term eating of excess sustenance in relation to the energy that an organism expends, leading to poor health, as in obesity in humans. Overnourishment is the main nutritional problem not only in America but in other developed nations. In these nations you mainly find people who consume food in excess of their nutrient requirements and are said to be overnourished. They also consume diets high in carbohydrate, fats and salt.

Foods that result in overnourishment include junk foods found in fast food restaurants especially those containing white sugar and many nutrients and not taking enough exercise. Junk food is a slang name for food item which is low in, or contain limited nutritional value. It includes foods high in salts, fats, sugars, additives and calories, and low in nutrient composition. Acute overeating is a symptom of eating disorder.

An excess intake of fat-soluble vitamins A and D for example could be toxic. The junk foods are presented by the manufacturers in such a way as to maximize taste and flavour and minimize nutritional value and this results in "empty calories". Like white sugar, the process of refining white flour used to produce white bread causes the leaching out of most of the nutrients, that it is possible to have "zero fat" cookies sweetened with white sugar which turns to fat as soon as the body digests it (Anderson and Barbara, 1995; <http://www.nutrition.gov/>

iii) **Balanced and Unbalanced Diet:** A balanced diet is one which contains all the essential nutrients in required proportion with water and roughage.A diet is said to be unbalanced when too much of one or more nutrient(s) is/are present in the diet to the exclusion of the appropriate amount of other nutrients.

iv) **Clinical Nutrition:** This deals with the application of nutrition in health and disease. It is the nutrition and management of in-patients in hospitals and out-patients at clinics. Clinical nutrition incorporates the scientific fields of both nutrition and dietetics

that aim to keep in patients, a balance in energy as well as providing a balanced amount of nutrients in the diets consumed by the patients.

In methods of clinical nutrition, the preferred route of administration is oral intake of diets. Alternative methods include enteral administration in nasogastric feeding and intravenous administration in parenteral nutrition.

v) **Clinical Malnutrition:** This refers to insufficient, excessive or imbalanced consumption of nutrients by in-patients in hospitals and out-patients at clinics. Clinical malnutrition may be caused by diseases, injuries and/or aging and by difficulties with the ingestion of food such as dementia (loss of memory), stroke, depression and dysphagia. These may be worsened by iatrogenic factors or inability of the health care entity to compensate for the aetiology of malnutrition. Many nutritional disorders/diseases require clinical nutritional approach in their management. These disorders (kwashiorkor, goiter, obesity, marasmus, beriberi, scurvy, rickets) may have arisen either as a result of starvation, undernutrition, overnutrition and nutrient deficiency. Criteria for the classification of clinical malnutrition are embodied in Table 6 below.

Table 6: Classification of Clinical Malnutrition

Patients	Criteria for Clinical Malnutrition
(a) Moderately undernourished (any of the two criteria)	(i) Body mass index of 20.1-22.0kg/m^2 (ii) 5-10% unintentional weight loss in the past six months.
(b) Severely undernourished (any of the three criteria)	(i) Body mass index less than or equal to 20kg/m^2 (ii) Greater than or equal to 5% unintentional weight loss in the past one month. (iii) Greater than or equal to 10% unintentional weight loss in the past six months.

Source: Kruizenga et al. (2010).

Nutritional Disorders due to Mineral Deficiency

Minerals are inorganic substances originating from rocks and ores which enter the food chain through the soil. There are 18 mineral nutrient elements which are classified as major or minor (trace) elements. The major minerals are calcium, phosphorous, sodium, chlorine, magnesium, potassium and sulphur. The minor ones are cobalt, copper, fluorine, iodine, manganese, molybdenum, selenium, zinc, chromium and nickel. These minerals function generally as components of the skeleton, in protein synthesis, oxygen transport, fluid and acid base balance in the body as electrolytes and as metal cofactors in enzyme reactions. Both deficiencies and excesses of these minerals can lead to diseases or nutritional disorders. Humans obtain minerals by eating plants grown on mineral-rich soils or by consuming animals that have fed on these plants. Some of these disorders are

(i) **Rickets and osteoporosis:** This is due to calcium defiency in diets. Long term calcium deficiency leads to rickets, and in menopausal women, it can lead to osteoporosis in which the bone deteriorates resulting in increased risk of fractures. Trace amounts of calcium are essential to blood clotting, intracellular signaling and muscle contraction. Large amounts are required in stronger, dense bone and teeth formation and in the diet especially during infancy, childhood and pregnancy.

Over retention of calcium or high calcium intake or absorption causes hypercalcaemia (elevated level of calcium in the blood), development of kidney stones, impaired kidney function, nausea, vomiting, constipation and increased urination. Food sources to prevent deficiency are vegetables, fruits.

(ii) **Iron Deficiency Anaemia (IDA):** This is due to inadequate iron intake in foods consumed. The groups most prone to the disease are infants, children, pre-menopausal women or women of child-bearing age. Iron is a component of haemoglobin, cytochrome and myoglobin. As haemoglobin, iron carries oxygen from the lungs to the tissues. Lack of sufficient iron in blood is a reason that some people cannot donate blood. Symptoms of IDA are fatigue, hair loss, weakness, irritability and brittle or grooved

nails. This IDA (severe lack of iron stores in the body resulting in low haemoglobin concentration) is the most widespread micronutrient deficiency affecting human health and well-being, work capacity and reproductive performance of individuals.

Excess iron or iron overload disorder is a disease caused by over-accumulation of iron in the body which affects the heart, liver and endocrine glands. IDA can be prevented by adequate intake of iron from the diets consumed. Food sources of iron include red meat, poultry, insects, beans, fortified bread, breakfast cereals and leafy vegetables.

(iii) **Keshan Disease:** This is caused by selenium deficiency, and also occurs in people who consume foods grown from selenium deficient soils.

(iv) **Growth Retardation:** This is due to deficiency of zinc in diets. In children, there is also impotence and delayed sexual maturation, diarrhoea, susceptibility to infection and death. Deficiency may be due to low dietary intake, malabsorption, chronic kidney and liver diseases, diabetes, sickle cell disease, eye and skin lesions and poor appetite. Food sources of zinc that prevent zinc disorder are soy foods, cooked dried beans, nuts, fortified cereals, peas and seeds.

(v) **Hypertension:** This is caused by lack of magnesium in diets. Excess magnesium causes weakness, nausea, vomiting, impaired breathing and hypotension. Note that calcium, magnesium and phosphorous are the major constituents of bones. Food sources of magnesium include fruits, nuts and vegetables.

(vi) **Hyponatremia:** This is low level of sodium in blood caused by inadequate sodium in diets consumed. Excessive sodium intake causes hypernatremia and hypertension. Excess water intake without replenishment of sodium and potassium salts also causes hyponatremia which can lead to water intoxication.

(vii) **Hypokalemia:** This is low level of potassium in blood due to deficiency of the mineral in foods consumed. Excess potassium in diets causes hyperkalemia and palpitations. Both potassium and sodium control water balance in the body.

Toxicology

Toxicology is a branch of medical science that deals with the type, nature, reactions and effects of toxins or poisons. In the biomedical sciences, toxicology deals with the adverse effects in humans resulting from exposure to drugs and other chemical substances. Human beings live in environments where hundreds of chemicals abound, and they ingest, inhale or absorb a number of these chemicals. Monosson (2006) defined toxicology as the dynamic interaction of chemicals with living systems. Toxicologists investigate how chemicals interact with biological systems by focusing on the adverse effects and outcomes caused by such interactions (http://www.eoearth.org/article/toxicology).

Historically, toxicology began with the early cave dwellers who recognized poisonous plants and animals and used their extracts for hunting or in warfare, and by 1500 B.C, written evidence showed that hemlock, opium, arrow poisons and certain metals were used to poison enemies or for state executions. By 1500 AD, Paracelsus determined that specific chemicals were actually responsible for the toxicity of a plant or animal poison, and stated that the response of the body to those chemicals depended on the dose received. From his studies, it was evident that small doses of a substance might be harmless whereas large doses could be toxic, and this is presently known as the "dose-response relationship" which is a major concept of toxicology. Vice-Chancellor Sir, Paracelsus is often quoted for his statement that "All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy" I agree with this statement because people have even died of water intoxication.

A Spanish physician, Orfila is often referred to as the founder of toxicology because he was the first to establish a systematic correlation between the chemical and biological properties of poisons of the time. By 1800 AD, he demonstrated effects of poisons on specific organs by analyzing autopsy materials for poisons and their associated tissue damage.

By the 20th century, the knowledge of toxicology and toxic effects of chemical agents on organs and cells had advanced with the discovery of the molecule of life, DNA, and is now being revealed at the molecular

level with virtually all toxic effects caused by changes in biochemicals and specific cellular molecules (Monoson, 2006).

Some Branches of Toxicology

Toxicology is a broad discipline that cannot solely be dealt with in this lecture, and hence a few branches and terminologies used are stated based on current knowledge and reports by Monosson (2006) and Plaa (2007).

(a) **Environmental Toxicology:** This deals with the adverse effects of chemicals present as pollutants of the air, water and soil to biological systems. Biologic targets to these pollutants are human beings, terrestrial and aquatic lives. The Food and Agriculture Organization of the World Health Organization (FAO/WHO) Joint Expert Commission on Food Additives has adopted the term "acceptable daily intake (ADI)" to denote the daily intake of a chemical which, during an entire lifetime, appears to be without appreciable risk.

(b) **Ecotoxicology:** This deals with the impact and toxic effects of chemical and physical agents on the populations and communities of living organisms within an ecosystem. Ecotoxicology differs from environmental toxicology in that an environmental process may exert severe effects on individual organisms, without having important impact on populations or on an ecosystem.

(c) **Occupational Toxicology:** This branch of toxicology deals with the study on chemicals found in a work place. The task of an occupational toxicologist is to identify the chemical agents, define the conditions for their safe use and prevent the absorption by the body of amounts that may cause harm. The American Conference of Governmental Industrial Hygienists periodically prepares lists of recommended threshold limit values (TLVs) for about 600 such chemicals, and these guidelines are re-evaluated as new information become available (Doull, 2001).

(d) **In Vitro Toxicology:** *In vitro* is "in glass or in the test tube" and it is different from *In vivo* or in the cell". This is the study of the

effects of toxic chemical substances on cultured bacteria or mammalian cells, and is employed primarily to identify potentially hazardous chemicals and/or to confirm the lack of certain toxic properties in the early stages of the development of potentially new useful substances such as therapeutic drugs, agricultural chemicals and direct food additives (http://en.wikipedia.org/wiki/ Invitrotoxicology, 2011). The *in vitro* toxicity testing can be a useful, time and cost-effective supplement to toxicity studies in living animals, especially now that animals cannot be used for laboratory experiments without ethical clearance from the "Animal Rights Group".

(e) **Aquatic Toxicology:** This is the study of the effects of manufactured chemicals and other anthropogenic and natural materials and activities on aquatic organisms at various organizational levels from subcellular via individual organisms to communities and ecosystems (Rand and Petrocelli, 1985). In addition to analytical testing for known pollutants, aquatic, whole effluent toxicity tests have been standardized and performed routinely as a tool for evaluating the potential harmful effects of effluents discharged into surface waters (United States Environmental Protection Agency, Whole Effluent Toxicity) (http://www.epa.gov/waterscience/methods/wet)

(f) **Food Toxicology:** This is the study of the types, nature, properties and effects of toxic substances found in natural or synthetic association with food. Vice-Chancellor Sir, of the different areas of toxicology explained so far, I wish to narrow down this lecture to food toxicology which is part of my field of specialization as a Nutritional Biochemist and Toxicologist.

Some Terminologies used in Toxicology

i) **Toxicant:** This is a chemical or physical substance that produces adverse biological effects (acute or chronic) of any nature. It may also be referred to as a xenobiotic or a chemical that is foreign to living organisms. The location in the body where these chemicals interact to cause adverse effects is known as the target tissue or

the site of action. Toxicants may affect only specific tissues or organs and not the whole body. These specific sites are known as the target organs or target tissues.

ii) **Toxin:** A toxin is a specific protein produced by a living organism such as plant or animal which exhibits immediate effect on an organism. Examples are mushroom toxin, and tetanus toxin. Organic toxins are large molecules which occur in living organisms and can be synthesized as well as be obtained from natural sources. Inorganic toxins are specific chemicals (minerals) that are not obtained from living systems.

iii) **Poison:** This is a toxicant that causes immediate illness or death when it is taken into the biological system in very small amount.

iv) **Toxic Agent:** This is any physical, chemical, or biological substance that produces an adverse biological effect. Example of a physical toxic agent is radiation; chemical toxic agent is cyanide and biological toxic agent is snake venom.

v) **Toxic Organisms:** If an invading organism excretes chemicals which is the basis for toxicity, the excreted substances are called biological toxins and the organisms are referred to as toxic organisms. Example is tetanus which is caused by a bacterium, *Clostridium tetani*. The latter does not cause disease by invading and destroying cells. It is the toxin (neurotoxin) excreted by the bacterium that travels to the nervous system that produces the disease.

vi) **Toxic Substance:** A toxic substance is a material which has toxic properties and even in low concentrations, results in abnormal metabolism in the organ such as the liver. It may be a discrete toxic chemical or a mixture of toxic chemicals, for e.g. lead chromate, asbestos and gasoline are all toxic substances. Lead chromate is a discrete toxic chemical. Asbestos is a toxic material that does not consist of an exact chemical composition, but a variety of minerals and fibers. Gasoline is a toxic substance rather than a toxic chemical because it contains a mixture of many chemicals. Toxic substances may not always have constant composition, and the composition of gasoline for example varies with the octane level, manufacturer and season

(http://www.eoearth.org/article/ toxicology). A toxic substance may be a **systemic toxicant** or organ toxicant. A systemic toxicant is one that affects the entire body or many organs rather than a specific site. For example, potassium cyanide (KCN) is a systemic toxicant because it affects virtually every cell and organ in the body by interfering with the ability of the cell to utilize oxygen.

vii) **Potency of a Chemical:** The potency of a chemical or its level of toxicity depends on its movement through the body to the target tissue (toxicokinetics), its ability to interact with the body to cause harm (toxicodynamics), and the dose the body receives (level of exposure). The concentration of a chemical that reaches the target tissue is a function of its kinetics, dynamics and exposure level and both the kinetics and dynamics depend upon the current biochemical status (enzyme concentration during the time of exposure and nutritional status) of the living organism.

viii) **Median Lethal Dose:** This is the dose of a chemical or drug required to kill 50% of the experimental animals or test population. It is denoted by LD_{50} defined over a period of time. These studies are called lethality studies and the most common LD_{50} test is the acute toxicity test. Here, experimental animals (rats) are given a single dose of a chemical and the LD_{50} is determined over a 24 hour period of time. Lethality test is used to provide insight into the relative potency of new chemicals (http://www.eoearth.org/ article/toxicology).

ix) **Hazard:** This is the ability of a chemical agent to cause injury or harm in a given situation. In order to assess hazard, the knowledge of the toxic effect of the hazardous substance and the concentration to which individuals are liable to be exposed is important.

x) **Risk:** This is the expected number of times (frequency) of occurrence of undesirable effect due to exposure to a chemical or physical agent. Dose-response data are used in the estimation of risk.

xi) **Route of Exposure:** Inhalation is the major route of entry of chemicals and atmospheric pollutants such as gases (SO_2, H_2S) into the body. There is also oral ingestion which is a minor route. For soil and water pollutants (e.g. heavy metals), the major route of exposure for human beings is oral ingestion.

xii) **Time of Exposure:** Toxic reactions differ based on the duration of exposure. Time of exposure is the duration of exposure of a test organism to a test solution. Single or multiple exposures that occur(s) over 24 or 48 hours denote acute exposure resulting in acute toxicity while multiple exposures occurring over a longer period of time represent a chronic exposure that brings about chronic toxicity.

Toxicity: This is the ability of a text substance (poison, toxicant) to cause adverse and undesirable effect on living systems. Toxicity is a function of the dose administered, the exposure concentration and duration of exposure.

Dose: This is the amount of a toxicant or poison or chemical agent that an organism receives into its system.

Lethal Concentration: This is the concentration of a toxic factor that causes death in a specified proportion of test organisms and is usually expressed as LC. LC_{50} is the concentration that kills 50% of exposed organisms at a specific time of observation, say 96 hours.

Inhibiting Concentration: This is toxicant concentration that impairs the activity of a biosystem. It is represented by IC such that IC_{75} is the concentration that will, for example, cause 75% impairment in the growth of fish relative to control.

Effective Concentration: This is denoted as EC and is the concentration of a toxicant estimated to cause a known sublethal effect in a given proportion of test organisms under a specified time such as 48 or 96 hr. A 48-hour EC_{25} is the effective concentration for 25% of the test organism in 48 hour for a change in biological activity. The sublethal effect may be loss of balance or change in respiration.

Toxicants in Natural Association with Foods

Natural Toxicants in Foods: These are called biological toxicants or endogenous dietary toxins found naturally in plant foods which interfere with the processes of living cells and tissues. They are also known as antinutritional factors. It has been reported that a major factor that limits the wider use of tropical plant foods is the widespread occurrence in them of a diverse range of natural compounds capable of precipitating deleterious effects in man and animals, and manifestations of toxicity range from severe reduction in food intake and nutrient utilization to profound neurological effects and even death (Osagie, 1998).

The toxic factors are widely distributed in the plant kingdom and in all parts of the plant, but the seed contains the highest concentration of the toxicants. The toxicants are found in roots and tubers, cereal grains, leafy vegetables, nuts and seeds and fruits with a more complex array of these antinutritional factors found in tropical legumes than any other species of crops.

Osagie (1998) reported that knowledge of toxic substances present in plant foods are useful in that (i) the toxicants are recognized as components of diet of humans and domestic animals and affect the overall nutritional value of foods (ii) it helps dieticians to avoid recommending foods that their patients cannot tolerate possibly because of inability to metabolize or detoxify certain substances therein (iii) amounts of certain substances that are relatively safe when consumed alone can sometimes, when taken together, have serious and even fatal effect e.g. tannins in a protein-marginal diet (iv) food regulatory bodies and public health authorities need to be informed about possible dangers related to widespread, long standing practice previously regarded as safe. For example, cassava has been consumed in the tropics for a long time without apparent consideration for the high cyanide content.

NATURAL TOXICANTS, THEIR DISTRIBUTION IN PLANTS AND PHYSIOLOGICAL EFFECT

1. **Protease inhibitors:** These are toxic proteins which constitute the most potent inhibitors and the most studied toxicants in plant foods. Examples are (i) trypsin inhibitors in legumes

(cowpea, groundnuts, African yam bean, bambara groundnut) and in eggs. (ii) Chymotrypsin inhibitor in potatoes (iii) Papain inhibitor in soybean, broad bean and egg white (iv) Elastase inhibitor in kidney bean (v) amylase inhibitor in wheat, mangoes and banana. These inhibitors have growth depressing effect in rats, mice and humans. Mechanisms of action of protease inhibitors is that of their ability to form stable complexes with the enzyme; the irreversible complexes undergo many types of enzyme-substrate complex interactions that bind the protein, making it unavailable for digestion to release the constituent amino acids of protein required for growth. For example,

Trypsin + trypsin inhibitor → Trypsin-trypsin inhibitor complex
↓Protein
Trypsin – trypsin inhibitor – protein – complex.

The presence of protease inhibitors in foods that we consume result in pancreatic hypertrophy (enlargement) and hyperplasia.

2. **Lectins:** These are toxic proteins that can bind specific sugars or glycoproteins – a reaction shown *in vitro* by the clumping or agglutination of erythrocytes (red blood cells) from various animal species, for which reason, they are also known as haemagglutinins. Lectins are found highest in cowpea (*Vigna unguiculata)* (2.17g/kg) followed by pigeon pea (*Cajanus cajan)* (1.28g/kg) and then soybean (*Glycine max)* (0.95g/kg) as reported (Ikegwuonu and Bassir, 1976a). Lectins also occur in lima beans (*Phaseolus lunatus*).

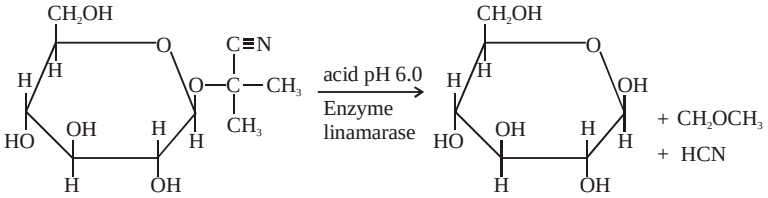
Physiological effects of lectins include:
(i) They cause the clumping of red blood cells.
(ii) They bind to the epithelial cells lining the small intestine resulting in severe growth depression and death.
(iii) Their toxicity stem from the production of intestinal lesions and histopathological changes in organs (liver, lungs, kidney and heart).

(iv) Oedema and fatty infiltration of the liver.

3. **Cyanogenic glycosides:** These are compounds which on hydrolysis by an enzyme or acid, produce toxic hydrogen cyanide. They include linamarin, lotaustralin and amygdalin. Linamarin (95%) and lotaustralin (5%) occur mainly in bitter cassava roots and leaves and not the sweet cassava. They occur in legume seeds (soybean, cowpea, African yam bean etc), yams, sorghum, sweet potatoes, lettuce and peas, while amygdalin occurs in almond, pear and the apples. In terms of chemical structure for linamarin and lotaustralin in particular, one of the methyl groups ($-CH_3$) in linamarin is replaced by an ethyl group ($-C_2H_5$) to obtain lotaustralin. Hence;

(i) Hydrolysis of linamarin produces glucose, dimethyl ketone and hydrogen cyanide (HCN).

(ii) Hydrolysis of lotaustralin produces glucose, ethylmethyl ketone and HCN



The consumption of foods containing cyanogens could cause acute or chronic cyanide toxicity. Acute toxicity is fatal resulting in a high rate of mortality and morbidity, while chronic toxicity has been linked to goitre (Ekpechi, 1967) and tropical ataxic neuropathy (Osuntokun, 1972) which is due to demyelination of the nervous tissues. In the mitochondrial electron transport chain, HCN, which is consumed as part of our diet inhibits the enzyme, cytochrome C oxidase, thereby hindering the transport of electrons to molecular oxygen to form water. The resultant effect is respiratory failure and death.

4. **Oligosaccharides:** These are carbohydrates which contain three to eight monosaccharide units linked together by glycosidic bonds. They are widely distributed in legumes, roots and tubers. Major producers of flatulence when these foods are eaten are raffinose, starchyose and verbascose. Man and animals lack the enzyme α-1,6-galactosidase in their intestinal mucosa, and hence cannot digest these oligosaccharides . When the legume source is not properly cooked and eaten, the raffinose oligosaccharides are found undigested, pass into the wall where intestinal bacterial fermentation occurs producing gases mainly hydrogen and carbon(IV)oxide, and hence flatulence (Wagner et al., 1976; Fleming, 1981). The reaction of these gases with water produces acid resulting in stomach discomfort, but the acidity can be neutralized by the intake of mist mag (magnesium trisilicate). Flatulence is accompanied by frequent belching, abdominal distention and pain, release of nauseating gas, diarrhoea and weakness.
5. **Dhurrin:** This is a poisonous natural compound found in millet and in the shoots, seeds and roots of sorghum and in local foods and beverages produced from sprouted sorghum grains. Its presence in these food materials detracts from their full nutritional potentials.
6. **Saponins:** These are glycosides found in sugar cane, pea, soybean and sugar beets, millet, bitter kola, mango, plantain, walnut, cocoyam tuber, pigeon pea and lima bean with high foaming capacity, and hence used to generate foam in beer. They have bitter taste. Deleterious effects of saponins include their hemolytic effect on red blood cells. They are cytotoxic and affect intestinal permeability. However, the beneficial effect of saponin is that it has cholesterol-lowering property (Oakenful and Sidhu, 1989). Since your life is in your hands, it will be your decision to consume or desist from foods high in saponin content.
7. **Favism:** This is induced by glycosides found in faba beans. The glycoside alters the membrane permeability of red blood cells leading to rupturing tendencies and hemolytic anaemia found associated with the favism-inducing glycosides.

8. **Gossypol:** It is a plant phenolic complex structure found in cotton seed and cotton seed oil which is toxic to various animal models. Symptoms of its toxicity include loss of body weight and apetite, diarrhoea, hemolytic anaemia and impairment of blood clotting mechanisms. Physiological effect is that it interferes with the digestion of proteins.

9. **Mycotoxins:** These are toxic substances produced as fungal metabolites. The search for environmental contaminants responsible for the high cancer frequency in Nigeria had inadvertently focused attention mainly on the presence of mycotoxins (Bababunmi et al., 1977). Most studied mycotoxin is aflatoxin which is produced by the fungus that belongs to the Aspergillus species. Aflatoxins are designated AFB_1, AFB_2, AFG_1, AFG_2 to show their fluorescence in blue or green UV light. Aspergillus species (which produce Aflatoxins) grow on foods (rice, groundnuts, garri, beans, yams) containing major nutrients and water. It also grows as mould on **moist bread** left for sometime. The practice in the village whereby consumers use knife to cut off the mould and eat the bread should be discouraged, because what they are consuming is aflatoxin that has permeated the entire loaf of bread. Aflatoxins are hepatotoxic (toxic to the liver), carcinogenic, prolong blood clotting time and produce osmotic swelling of the mitochondria thereby affecting biochemical pathways that generate energy.

Plate 13. A man in a Nigerian village cutting off mould that has grown on a N250.00 loaf of stale bread prior to consumption

10. **Goitrogens:** are toxins which cause goitre in animals and humans by interfering with iodine utilization. They are usually called glucosinolates, because on enzymatic hydrolysis/breakdown, they produce glucose, a sulphur containing group and isothiocyanate. The breakdown of isothiocyanate produces the main toxic factor, hydrogen cyanide (HCN). Goitrogens occur in vegetables, kale and cabbage.
11. **Alkaloids:** These are a class of basic, aromatic, nitrogen-containing plant products which have complex structures and possess significant pharmacological properties. They are found in some species of bitter yam, kola nuts, *Mucuna pruriens*, cocoa beans which contains the alkaloid theobromine, potato which contains the steroidglyco alkaloid e.g. solanine that interferes with transmission of nerve impulses and is hemolytically active and toxic to humans causing neurological disorders and gastrointestinal upsets. Examples of alkaloids are morphine, cocaine, nicotine (a stimulant whose metabolite N-nitroso nicotine is a potent carcinogen), indometacin, caffeine, heroin, etc.

12. **Oxalate:** is a two-carbon dicarboxylic acid anion produced and accumulated in crop plants as soluble salts of sodium, potassium or ammonium oxalate. It also occurs as oxalic acid or as insoluble calcium oxalate in vegetables (spinach) cocoa, tea, yams, cocoyams, fruits, sweet potatoes. Oxalate interferes with mineral availability by binding to divalent cations (Ca^{2+}, Mg^{2+}, Zn^{2+}) making them unavailable for cell utilization. Calcium oxalate crystals in food crops cause acridity irritating to the digestive tract when the foods are eaten. High concentration of oxalate in the diets we consume can increase the risk of kidney calcium absorption, resulting in renal calculus or kidney stone and hence, oxalate poisoning.
13. **Tannin:** It is any polyphenolic compound having a molecular weight greater than 500. There is hydrolysable tannins (those that can be hydrolysed into carbohydrate mixture and phenols)

and condensed tannins, which are complex polymers. Tannins occur in root crops, legumes, cowpea, lima bean, pepper, fruits, various yam species, sorghum, plantain, sweet potatoes, millet, maize, breadfruit, star apple, raphia palm (peel and pulp). Although tannins play a major role in the plant's defense against fungi and insects, they have the following deleterious effects as reported (Butler, 1989).

(i) Tannins decrease protein quality by interfering with protein digestibility and palatability.

They cause damage to the intestinal tract, and interfere with the absorption of iron, and its toxicity may result in a carcinogenic effect.

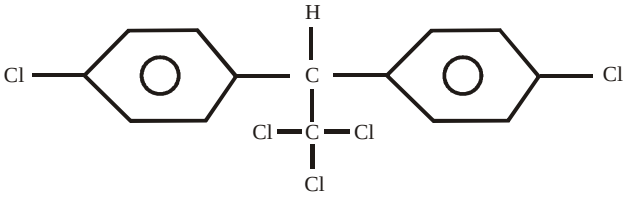
14. **Phytate:** Phytic acid is a hexaphosphate derivative of inositol and is a form in which phosphorus is stored in plants. It is found in tubers and roots, cereals, vegetables, most legumes such as soya bean, then in palm kernel seed and cotton seed meal. It forms insoluble salts with divalent metal ions (calcium, magnesium, iron and zinc), and hence interferes with mineral availability since it renders the minerals unavailable for absorption into the body. Phytate also affects protein digestibility by binding with proteolytic enzyme and forming a chelate with divalent metals.

15. **Other Toxicants:** These include avidin in egg white which is a biotin antagonist, and citral found in orange peel as a vitamin A and C antagonist. In linseed meal is linetin which interferes with vitamin B6 (pyridoxine) utilization. *Lathyrus sativus* used as cattle feed and in making bread in the absence of wheat can cause a neurological disease (lathyrism). Lathyrism is characterized by a feeling of heaviness of the legs and weakness. The disease is caused by the toxic agent (β-amino propionitrile) in the seeds of *Lathyrus sativus*.

Environmental Toxicants/Contaminants in Foods

These are toxic factors found in the environment (air, water, soil) which interact with the foods we consume. They include:

(i) Pesticides: They destroy pests such as mosquitoes, cockroaches etc. Example is such as dichlorodiphenyltrichloroethane (DDT) which is toxic to humans but mosquitoes can metabolize active DDT to inactive compound that is not toxic to them.



Dichlorodiphenyltrichloroethane (DDT)

The organo phosphorus compound parathion (an insecticide) is non-toxic, but insects (mosquitoes) metabolise it to the toxic compound, paraoxon.

(ii) Herbicides are used to kill weeds, examples are 2, 4-dichlorophenoxy acetic acid and 2,4,5-trichlorophenoxy acetic acid, and in the process of using them, they get into foods and are consumed by humans.

(iii) Rodenticides kill rodents. Example is α-naphthylthiourea which is not toxic, but is metabolized to produce toxic hydrogen sulphide that can poison the respiratory system.

Environmental Contaminants

These are chemicals found in the environment in which food is grown, harvested, transported, stored, packaged, processed and consumed. The physical contact of the food with its environment results in food contamination. Possible sources of food contamination are:

(i) Soil which contains perchlorates, toxic heavy metals (cadmium, nickel, mercury, arsenic etc).

(ii) Water due to the presence of mercury, arsenic etc.

(iii) Air which contains polycyclic aromatic hydrocarbons, radionuclides such as ^{90}Strontium and ^{137}Caesium.

(iv) Processing and cooking equipment which are the sources of copper, cleansing agents, lubricants, etc.

(v) In air, soil and water are polychlorinated biphenyls (PCB) and polybrominated biphenyl ethers (PBBE) and dioxins.

(vi) Packing materials which contain tin, lead, antimony, perfluorooctanoic acid as food contaminants.

(vii) Naturally-occurring toxins such as mushroom toxins, mycotoxins (aflatoxins), shell fish toxins that cause shellfish poisoning, alkaloids, phytolectins etc.

Food Contamination

This is the unintentional introduction or occurrence of a contaminant (any biological, chemical or physical agent or substances foreign to food) in food which may compromise food value, quality,safety and edibility. The physical agent could be high dose irradiation. Contamination may occur via environmental pollution as in the case of toxic metal pollutants/toxicants or via the intentional use of agrochemicals such as pesticides (insecticides, rodenticides, herbicides), plant growth regulators (gibberellins, auxins, ethylene), fertilizers and veterinary drugs (nitrofuran, chloramphenicol, fluoroquinolones and bovine somatotropin). These contaminants in food can cause consumer illness/adverse health effects. Apart from food, the contaminants enter the body through the skin, eyes, lungs, and mouth where they are stored in body fat and accumulate over time if the body cannot eliminate them. The emerging food contaminants are those that have been found in foods most recently, as compared to most contaminants that have been known for many years. Examples of the emerging food contaminants are perchlorate, perfluoro octanoic acid (PFOA), furan, acrylamide, benzene and monochloro propane diol (MCPD).

Health Effects of Environmental Toxicants/ Contaminants in Foods that we Consume

Dr. Joseph Mercola is a Leader in the United States Wellness Movement, a New York Times best selling Author and founder of Mercola.com, the second most visited non-governmental health website after web MD.

Below are the top ten most common environmental toxins that are **among the most** prevalent in the air, water and/or food supply, their sources and health effects, as reported (Mercola.com).

(i) **Polychlorinated biphenyls (PCBs):** These are environmental organic pollutant found in farm-raised salmon fed meals of ground-up fish that have absorbed PCBs in the environment. PCBs cause cancer and impaired foetal brain development.

(ii) **Pesticides:** Pesticides are highly toxic and neurotoxic. The sources are foods (fruits, vegetables, apple or its juice and commercially raised meat) and bug sprays. According to the U.S. Environmental Protection Agency (EPA), 60% of herbicides, 90% of fungicides and 30% of insecticides are known to be carcinogenic as they cause cancer. They also cause Parkinson's disease, birth defects, miscarriage, brain and nerve damage, blocking the absorption of nutrients in foods.

(iii) **Mould and other fungal toxins:** Example is the mycotoxin/ fungal toxin such as aflatoxin. Sources are contaminated buildings, foods like peanuts, wheat, corn and alcoholic beverages. These food toxicants/contaminants cause cancer, heart disease, asthma, multiple sclerosis, diabetes and allergic reactions.

(iv) **Phthalates:** They are used to lengthen the life of fragrances and soften plastics. The major sources are plastic wrap, plastic bottles, plastic food storage containers – all of which leach phthalates into the food we eat. They are dangerous to children in particular by mimicking hormones and so, causes damage to the endocrine system.

(v) **Volatile organic compounds (VOCs):** These are a major contributing factor to ozone (O_3), and are air pollutants. They are present in many household products such as drinking water, carpets, paints, deodorants, cosmetics, air freshners, cleaning fluids, dry cleaned clothing and moth repellants. These get into foods we eat, and health risks include cancer, eye and respiratory track irritation, visual disorders, headache, dizziness and memory impairment.

(vi) **Dioxins:** These compounds are formed from combustion processes such as waste incineration and smoke from burning of wood and coal. High concentrations of dioxins are found in smoke due to fires from oil and gas explosion/flaring as in the

16th January, 2012 Chevron gas explosion in Koluama I & II Communities in Brass Local Government Area of Bayelsa State that lasted 46 days before the fire was put off. Major sources are all forms of animal fats. Over 95% of exposure to dioxins comes from eating commercial animal fats. Health risks include cancer, reproductive and developmental disorders, chloracne (a severe skin disease with acne-like lesions), skin rashes and discolouration, excessive body hair and mild liver damage.

(vii) **Asbestos:** These are insulating materials which when old and crumbly, release fibres into the air. Sources are insulation on floors, ceilings, water pipes and heating ducts. Health problems include cancer, scarring of the lung tissue and mesothelioma (a rare form of cancer).

(viii) **Heavy metals:** Arsenic, mercury, cadmium, lead and aluminium are prevalent in the environment, and can accumulate in soft tissues of the body. Major sources are drinking water, fish, vaccines, pesticides, preserved wood, antiperspirant, building materials, dental amalgams and chlorine plants. Heavy metals cause cancer, neurological disorders, fatigue, nausea, vomiting, decreased production of red and white blood cells, abnormal heart rhythm (heart beat) and damage to blood vessels.

(ix) **Chloroform:** This colourless liquid has a pleasant non-irritating odour and a slightly sweet taste and formed when chlorine is added to water. Air, drinking water and food can contain chloroform. Consumption of foods containing chloroform can cause cancer, reproductive damage, birth defects, dizziness, headache, fatigue as well as liver and kidney damage.

(x) **Chlorine:** This is a yellow-green highly toxic gas and one of the most heavily used chemical agents obtained from household cleaners, drinking water (in minute and physiologically tolerable amounts), air when living near a paper plant that uses chlorine in industrial processes. Chlorine causes sore throat, coughing, eye and skin irritation, rapid/fast breathing, narrowing of the bronchi, blue colouring of the skin, accumulation of fluids in the lungs, pain in the lung region, severe eye and skin burns, lung collapse and reactive air ways dysfunction syndrome (RADS) – a

type of asthma (Mercola.com). The contaminant/toxicant levels in foods are regulated by the EPA via a system of standards called **food tolerances**, which is a legal limit that the concentration of a toxicant/contaminant in a particular food must not exceed.

Other Environmental Food Contaminants

(i) **Banned Pesticides:** These include lindane in tomatoes and the highly toxic methamidophos in tangerines, grapes and straw berries. In India, soft drinks were found contaminated with banned pesticides such as lindane, DDT and malathion and in China, powdered ginger had been contaminated with the banned pesticide, aldicarb. News of formaldehyde found in Vietnamese national dish (pho) as well as in fruits and vegetables broke in 2007 Vietman Food Scare. Formaldehyde is a carcinogen which in water produces formalin used in the preservation of anatomical specimens.

(ii) **Hair in Food:** Waxes and other hair products are contaminants on the hair that cause choking and repulsion – induced vomiting. Hair is not easily digestible and in the United Kingdom, it breaks the regulations of the U.K Food Safety Act of 1990 to serve people food which contains hair in restaurants (Valdes-Biles and Ziobro, 2007). To prepare or serve food, one should wear complete capture hairnets and people working in the food industry are required to cover their hair.

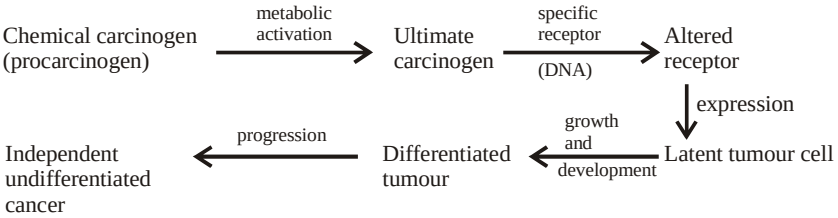
(iii) **Unavoidable processing contaminants:** They are formed by chemical reactions of food constituents during processing and include trans fat, benzene, acrylamide, polycyclic aromatic hydrocarbons, histamines and nitrosamines.

Most environmental food toxicants and contaminants have been implicated in cancer. What is then carcinogenesis and by what mechanism does it occur?

Carcinogenesis

The induction of cancer in an organism is termed carcinogenesis. In this process, a normal cell is transformed into a cancer cell by a cancer-causing agent or carcinogen. Carcinogenic polycyclic aromatic hydrocarbons (PAHs) have been identified in urban air (Morlin et al., 1979). The carcinogenic PAH had earlier been detected in smoke, particularly of cigarette, and the unavoidable conclusion reached after a twenty-year study of mortality in relation to smoking was that cigarette smoking was a direct cause of cancer of the lungs, oesophagus and respiratory site tumors (Hoffman and Wynder, 1972).

Mechanism of Carcinogenesis



Hence, the first steps of chemical carcinogenesis involving metabolic activation of procarcinogen and the reaction of resulting ultimate carcinogen with specific cellular receptor (DNA) to form altered receptor and its expression to form latent tumour cell which grows and develops into differentiated tumour that undergoes progression to form independent undifferentiated cancer, show positive events that are modified by macromolecular synthesis, control of differentiation, action of genes, co-carcinogens, growth stimulants, inhibitors, nutritional status, endocrine status, surgery, radiation, chemotherapy, immunotherapy and immunologic competence (Miller and Miller, 1965, 1971; Weisburger et al., 1972; Irvin, 1973). If these steps are not controlled by the above named modifiers, malignancy results.

A malignant cell is a tumour that invades and destroys the tissue in which it originates and can spread to other sites in the body via the blood stream and lymphatic system. It is a disorder that is cancerous and life-threatening if untreated. Benign describes a tumour that does not

invade and destroy the tissue in which it originates or spread to distant sites in the body i.e. a tumour that is not cancerous. It is any disorder that does not produce harmful effects.

Contamination of Foods by Microbes

This occurs due to improper cooking, poor hygiene and handling of food.

- *E. coli* bacterial contamination of raw milk, water, vegetables and undercooked meat causes stomach upset, nausea and vomiting.
- *Clostridium botulina* contamination of canned food causes diarrhoea and vomiting resulting in dehydration. Fluid replacement therapy is advised.
- Salmonella contamination of egg, poultry, beef and dairy products result in abdominal cramps.
- Eating foods (meat, poultry) and foods prepared 24 hours before consumption that are not reheated properly and contaminated by *Clostridium perfringens* causes fever with gastrointestinal symptoms.

As a precautionary measure, one should cook food to the appropriate temperature, avoid cross contamination of foods, wash your hands and cooking utensils properly and frequently, and ensure immediate refrigeration of leftovers (foods).

Toxicants Produced During Heat Treatment of Foods

Heating causes pyrolysis of some food nutrients such as fats and oils. Major products of pyrolysis of fat are the polycyclic aromatic hydrocarbons (PAH) and the heterocyclic amines, and these are potential cancer-causing agents. The heterocyclic amines (HCAs) are the products obtained from the amino acids, mainly tryptophan. The source of PAHs is the smoke generated from pyrolyzed fat (especially from meat with the highest fat content) dripped from the meat onto the hot coals. Polycyclic aromatic hydrocarbon carcinogens had long been reported in chimney smoke (Pott, 1775). The induction of cancer by PAH from smoke had also long been reported (Wolf, 1952).

Vice-Chancellor Sir, during smoking as in the preparation of 'suya', some substances deposited on the food (meat) are carcinogenic

and teratogenic. They increase the risk of gastrointestinal cancer and affect sperm cell formation in populations where there are high intakes of smoked foods. Individuals who have formed the habit of over-consumption of 'suya' and -*also anu kporo nku n'eju onu (dried meat that fills the mouth) and 'washing down' with litres of alcoholic drinks are hereby warned to desist from such practice by moderating intake because they are at high risk of having colonic or gastrointestinal cancer. Cooking in a way to prevent the smoke from dripped fat, reduces or eliminates the PAH. Three potent polycyclic aromatic hydrocarbon (PAH) carcinogens namely 20-methylcholanthrene, 3, 4-benzo(α)pyrene and 7,12-dimethyl-benzanthracene have also been detected in fish samples that were smoked under local conditions (Onyeike, 1982).

Squamous cell
Persistent bleeding is common with this rarely deadly cancer. Wartz, scaly patches, open sores and rapidly growing bumps are telltale signs.

Basal cell
Thus is the most common skin cancer. This nonlethal blemish can be a shiny bump, a pink growth, a scar-like area or an open sore that does not heal easily.

Melanoma
This deadly cancer is usually larger than a pencil's eraser, multicoloured and changes size and shape. It also shows asymmetry and has uneven borders.

Plate 14. Skin cancers induced by carcinogens in foods.
Source: http://blog.drseymourweaver.com/dermatology-blog/wpcontent/uploads/2012/02/skin-cancers.gif

Consumers of Suya

Smoked Meat (Suya)

Smoked Chicken

Fried fish

Plate 15. Consumers of smoked meat (suya), fried fish and smoked chicken

High temperature cooking of red meat (beef and pork), fish, chicken produces heterocyclic amines. High-temperature cooking (frying and broiling) produce higher concentrations of HCAs than low-temperature cooking (boiling and use of microwave).

The mutagenic potency of HCAs raise concern about possible carcinogenicity. These toxicants (PAHs and HCAs) can be reduced by

(i) avoiding the charring of food during cooking.

(ii) Avoiding direct contact of meat and fish with naked gas flame or charcoal.

(iii) Cooking meat and fish in aluminium foil and mechanical separation of charred parts of meat and fish from the edible portion.

Acrylamide, which is a **neurotoxin** and a known **carcinogen** in rats and humans is produced when starchy foods are cooked at high heat such as when foods are **deep fried, baked, roasted** or **toasted**, processed poultry products, instant malt drinks, chocolate powder and roasted coffee powder processed at temperature above 120°C or more (Kazmi, 2005). Hence, high intake of fried and baked foods (potato chips, processed cereals, cookies and bread) should be discouraged especially by cigarette smokers because cigarette smoke is also a source of acrylamide.

The mechanism by which acrylamide gets into fried and baked food: The amino acid, asparagine found in starchy foods at temperatures above 100°C binds with glucose and in the acrylamide pathway, a

maillard product, N-glycoside cleaves at a carbon-nitrogen bond, producing the carbon skeleton and a terminal amide group at asparagines, which transits to acrylamide. Food fried in vegetable oils and trans fat are high-risk foods that affect human health when they are not eaten in moderation, as part of a well-balanced diet (Meyers, 2006). Fried foods contain polyunsaturated fats which become rancid when exposed to oxygen and produce large amounts of free radicals which have damaging effect in the body. The oils can cause aging, inflammation, cancer and weight gain.

Fried foods are high in fat and salt content, low in calcium and fibre and contribute to obesity and chronic diseases. Fibre lowers cholesterol level and increases the removal of bulk stool thus decreasing the risk of cancer and cardiovascular disease. High salt content contributes to high blood pressure, stroke and kidney problems. Low calcium leads to increased risk for osteoporosis and bone fractures.

Eating fried food away from home is associated with dietary patterns leading to body weight gain and chronic diseases. For example, drinking sugar-sweetened beverages is associated with weight gain; high intake of trans fat is linked to heart disease; low intake of fruits and vegetables is linked to cancer, and a high glycemic load (glucose consumption) is associated with type 2 diabetes (Antonios and MacGregor, 1996).

In an interview with UNIPORT Weekly, Orisakwe (2011) asserted that "What is eating us up is what we eat". He described the general eating habit of Nigerians as poor, and stated that we eat all sorts of food, and no one has ever bothered to analyze the contents of what is consumed to determine their suitability for our total well being. As rightly stated by the Clinical Pharmacist at the University of Port Harcourt, Nigeria, Health Practitioners have not been given enough impetus to function effectively in the country and wondered why Nigerians preferred processed foods in place of abundant natural foods that would enhance their health, emphasizing that it is improper to throw away what is healthy and go for junks that compromise our total well being.

SUMMARY OF MY RESEARCH CONTRIBUTIONS TO KNOWLEDGE

Vice-Chancellor Sir, on the research contributions which led to my elevation to the rank of Professor of Biochemistry, my research and publication after professionship and which together form the basis for what I now profess, permit me to take this distinguished audience through the lines below.

1. Proximate/Nutrient and Antinutrient Composition of Foods

Raw vegetable seeds of oil bean, melon, castor oil and fluted pumpkin used as soup condiments in Nigeria East of the Niger were evaluated, and found to be good sources of lipids 40-54%, proteins 24-34%, ash 2.94-5.96%, vitamin C, energy 536-639 kcal/100g and the minerals calcium, magnesium, zinc, iron and manganese (Onyeike and Onwuka, 1999). Compared to cooked and unfermented seeds, cooking followed by fermentation decreased ash, carbohydrate, vitamin C and minerals and is recommendable since it increased protein, fat, energy content and caused the destruction of toxicants, improvement in texture and taste, enhanced flavour and increased nutritional value and shelf-life.

Through histochemical studies, we found tannins in ripe and unripe fruits of some cultivars of plantain, cooking and desert bananas with the highest concentrations of tanniniferous cells in the epidermis followed by the ground tissue of the peel of unripe fruits (Osuji et al., 1998). It was also found that the activity of the antinutrient, tannin was considerably reduced by ripening. The quantity and distribution of tannins in the Musa cultivars investigated were found to be taxonomically undiagnostic.

The effect of cooking and roasting on the nutrient composition and levels of some toxicants in three species of cocoyam tubers (*Xanthosoma saggitifolium, Colocasia esculenta and Colocasia antiquorum*) was investigated (Onyeike and Nwideezia, 2001). The three cocoyams were found to be good sources of carbohydrate, fibre, ash and the minerals copper, zinc, iron, chloride and sulphate, but low in protein and fats. Cooking and roasting increased ash, fibre, minerals, but

decreased protein, fat, carbohydrate, energy and the toxicants (oxalate, saponins, phytate and cyanogenic glycosides) thereby enhancing their consumption.

Four edible fats and oils (groundnut oil, red palm oil, blue band margarine and butter) consumed in most Nigerian homes have been shown to be of high nutritional and calorific value, and hence good in terms of edibility especially red palm oil and groundnut oil which contained higher degrees of unsaturation (Onyeike et al., 2001). The samples were low in moisture, crude protein, and carbohydrate, but high in crude fat (83-94%) and energy content (817-869 Kcal/100g). There were good physicochemical properties as well as excellent organoleptic properties (colour, odour and texture) as assessed using a nine-point Hedonic scale of 1 = dislike extremely and 9 = like extremely.

Our study on Nigerian oil seeds (castor, coconut, dikanut, groundnut, melon, oil bean and palm kernel) showed excellent nutrient and energy composition, and good physicochemical properties in terms of colour, specific gravity, melting point, setting point, acid value, iodine value, peroxide value and percent free fatty acid as oleic acid and saponification number (which ranged from 338 in coconut seed to 979 in melon seed (Onyeike and Acheru, 2002). The oil extracts were reported useful as edible oils (low free fatty acid and peroxide values, low iodine values and susceptibility to oxidative rancidity) and for industrial applications as in soap production. Our findings in this work offer a scientific basis for the use of the seeds both in human diet, and the manufacture of some commercial products.

Raphia palm beetle (*Oryctes rhinoceros*) is called Osori, tam and utukuru by the Ijaw, Ogoni and Ibo respectively. Raphia palm weevil (*Rhyncophorus pheonicis*) is called eruru in Ibo and nten in Efik and Ibibo. Both are called "diet" if you are travelling from Patani to Benin through Warri. Vice-Chancellor Sir, on account of our work on these samples, we received a letter of commendation from an Association of Ph.D Students in America's best Ten Universities. It was shown that the larvae of these lesser known food materials have the potential of providing large amounts of nutrients, (mainly proteins, fats, ash) and high nutritive and energy value especially the palm weevil with good complement of iron, copper and phosphorus (Onyeike et al., 2005). They

were adjudged very beneficial in meeting human requirements for amino acids of proteins that are indispensable, the high concentration of various essential and non-essential amino acids as well as the sulphur-containing amino acids. In both samples, valine was found to have the lowest chemical score of 51.2% which revealed it as the most limiting amino acid for protein quality.

Trace metal (iron, zinc, copper, nickel, cadmium) levels in staple foods (yam, cassava, cocoyam and maize) from oil-producing areas of Eleme, Ogoni, Okrika and Nembe were studied and found to be significantly higher than values from non oil-producing area of Abakaliki (Akaninwor et al, 2006).

Quantitative high performance liquid chromatographic analysis of the leaves of *Acalypha wilkesiana* Muell Arg. was investigated, and the leaves were found to be rich in flavonoids, carotenoids, phytosterols, but poor in simple terpenes indicating that the leaves are potential sources of allelochemicals and neutrceuticals thereby justifying their use in traditional medicine (Onyeike et al., 2010). For instance, the flavonoids which are pigments that are responsible for the colours found in fruits, vegetables, herbs, seeds, spices, stems, flowers (Middleton et al., 2000) are important in human diet as antioxidants and anti-inflammatory agents (Soetan, 2008) and are associated with reduced risk of cancer and cardiovascular diseases (Middleton et al., 2000; Grubesic et al., 2007).

We investigated the genus Sanseviera whose common names include mother in-laws tongue, devil's tongue and snake plant (USDA, 2008) comprising about 60 species (Evans, 2005).

Using gas chromatography, the presence of total alkaloids, allicins, glycosides and saponins was established and the levels quantified in the leaves of *Sanseviera liberica* Gerome and Labroy (Ikewuchi et al, 2011). On dry wet basis, the leaves were rich in alkaloids (317.4mg/kg) low in allicin (3.815mg/kg) and saponin (1.933mg/kg) and lowest in glycoside (0.075mg/kg), and these findings lend support to the use of the plant in traditional medicine for the treatment of asthma, abdominal pains, diarrhoea, eczema, gonorrhoea, haemorrhoids, hypertension, piles, sexual weakness, snake bites and wounds of the foot (Gill, 1992; Adeyemi et al., 2009).

Our evaluation of the nutrient and antinutrient status of the traditional foods (Onunu and Mgbam) of the Ikwerre people of Nigeria showed good nutrient composition with the values of protein, fat, ash and energy higher in Mgbam than in Onunu and the reverse was obtained for values of carbohydrate, fibre and moisture (Amadi et al., 2011). Although, values of antinutrients (tannins, cyanogenic glycosides, flavonoids and oxalates) were higher in Mgbam compared to Onunu, they were in general of physiologically tolerable levels and further decreased by heat treatment.

We found in these traditional diets, low levels of saturated and high levels of unsaturated fatty acids, with a profile of essential and non-essential amino acids whose chemical scores were comparable to those of hen's egg (Amadi et al., 2011). Methionine with a chemical score of 28.6% was the limiting amino acid in Onunu, while valine with a chemical score of 71.3% was the limiting amino acid in Mgbam making the latter, the best of the two diets nutritionally.

Our work on spices showed that in *M. myristica* (Ehuru), crude protein, crude fat, total carbohydrate and fibre were found to be 10.7, 41.2, 28.8, and 8.60% respectively while in *T. tetraptera* (uhiorkirihio), the values were 13.8, 2.10, 69.8 and 3.73% respectively; calorific value (kcal/100g sample) was higher in *M. myristica* (539 ± 1.04) than *T. tetraptera* (353 ± 0.75) (Agomuo et al., 2011). Essential fatty acids found in *M. myristica* were linolenic acid 39.81%, linoleic acid 44.60% and α-linolenic acid 2.37%, while in *T. tetraptera* were oleic acid 26.97% and linoleic acid 19.38%; the saturated fatty acids were higher in *T. tetraptera* – palmitoleic acid 33.21% and palmitic acid 20.44% compared to values in *M. myristica* – palmitoleic acid 0.42% and palmitic acid 5.42%. The findings indicate that the samples have good nutritional values especially *M. myristica* (Agomuo et al., 2011).

2. Studies on Soaking of Food Samples

In order to address the problem of hard-to-cook phenomenon, African yam bean (AYB) seeds were soaked in water and various concentrations of sodium chloride (NaCl) and sodium sesquicarbonate ($Na_2CO_3.NaHCO_3.2H_2O$) solutions. Loss of protein to the soak solution was found to increase with soaking up to the 18th hour, after which a

sharp decrease in protein loss occurred at the 24th hour (Onyeike and Ayalogu, 1996). Protein losses were independent of salt concentrations due to non-uniform leaching and sample softening was best in sodium sesquicarbonate solution. It was proposed that the presence of sodium salts may have resulted in greater softening of the seed by causing a dissolution of the adjacent hydrogen bonds and rupturing of the cell wall and middle lamella of the seed microstructure thereby permitting the release of proteins from the matrix into the soak solutions (Onyeike and Ayalogu, 1996).

Hydration coefficient (HC) increased as soaking of AYB seeds in water, NaCl and $Na_2CO_3.NaHCO_3.2H_2O$ solutions increased from 6-18hr, but decreased at the 24th hour, and was higher in sodium sesquicarbonate than sodium chloride at the same salt concentration resulting in greater reduction in cooking time in samples soaked in $Na_2CO_3.NaHCO_3.2H_2O$ than in NaCl (Onyeike and Uzogara, 2000).

3. Heat Treatment and Proximate/Nutrient Composition of Food Samples

Our study has shown that heat treatment had no significant ($p<0.05$) effect on the proximate nutrient composition and calorific values of melon seeds, dikanut seeds and cocoyam tubers mostly used as conventional soup thickeners in Southern Nigeria with melon having the best nutritive value and is thus recommendable for cooking (Onyeike et al., 1995).

Since defatting decreased crude fat and energy value and increased protein, carbohydrate and ash, we recommended that foods designed to overcome protein malnutrition should be formulated from defatted and heat processed samples, but defatting should be discouraged in the context of energy malnutrition.

Investigation of proximate composition of cashew nut seed flour showed low moisture and carbohydrate content, but high levels of ash, crude protein and fat, calorific value and mineral elements. The levels of antinutrients (tannins, oxalates, phytates and cyanogenic glycosides) were decreased by roasting making the nutrients available for utilization in the body (Onyeike and Ikuru, 1998).

In raw, boiled and fried groundnut seed pastes investigated for nutrient composition and lipid characterization, crude protein ranged from 19-28% while crude fat ranged from 25-51%. Heat processing generally decreased the protein, fat, Fe, Zn, energy content, vitamins A and C, free fatty acid and peroxide value, but had no significant effect on Cu, acid and iodine values and saponification number (Onyeike and Oguike, 2003). These findings may offer scientific basis for the use of heat processed seeds as food for humans and the oil extracts for the manufacture of industrial products.

We studied the influence of heat processing (cooking) on the nutrient composition of vegetable leaves (green leaf, bitter leaf, oha leaf, hard leaf, water leaf and fluted pumpkin leaf) consumed in Nigeria, and found them to be good sources of the minerals (Na, Mg, Fe, Zn, Cu) but poor sources of crude fat and protein, total carbohydrate and calories (Onyeike et al., 2003). Cooking decreased ash, protein, fat, ascorbic acid and the divalent metals (Mg, Fe, Zn, Cu) but increased the availability of the monovalent sodium (Na) in all the samples investigated.

Proximate composition and energy values of raw and heat processed staple foods (yam, cassava, cocoyam and maize) from oil-producing (Eleme, Ogoni, Okrika, Nembe) areas of Rivers and Bayelsa States and Abakaliki (a non-oil producing area in Ebonyi State, Nigeria) were investigated (Onyeike et al., 2008). The samples were high in moisture and carbohydrate, but low in protein, fat, ash and calorie. Except for moisture and ash, the nutrients were generally lower in samples from oil-producing areas. Heat treatment increased moisture, but decreased other nutrients and energy values in all the food samples irrespective of source.

4. Processing and the Levels of Toxicants in Foods

The presence of the toxic protein, trypsin inhibitors has been studied in the African yam bean seeds (*Sphenostylis stenocarpa*), and through a kinetic approach, heat treatment was shown to inactivate the African yam bean trypsin inhibitors in order to improve the protein quality and derive the full nutritional potential of the pulse (Onyeike et al., 1991).

Vice-Chancellor Sir, I have received several commendations from individuals and organizations world-wide on the quality of my publications. I wish to state here that out of the 68 journal articles which

I have published in local, international and foreign journals to date, this article (Onyeike et al., 1991) is adjudged the overall best well-researched scientific paper. It was accepted for publication without modification by the Nigerian Journal of Biochemistry and Molecular Biology (an official Journal of Nigerian Society of Biochemistry and Molecular Biology). It was also accepted for publication without modification by Food Chemistry – a foreign Journal based at the University of Reading, United Kingdom, and the University of Reading is the World's Centre of Excellence for Food Studies. Till date, I have received a total of 62 requests for reprints of that article world-wide.

We investigated the effects of extraction time, dilution factors and heat processing on trypsin inhibitor activity, and found extraction time of 1 and 3 hr adequate to extract maximum amount of the inhibitor from raw and heat processed African yam bean samples respectively (Onyeike and Ayalogu, 1999). Dilution factors of 1:50 and 1:10 dilutions were best in extracting trypsin inhibitors from raw and heat processed samples. 1:50 dilution gave % trypsin inhibition of 52.4% while 1:10 dilution gave 51.9% and both fell within the range of 40-60% inhibition reported by Kakade et al., (1974). Trypsin inhibitor activity (TIA) decreased over time of heat treatment in a manner that indicated first order reaction kinetics when the bean flours were heated between 70 and 80^{o}C. At 100^{o}C, loss in TIA with time of heat treatment was found to be biphasic.

We have also shown that variety (marble or brown) did not considerably affect the nutrient values of raw, autoclaved and cooked AYB, though the proximate composition and levels of the toxic factors (cyanogenic glycosides, oxalates, tannins, saponins and trypsin inhibitors) were slightly higher in the brown compared to the marble variety (Onyeike and Omubo-Dede, 2002). Autoclaving decreased these toxicants which were further reduced by cooking to physiologically tolerable levels.

In our study on the effect of ripening on the nutrient and antinutrient factors in Mexican avocado pear, we reported that ripening increased crude fat, ash, calorific value; Na, K, Zn, Mg, Ca, Cl^{-}, NO_3^{-} and PO_4^{3-} (Onyeike et al., 2002) but did not significantly ($p \leq 0.05$) affect crude protein, fibre and total carbohydrate. The concentrations of the

antinutritional factors – cyanogenic glycosides, tannins, saponins and oxalates were found to be significantly ($p<0.05$) decreased by ripening to the extent of 50%, 66.7%, 42.3% and 75.0% respectively.

5. Nutritional Evaluation of Protein Quality of Formulated Diets using Rat Feeding Studies

Our work on the influence of heat processing of African yam bean (AYB) seed flour on the growth and organ weights of rats indicated that autoclaving and cooking improved the growth and organ weights of rats due to heat destruction of toxic factors in AYB especially trypsin inhibitors (Onyeike et al., 1995). Autoclaving at 121°C, 15 psi for 30min and cooking for 3 hr increased body weight gain by 75.4% and 63.2% respectively, while feed utilization was increased by 79.6% and 62.9% respectively.

Our findings (Tables 7a and 7b) in this area of research generally indicate that heat processing (autoclaving, cooking, oven drying) of food samples improved the growth and organ weights of rats due to heat inactivation of the inherent toxicants which are known to be the main culprits of the poor nutritive value of food materials. Raw food materials incorporated into the diet depressed the growth of rats and failed to improve their organ weights resulting in pathological changes such as the enlargement of the pancreas (pancreatic hypertrophy) and hyperplasia. Food samples only soaked in water or 4% sodium chloride or 1% sodium sesquicarbonate did not improve nutritional parameters as well as absolute and relative organ weights of rats, indicating that the processing methods were inadequate in destroying and eliminating the toxicants in natural association with the food samples.

Diets formulated from heat processed African yam bean-rice-prawn mixture and also cowpea-millet-crayfish mixture could be adopted as weaning foods due to their high nutritional qualities which are comparable to that of a commercial infant formula, Nutrend.

In vivo studies was carried out with weanling albino rats of the Wistar strain fed Onunu and Mgbam traditional diets of the Ikwerre people of the Niger Delta, Nigeria for 28 days. As reported by Amadi et al. (2012), body weight change (g) of rats after 28 day-feeding was highest in Nutrend (84.14±1.99) followed by Mgbam (54.31±4.14), Onunu (32.10±1.14)

and lowest in Basal (5.52±6.38) while protein efficiency ratio was highest in Nutrend (1.93±0.13) followed by Mgbam (1.68±0.03) and lowest in Onunu (1.11±0.02). Net protein utilization was 60.0±0.02 in Mgbam, 55.0±0.02 in Nutrend and 42.5±0.03 in Onunu while the biological value was highest in Nutrend (87.1±5.90) followed by Mgbam (63.6±6.54) and lowest in Onunu (43.8±5.37).

For each of the organs (heart, kidneys, liver, spleen, pancreas and lungs), improvement in organ weight was highest in rats fed Nutrend, followed by rats fed Mgbam, then Onunu and was lowest in rats adapted to the basal diet (Amadi et al., 2012).

6. Functional Properties of Proteins in Foods

Protein functionality denotes any physicochemical property affecting the processing and behaviour of protein in the development of new food systems as presented by the quality attributes of the final food product. It reflects the complex interactions between the composition, structure, conformation, physicochemical properties, other food components and the nature of the environment in which these are associated (Kinsella, 1976).

We evaluated the functional properties of flours of raw and heat processed melon seed, dikanut seed, cocoyam tuber (Onyeike and Olungwe, 1998) and African yam bean seeds (Onyeike and Ayalogu, 1999) and found that the flours exhibited good gelation capacity, oil and water absorption capacity and stability, foaming capacity and stability and protein solubility as affected by pH. Minimum protein solubility for African yam bean was at pH 4.0, and for other samples, it occurred at pH 8.0 showing protein precipitation and isolation at these pH values.

Our study showed that heat treatment (autoclaving at 121^{o}C, 15 psi for 15 to 30 min) caused dissociation of protein subunits, increase in the surface area of the protein and exposed more oil and water binding sites, but decreased emulsion and foaming capacities and stabilities as well as protein solubility at every pH investigated due to heat denaturation of proteins. These findings are important in the development of new functional products by food industries.

Table 7a: Performance characteristics of rats fed different diets for 28 days

	Diet	BWG(g)	PER	TND %	NPU %	BV %	FU (mg/g)	Reference
1.	Raw AYB, cooked rice and prawn mixture	32.2	1.22	94.7	48.9	50.2	204	Onyeike and Morris (1996)
2.	Cooked AYB, cooked rice and prawn mixture	40.9	1.60	99.2	70.7	71.3	263	
3.	Positive reference diet, Nutrend	64.9	2.52	99.6	72.0	72.3	407	
1.	AYB soaked in water for 18hr	11.9	0.34	98.2	77.4	78.8	43.9	Onyeike et al. (1998)
2.	AYB soaked in 1% akanwu for 18hr	12.4	0.38	99.6	81.7	82.1	51.6	
3.	Positive reference diet, Nutrend	61.2	1.28	99.4	61.2	61.5	205	
1.	Raw AYB	14.2	0.27	93.6	56.8	60.7	-	Onyeike et al. (1999)
2.	AYB autoclaved at 121^{o}C, 15psi for 30 mins	60.6	1.83	96.6	76.9	79.6	-	
3.	Nutrend (reference)	80.0	2.60	98.4	86.8	88.2	-	
1.	Oil polluted catfish	32.8	1.10	97.5	49.8	50.5	-	Onyeike et al. (2000)
2.	Unpolluted catfish	65.0	1.74	97.3	52.0	53.3	-	
3.	Reference (whole Nutrend)	107	1.69	98.3	45.3	45.3	-	

BWG = Body weight gain at the end of feeding studies
PER = Protein efficiency ratio TND = True nitrogen digestibility
NPU = Net protein utilization BV = Biological value
FU = Feed utilization

Table 7b: Performance characteristics of rats fed different diets for 28 days

	Diet	BWG(g)	PER	TND %	NPU %	BV %	FU (mg/g)	Reference
1.	Oven dried (80°C for 24 hr) of larvae of raphia palm beetle	7.50	0.30	96.3	49.5	51.4	35.5	Ayalogu et al (2003)
2.	Oven dried (80°C for 24 hr) of larvae of palm weevil	13.3	0.35	98.1	59.1	60.2	41.4	
3.	Reference Nutrend	113	1.67	94.2	55.4	58.8	267	
1.	Raw cashew nut seed flour	28.1	1.71	87.5	52.9	60.5	228	Onyeike and Nkwuzor (2006)
2.	Cashew nut seed flour autoclaved at 121°C, 15psi for 90 min	64.2	2.65	85.3	70.8	83.0	324	
3.	Whole Nutrend	112	3.03	93.0	81.9	88.1	509	
1.	Raw cowpea/cooked millet/ dried crafish mix	71.0	1.71	96.1	69.0	71.8	222	Onyeike and Uzoka (2006)
2.	Cooked cowpea/cooked millet/ dried crafish mixture	82.3	1.96	95.5	73.6	82.4	316	
3.	Whole Nutrend	129	2.62	93.1	85.8	92.2	427	

BWG = Body weight gain at the end of feeding studies
PER = Protein efficiency ratio TND = True nitrogen digestibility
NPU = Net protein utilization BV = Biological value

FU = Feed utilization

7. Environmental Biochemistry

We investigated the physicochemical properties and inorganic ion levels of soils and streams/rivers in oil-producing communities of Yorla, Zaakpon and Goi in Ogoniland, Niger Delta, Nigeria as affected by crude oil spillage, and found the soils and streams polluted with crude oil (Onyeike and Ogbuja, 1999; Onyeike et al., 2002). Our findings showed significantly ($p \leq 0.05$) higher concentrations of exchangeable cations and trace metals (Ca, Mg, Na, K, Cu, Mn, Fe and Zn) and heavy metals (Pb, Cd, Cr, Ni and As) in the polluted soils and streams compared to their controls, and values were also significantly higher in Yorla, Zaakpon and control compared to Goi North, Goi South and Goi control. Values of trace and heavy metals and the anions phosphate, nitrate, sulphate and chloride indicated that the soils and rivers of Yorla, Zaakpon and Goi were generally polluted with inorganic ions, with Yorla and Zaakpon soils and rivers more polluted than Goi. The soils and rivers were considered unacceptable for domestic and industrial uses if not treated, and soils (farmlands) may also become unsuitable for agricultural purposes.

The effect of consuming fish caught from crude oil contaminated fresh water from Adanta stream, Isiokpo in Ikwerre, Rivers State on the relative organ weights and carcass lipid levels of rats was investigated (Ibegbulem et al., 2006). It was found that relative organ weights of rats fed diets formulated from polluted and unpolluted fresh water fish samples did not vary significantly, but carcass lipid levels of rats fed polluted samples increased significantly ($p = 0.05$) over those of rats adapted to unpolluted freshwater fish sample diets.

The growth performance and nutrient composition of fluted pumpkin (*Telfairia occidentalis*) planted in soil polluted with varied levels of water-soluble fractions (WSF) of crude oil (Bonny light) were evaluated to assess the effectiveness of organic nutrients (poultry manure and sawdust) in the remediation of WSF-contaminated soils (Wegwu and Onyeike, 2006). Our findings showed that application of the WSF delayed germination. However, treatments with sawdust and poultry manure enhanced the germination and nutrient potential. Generally, the

increased percentage of germination in the nutrient-supplemented WSF-polluted soil was a demonstration of the efficiency of sawdust and poultry manure in the remediation of oil-polluted soils.

Mucuna pruriens, a fast-growing, high biomass – accumulating plant was investigated to underscore its suitability for metal (cadmium and copper) extraction in an oil spill condition, and process enhancement was made using NPK, urea and poultry manure fertilizers (Nwaichi et al., 2009). The plant accumulated up to 32mg kg^{-1} cadmium and 62mg kg^{-1} copper in the tissue of both root and shoot and achieved above 50% contaminant removal for both cadmium and copper. Based on plant growth parameters measured (plant height, leaf area, produced biomass and vigour) poultry manure assisted phytoextraction was the best option compared to NPK and urea.

The toxic effects on *Vigna subterranean* legume plants grown for two weeks in a simulated petroleum (up to 50ml/kg soil) contaminated soil was investigated using polluted soil unamended or amended with NPK, urea or poultry manure. The amendments reduced the inherent phytotoxicity of the petroleum sample and the measurable uptake of contaminants (Nwaichi et al., 2010). We recommend poultry manure for such management practice especially at lower doses of the contaminants. Rats fed un-amended contaminated diet for 10 days were found to suffer enlarged stomach wall, poor relative growth rate, poor body weight gain and protein efficiency ratio as well as pancreatic enlargement.

The potential of bambara groundnut (*Vigna subterranean*) for phytoextraction of copper in a crude oil contaminated soil, to which amendments (poultry manure, NPK and urea) were added to increase the metal uptake and translocation to aerial biomass was investigated (Nwaichi et al., 2010). It was found that poultry manure was the most effective amendment for enhancing copper uptake and translocation with shoot tissue copper levels of 118mg kg^{-1} compared to 98.3 and 93.0 mg kg^{-1} obtained for NPK and urea amendments respectively, Hazard characterization or risk assessment with rats on inherent biomagnifications due to contaminant load showed poor organ weights and optimum digestibility, poor rat growth and pancreatic hypertrophy in rats adapted to the diet as compared to controls due to the potential toxic effect of phytoextracted or bioaccumulated copper.

Using pot experiments and simulated crude oil polluted soils to which chicken manure, urea and NPK fertilizers were incorporated as biostimulators for copper uptake, Nwaichi and Onyeike (2010) found that, poultry manure assisted phytoextraction of copper with Mucuna plants by all indices than urea and NPK.

Mucuna showed greater copper tolerance (higher accumulation of copper in the shoots compared to the roots) which is advantageous at green remediation. Although there was no measurable copper uptake with urea amendments, it could be useful for enhancing contaminant mobilization from soil samples.

We investigated the hydrocarbon (HC) contaminant removal efficiency of Bambara groundnuts and biomagnification in un-amended or amended (with NPK, urea, poultry manure) soil samples and found that amendments improved phytoextraction thus: urea (63.4%), NPK (66%), poultry manure (70.0%) for polycyclic aromatic hydrocarbon (PAH) and urea (78.8%), NPK (79.8%), poultry manure (87.9%) for BTEX (benzene, toluene, ethyl benzene, xylene) (Nwaichi et al., 2010). Hazard characterization using rat-feeding studies for 28 days showed that the potentially toxic PAH and BTEX diets affected feed digestibility resulting in decreased sleeping time and poor growth as well as pancreatic hypertrophy and hyperplasia in test rats compared to control.

Hypertrophy describes increase in the size of a tissue or organ brought about by the enlargement of its cells rather than by cell multiplication (as during normal growth and tumour formation). Muscles undergo this change in response to increased work. Hyperplasia is the increased production and growth of normal cells in a tissue or organ. The affected part becomes larger but retains its normal form as in benign prostatic hyperplasia. During pregnancy, the breasts grow in this manner.

Comparing chicken manure and urea fertilizer as potential soil amendments for enhanced phytoextraction of heavy metals, Nwaichi et al. (2010) found that chicken manure caused less cadmium solubilization and increased shoot cadmium accumulation compared to urea fertilizer. Chicken manure amended treatment showed greater cadmium tolerance for *Mucuna pruriens* and *Sphenostylis stenocarpa*, and the latter did not support phytoextraction of cadmium. Even under conditions of heavy

metal (Fe, Cd, Cu) stress, amendments especially with chicken manure can increase biomass production and nutrient (Ca, Mg and nitrate) uptake and distribution.

Growth performance and phytoremediation of soil artificially contaminated with crude oil (50ml/ug soil) using Centrosema pubescen for 12 weeks, with the soil either un-amended or amended with NPK, urea or chicken manure were investigated by Gas Chromatographic analysis (Nwaichi et al., 2011).

The greatest percent removal of BTEX and carcinogenic PAH occurred at the highest contaminant doses of 10mg/kg BTEX, 43mg/kg PAH and 561.3mg/kg oil and grease. There was no measurable plant uptake of contaminant and inhibition of plant growth was proportional to the dose of crude oil but manure amendment was very effective at reducing growth inhibition and phytotoxicity.

Investigation of soil metal clean-up by *Centrosema pubescen* plant which showed the ability to survive on soils containing hydrocarbons and metal contaminants in a simulated study, young seedlings grown in bonny light crude oil contaminated soils were found capable of enhancing significant reduction of large amounts of PAH and heavy metal (cadmium, copper and iron) contaminants, and clean-up improved with biostimulation using poultry manure which also increased plant root nodulation and hence, microbial action (Nwaichi and Onyeike, 2011).

In our study on the interaction of selected minerals with organic pollutants, it was found that soil minerals affected the dynamics and transformations of organic materials and metabolic processes in a stressed soil type (oil spill site) with modifications due to clean-up (Nwaichi and Onyeike, 2011).

The assessment of pH variation and lipase activities as markers of crude oil bioremediation using chicken drops for bioaugmentation of crude oil polluted site has been reported (Uwakwe et al., 2012). pH of topsoil of the bioaugmented site increased from 6.89±0.01 to 7.90±0.05 while for the control it increased from 4.42±0.01 to 5.27±0.02 and for the natural attenuated site, values increased from 4.68±0.29 to 5.63±0.01. Lipase has been found useful in monitoring bioremediation of crude oil

spillage by its ability to degrade petroleum hydrocarbons and utilize them as both energy and carbon sources.

8. Chemical and Sensory Evaluation of Foods

In South East Nigeria, melon fungus (MF) is called ike usu or ero usu. Ero is mushroom and usu is melon fungus, and MF is a soup thickening agent which is combined with melon seed paste in the preparation of the popular Nigerian egusi soup.

Our study showed that processing of MF into melon fungus cake (MFC) used to eat oil-bean salad, stockfish and drink palm wine or beer increased its moisture content, ash, crude fat, fibre, energy value and minerals, but decreased protein, carbohydrate and ascorbic acid (Onyeike and Ehirim, 2001). Evaluation of the sensory attributes of MFC by 20 members of the panel using a nine-point Hedonic scale where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely, showed that aroma, mouth feel and overall acceptability (6.85 ± 1.87, 6.90 ± 0.79 and 8.00 ± 0.88 respectively) were higher in MFC than MF (4.95 ± 1.64, 3.80 ± 1.88 and 6.35 ± 1.14 respectively), but colour and sourness did not differ significantly (Onyeike and Ehirim, 2001).

Our mineral and sensory evaluation of "Onunu and Mgbam" traditional diets of the Ikwerre people of Nigeria using the method of Onyeike and Ehirim (2001) showed them to be composed of good mineral element (K, Ca, Mn, Cu, Zn, Mg, Na, Fe) status and organoleptic properties – appearance, taste, aroma, texture, colour, and in terms of overall acceptability, Mgbam (with a mean score of 8.10 ± 0.64) was more acceptable than Onunu with a mean score of 7.95 ± 0.68 (Amadi et al., 2012).

9. Medical Biochemistry, Enzymology and Toxicology

In this area of research, Uwakwe and Onyeike (2003) studied sickle cell haemoglobin (HbS) gelation and rate of osmotic fragility of HbS red blood cells, and found that at nicotinic acid (a vitamin) concentrations of 1.0mM and 10.0mM, HbS gelation (polymerization) was reduced by 8.93 and 21.4% respectively after a 10 min incubation, while HbS red blood cell

haemolysis was reduced by 18.5 and 50.0% respectively in a concentration - dependent manner. This nutritional prophylactic, nicotinic acid (a vitamin) was therefore considered a necessary and beneficial factor in the diets of sickle cell patients and could be exploited in the nutritional management of sickle cell disease.

Our work on the protein levels in the urine of 90 pregnant and 30 non-pregnant women in Rivers State, Nigeria showed that due to high protein diet, protenuria occurred during pregnancy (56.3mg/100ml urine compared to 35.3mg/100ml for non-pregnant women) and values decreased with age of pregnancy from 56.3mg/100ml at the first trimester to 28.3mg/100ml at the third trimester (Ibeh et al., 2006). This finding may offer scientific basis for the monitoring and treatment of pregnant women for healthy living and safe delivery of their babies.

We screened for health status through the activities of liver marker enzymes in sera of sixty (60) pregnant women from oil-producing areas (Eleme, Ogoni, Okrika, Nembe) and 15 women from non oil-producing area (Abakaliki) feeding on staple foods from these areas (Akaninwor et al., 2006). Higher activities of the enzymes alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP) which were obtained in pregnant women from oil-producing areas compared to those from non-oil producing area in the first, second and third trimesters were indicative of possible susceptibility to jaundice and hepatitis and may be responsible for neonatal jaundice often found in such areas. Constant monitoring of the activities of these enzymes as routine antenatal check-up in pregnant women from oil producing areas is advocated.

In a review on obesity and chronic diseases – the changing nutritional pattern in Nigeria, Nwosu and Onyeike (2009) warned against the changing lifestyle which is being more sedentary due to increased civilization and consumption of excess fat in convenience foods, that play a role in the aetiology of obesity. There should be promotion of food and lifestyle choices that reduce the risk of chronic diseases (heart problems, cancers, artherelerosclerosis, stroke/hypertension, type 2 diabetes mellitus) by emphasizing fitness to reduce weight, eating whole grains, legumes, herbs, spices, fruits, vegetables, fish and meat and cutting down on intake of smoked red meat, alcohol, salt, sugar, foods containing

contaminants and toxicants and finally, maintaining a positive outlook in life.

Sansevieria liberica Gerome and *Labroy* is a plant commonly called bowstring hemp. Its roots and leaves are used in traditional medicine for the treatment of asthma, diarrhoea, abdominal pains and hypertension (Gill, 1992; Adeyemi et al., 2009).

The aqueous leaf extract which we administered to salt-loaded rats did not affect liver and kidney functions, produced higher plasma calcium and potassium levels, red cell and white cell counts and significantly lowered plasma sodium and chloride levels (Ikewuchi et al., 2010). Our findings support the use of the plant in the management of hypertension, and suggest that the extract may be a potassium sparing diuretic whose antihypertensive action may be mediated through alteration of plasma sodium and potassium levels or increases in muscle tone due to changes in plasma calcium levels.

We have reported similar findings with aqueous leaf extract of *Sansevieria senegambica* Baker, which in addition produced leukocytosis but had no negative effects on enzyme markers of liver and kidney functions (Ayalogu et al., 2011).

Sansevieria senegambica Baker which is also called mother in-law's tongue, devil's tongue and snake plant is used in traditional medical practice in Southern Nigeria for the treatment of bronchitis, inflammation, cough, boils and hypertension. Our study on the aqueous leaf extract of the plant showed that it can protect against artherosclerosis and cardiovascular complications either through its body weight-reducing effect or lowering of its plasma total low density lipoprotein cholesterol thereby confirming its use in the management of hypertension (Ikewuchi et al., 2011).

Tridax procumbens commonly called coat buttons, tridax daisy or simply tridax is a plant that is traditionally used to manage hypertension (Salabdeen et al., 2004). Aqueous extract of the leaves orally administered daily to sub-chronic salt-loaded rats at 150 and 200mg/kg body weight was found to lower mean daily weight gain, plasma LDL (the bad cholesterol), total and VLDL cholesterol, and increased plasma HDL cholesterol (good cholesterol) without significant alterations in organ sizes and weight (Ikewuchi et al., 2011). Our findings

indicate a likely dose-dependent cardioprotective potential of the extract on the hypertensives.

The leaf of *Acalypha wilkesiana* plant is commonly called copper leaf, Joseph's coat, fire dragon, beef steak plant and match-me-if-you-can (Christman, 2004). It is found widespread in the tropics of Africa, America and Asia. It is used in traditional health care practice for the management of hypertension, gastrointestinal disorders, fungal skin infections, diabetes mellitus, headache, colds, malaria (Akinyemi et al., 2005), breast tumors and inflammation (Bussing et al., 1999; Taraphdar et al., 2001). We found that the aqueous extracts of the leaves administered to sub chronic salt-loaded rats lowered the systolic, diastolic and mean arterial blood pressures of the test rats and also lowered and stabilized pulse rates in comparison to the test controls, thereby confirming the antihypertensive activity of the leaves, and supports their use in traditional medicine for the management of hypertension (Ikewuchi et al., 2011). We also found that the daily oral consumption of an aqueous extract of the leaves was prophylactic to carbon tetrachloride poisoning as treatment with the extract protected the rat liver against carbon tetrachloride-induced hepatotoxicity/hepatic cytotoxicity, thereby justifying the use of the plant extract in African traditional health care for the management of liver problems (Ikewuchi et al., 2011).

10. Pharmacological Biochemistry and Toxicology

In this field of research, we have demonstrated that on dry weight basis, the leaves of *Sanseviera liberica* Gerome and Labroy is rich in crude protein (49.8%), ash (6.72%), moisture (56.1%), fibre (13.4%); but low in crude lipid (0.23%) and carbohydrate (9.32%), while phytochemical screening showed the presence of alkaloids, carotenoids, flavonoids, phytates, saponins and tannins (Ikewuchi et al., 2010). The study has shown the sample as a potential source of protein, ash and fibre, and supports the medicinal use of the plant. Similar findings were made with *Acalypha wilkesiana* in phytochemical composition; only that higher nutrient values on dry weight basis were obtained for crude fibre (51.1%) and total carbohydrate (29.5%) with a lower value of 9.29% in crude protein (Ikewuchi et al., 2010).

The African mistletoe (*Tapinanthus bangwensis*) is a semi-parasitic plant found growing on a host of evergreen trees and is used by traditional medicine practitioners to treat cancers, diabetes mellitus and hypertension (Grossarth-Maticek, 2007; Obatomi et al., 1994 and Kafuru, 1993).

Our work on the crude methanolic extract and fractions of African mistletoe leaves from Nigeria (this work took my Ph.D student, Dr. Kingsley C. Patrick-Iwuanyanwu to a Laboratory in Pakistan) on Wistar albino rats showed that the methanol extract (MeOH) and partitioned fractions, ethylyacetate (EtOAc) and butanol (BuOH) of the leaves possess anti-inflammatory effect and this finding may justify the use of the plant in the management of inflammatory diseases (Patrick-Iwuanyanwu et al., 2010a). In another study, we found that the extracts possess strong antioxidant properties and hepatoprotective potentials against carbon tetrachloride-induced hepatotoxicity (liver damage) in rats (Patrick-Iwuanyanwu et al., 2010b). We investigated further, the leaves of Ring worm plant (*Senna alata*) from Nigeria commonly called "candle bush" because of the shape of its inflorescence. The Yoruba people of South West Nigeria call it "Asuwon oyinbo". In Adamawa and Taraba States Nigeria, as well as Ghana and Ivory Coast, the root, stem and leaves are used in herbal medicines to treat burns, skin and wound infections, diarrhoea and dysentery, gastrointestinal problems, upper respiratory and urinary track infections and asthma (El-Mahmood et al., 2008; Irvine, 1961).

Our findings on this plant indicate that crude methanolic extract (MeOH) and partitioned fractions (EtOAc and BuOH) like those of African mistletoe possess anti-inflammatory effect justifying the use of the plant in herbal medicine for the treatment of inflammatory diseases (Patrick-Iwuanyanwu et al., 2011).

Increase in blood pulse pressure, predicts cardiovascular and coronary artery disease, myocardial infarction and conjestive heart failure. We have demonstrated that aqueous extract of the leaves of *Tridax procumbens* orally administered daily by intragastric gavages at 150mg/kg and 200mg/kg body weight prevented in rats, the salt loading-induced upsurge (increase) in pulse pressure, and reduced systolic and diastolic pressures, and hence can lower cardiovascular risk thereby

confirming its use in the management of hypertension (Ikewuchi et al., 2011).

Because of the ethnopharmacological relevance of the leaves of *Acalypha wilkesiana*, we investigated the effect of aqueous extract on the haematology, plasma biochemistry and ocular indices of oxidative stress in alloxan-induced diabetic rats (Ikewuchi et al., 2011). Using gas chromatographic analysis, we identified 29 (twenty nine) known flavonoids in the extract mainly 29.8% apigenin, 15% quercetin, 11.1% naringenin, 10.6% kaempferol, 9.05% epicatechin among others.

The extract lowered plasma glucose, enzyme (ALT and AST) activities, triglycerides, urea, lymphocytes, *ocular malondialdehyde* levels, but increased plasma calcium, total white cell and red cell counts, high density lipoprotein cholesterol and ocular ascorbic acid content. Our study showed that the extract contained pharmacologically active compounds, was hypoglycemic and enhanced the functional integrity of the liver and kidney of diabetic rats, protected against oxidative stress in ocular tissues, improved the lipid profile and thus exhibited cardioprotective potential which supported its use in traditional health care practice for the management of diabetes mellitus and hypertension (Ikewuchi et al., 2011).

Our recent study confirms the use of *Sanseviera liberica Gerome* and *Labroy* in the management of hypertension in traditional medicine practice since test rats orally administered the aqueous leaf extract (250mg/kg body weight) against the control group that received appropriate volume of water had lowered systolic pressure, reduction in diastolic and mean arterial pressures, more stable and lowered pulse rate (Ikewuchi et al., 2012). Fast heart rate is associated with increased risk of death from cardiovascular and non-cardiovascular causes (Palatini, 1999), and hence, the lowered heart rate produced by the leaf extract portends its ability to reduce cardiovascular risk (Ikewuchi et al., 2012).

Recommendations

In 2008, the entire world witnessed food crisis. In order to solve food problems in Nigeria, it is recommended that

(i) Federal government should fund research in science, technology and agriculture so that enough food should be produced and

distributed at relatively low cost. The last research grant which I received from this University was in 1994 and the value was N50,000.00 (fifty thousand Naira) only, which was not enough to buy a single chemical, silver nitrate. A research on this type of grant may start and end at the University Senior Staff Club, and this does not make sense. What many professors are compelled to do in their various fields is to climb an iroko tree with bare hands using feeding money to do research, and a reversal of this trend is recommended through adequate research funding.

(ii) Policy actions of Nigerian governments should include reduction of taxes on food and to release food stocks, removal of value added tax on baby foods, edible oils, rice and grains; reduction of electricity and utility bills and introducing special programmes for school and hospital feeding.

(iii) Federal Government should establish a Centre for the Management of Nutritional Disorders in each of the six geo-political zones in Nigeria. In these centres (a) Experts in food, nutrition, dietetics and toxicology should be engaged to run short-term intensive courses on food and nutrition education for staff from General and Teaching Hospitals, Clinics, Health Centres and individuals involved in Catering and Hotel Management. (b) The Centres should have Rehabilitation Units where patients with different nutritional disorders are catered for, free of charge and this should be funded from at least 1% of the Federal government annual budget. This is important because it is not acceptable to see, in this technological era, many citizens of the giant of Africa (Nigeria) suffering from protein-energy malnutrition, kwashiorkor, marasmus, goitre, diabetes, diet-related hypertension, marasmic-kwashiorkor and several disorders due to vitamin and mineral deficiencies.

(iv) A Food Regulatory Body should also be put in place in each State in Nigeria to ensure that the right type of food is consumed (food that is balanced, high in nutrients free or unavoidably low in natural and synthetic toxicants, unadulterated, well processed, devoid of environmental contaminants and safe). Federal and State governments are called upon to evolve measures aimed at

helping the populace manage their lifestyles and prevent disorders due to malnutrition.

(v) Food is a human right and Federal/State governments should ensure that the citizens are well fed by promoting urban gardens, and agrarian reforms that include support systems (subsidizing the cost of fertilizer and ensuring its proper distribution) for farmers and sustainable agricultural techniques that enhance the environments.

(vi) Vice-Chancellor Sir, many of our research findings in the area of Medical and Pharmacological Biochemistry and Toxicology have shown that the plants we investigated have ethnopharmacological importance and confirm their use in traditional health care (medicine) practice for the treatment and management of abdominal pains, diarrhoea, asthma, hypertension, carbon tetrachloride-induced hepatotoxicity/ hepatic cytotoxicity, diabetes mellitus, cancers, inflammatory diseases, cardiovascular (heart) diseases such as conjestive heart failure, upper respiratory and urinary tract infections. Since it does no longer make sense to dismiss the findings in herbal medicine with a wave of the hand, a collaboration between the Practitioners of Orthodox and Traditional Medicine is strongly advocated to ensure total health care delivery in Nigeria.

Concluding Remarks

Vice-Chancellor Sir, I have taught at the Primary, Secondary and University levels from 1977 till date. I have successfully supervised more than 20 M.Sc candidates, and 6 Ph.D holders who are Lecturers in some Universities including Uniport, and may in due course become professors, while other M.Sc and Ph.D supervisees are at various stages of their research work. With high sense of humility, I wish to leave this distinguished audience to assess the extent to which I have contributed to human capital development in Nigeria. I have spent more than 85% of my life activities since 1991 when I assumed duty in Uniport teaching and supervising my undergraduate and postgraduate students and conducting research in Biochemistry. I have till date published a total of 68 articles most of which are in high impact journals across the globe, 10

chapters in refereed books, 1 most of which are (one) book which I edited and have presented 26 papers at conferences with many other manuscripts at the various stages in the review process. My research findings have made original contributions to existing knowledge, for which reprints of my works are from time to time sought for world-wide.

I have served the University of Port Harcourt as Head, Department of Biochemistry and Chairman, Senate Appeals Committee on Certificate Verification, and in various professional activities, University/Public service including serving as External Examiner in many Universities for the B.Sc, M.Sc and Ph.D degrees and External Assessor of candidates for Professorial positions. I therefore have a feeling of having contributed to community service in this country.

Vice-Chancellor Sir, distinguished ladies and gentlemen, this Inaugural Lecture is therefore a logical outcome of my many years of teaching, research and community service. I have tried the best I can to explain in an understandable manner, the concepts associated with the lecture topic. I had briefly summarized my research contributions which form the basis for what I profess today, and the direction which I intend to go in future.

In evaluating the learning experiences from this lecture, I have two questions for my distinguished audience.

(i) If a woman chooses to consume foods containing appreciable amounts of nutrients required for growth in a balanced diet that is well processed and the toxicants appropriately destroyed, is her life in her hands?

(ii) If on the other hand, a man decides to eat foods deficient in growth-promoting nutrients, not properly processed and containing high concentrations of toxic factors that are not physiologically tolerable, is his life in his hands?

From the Holy Gospel according to John 6:24-27, when the crowd saw that neither Jesus nor his disciples were there, they themselves got into the boats and came to Capernaum looking for Jesus. And when they found him across the sea, they said to him, “Rabbi (Teacher), when did you get here?” Jesus answered them and said, “Amen, amen I say to you; you are looking for me not because you saw signs but because you **ate**

the loaves and were filled. Do not work for food that perishes, but for the food that endures for eternal life which the son of man will give you."

Vice-Chancellor Sir, if I should respond to the two questions above on behalf of this distinguished audience, I would state that we eat food inorder to sustain life. The food we eat contains nutrients that are nourishing, and toxicants or antinutritional factors that detract from the full nutritional potentials of the food we consume. There is then food in health and in disease. We can decide to eat to live when we consider the first question above or eat to die considering the second question. The life of a food consumer is therefore in his hands since he/she has the prerogative/privilege/right/choice to either eat to live or eat to die.

Vice-Chancellor Sir, Ladies and Gentlemen, I thank you most sincerely for listening.

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CITATION ON

PROFESSOR EUGENE NWAOGWUGWU ONYEIKE.
B.Sc *(UPH),* PGDE *(UNN),* M.Sc, Ph.D *(UPH),* MNSBMB.

Introduction
Vice-Chancellor Sir, I feel honoured and privileged to be nominated as University Orator to introduce Professor E.N. Onyeike, the 99th Inaugural Lecturer of the University of Port Harcourt, Choba, Rivers State, Nigeria. Prof. Onyeike is a distinguished Teacher and accomplished Research Biochemist, an Academic Leader, a Mentor and a Great Scientist, who, on account of his widely published research findings is an internationally recognized Scholar.

Professor E.N. Onyeike was born on 10th December, 1955 at Kauranamoda in the present Zamfara State, North West, Nigeria into the family of a staff of the Nigerian Railway Corporation, Ezinna Paul Nwaogwugwu Onyeike (in memorian) of Oparachi Mbaukwu Ihitte, and Ezinne (Mrs) Sussana Onuawuchi Onyeike (Nee Abosi) (in memorian) of Umunagbor Amagbor Ihitte, both in Ezinihitte Mbaise Local Government Area of Imo State, Nigeria. He is the third child and second son in a family of initially ten children (four girls and six boys), but now three women and four men. His parents qualified and took the traditional title of "Igbu Ewu Ukwu" (killing of goat for the waist title).

Education:
From Kauranamoda, Professor E.N. Onyeike returned to Eastern Nigeria and started his primary education at the Local Authority School (now Community Primary School) Oparachi, Mbaukwu Ihitte in Infant 1

(1959), Infant 2 (1960) and Standards 1-3 (1961-1963). In 1964, the Elementary School System commenced, and he was in Elementary 5, and so, took his First School Leaving Certificate (FSLC) Examination in 1965. He passed the competitive secondary school entrance examination in 1966, but did not go to the College between 1966 and 1971 (for 6 years) due to the effect of the crisis in the North (1966) and subsequent outbreak of the Nigerian/Biafran civil war (1967-1970) which he painfully experienced. With the end of the war on 12th January, 1970, he could not also enter the Secondary School that year for lack of school fees, as his father, who worked with the Nigerian Railway Corporation for 35 years returned from Kauranamoda to Mbaise in 1969 with only his head, and losing all his property and investments in the North for which the Onyeike family was among the families during the war that were tagged "Ndi jiri isi ha lo" (those who came back with their heads).

In 1971, Prof. Onyeike followed his elder sister Mrs. Joy E. Onuoha and her husband Mr. Joseph F.N. Onuoha to Ndiufu Achara Ikwo in Abakaliki, where he re-took the FSLC examination and the East Central State Common Entrance Examination into Secondary Schools. In 1972, he was admitted into Boys Secondary School (now Ezza High School), Ezzikwo in Abakaliki and he obtained his WASC (Division 2) in 1976.

In Class 1, he became enlisted as one of the best first eleven players of the Football Team, and was later the Games and Sports Prefect/Football Captain of Ezzikwo High School that beat many Secondary and Technical Schools in the then Abakaliki Zone. Prof. Onyeike was also one of the best four students in his class from Year 1-5. Others are Arc. Zachaeus O. Ijeoma (Managing Director, Maurij-Zakij (Nig.) Ltd, Architects, Builders and Quantity Surveyors at Rumuokwurusi, Port Harcourt), Dr. Hilary N. Ezeh (Senior Lecturer in Geology, Ebonyi State University, Abakaliki, who is currently being assessed for promotion to the rank of Professor) and Mr. Michael A. Uzor (Director-General, Federal Information Centre, Awka, Anambra State). Ezzikwo High School Abakaliki expected Prof. Onyeike in Division 1 with Distinction in WASC examination which he had maintained over the years and in MOCK examination, but he could not achieve that because the Prefects including Prof. Onyeike were detained in Police custody

from where they were writing WAEC examinations due to violent and destructive riot organized and executed by Year 4 students who called themselves the "Mao Mao" Group without the knowledge of the end victims (the prefects) who were punished by the School Administration for the offence they did not commit - an action which the Administration of Mr. P.N.O. Ezeunu as Principal later regretted when they learnt about the real culprits that rioted. The effect, which Prof. Onyeike regrets was the poor WAEC result of Ezzikwo High School that year (Division 1 with Distinction = 0; Division 1 = 1; Division 2 = 6; Division 3 = 8; Statement of Result (SR) = 65 candidates).

In October 1978, he gained admission into four higher institutions including University of Port Harcourt and opted for the latter, where he graduated with a B.Sc (Hons) Biochemistry (2^2) in 1982. Again, Prof. Onyeike was one of the second set of graduating students of the University of Port Harcourt when students were used as experimental guinea pigs. Out of about 60 students admitted into the Biochemistry programme of the former School of Chemical Sciences, Uniport in 1978, only 13 graduated in 1982 with one candidate in 2^1, eleven 2^2 and one 3rd Class.

In 1985, he was admitted into the Postgraduate programme of the University of Nigeria, Nsukka where he obtained the PGD in Education (Credit) in 1986 that distinguishes him today as a Teacher. Back to his Alma mater later in December 1986, he enrolled for an M.Sc programme which was deferred from 1985 to 1986, and was one of the 3 out of 10 candidates enrolled for the programme that successfully defended the M.Sc Thesis in 1988. The zeal to pursue a terminal degree programme was occasioned by his ability to obtain at the M.Sc level, the mandatory CGPA of 4.00 and above on a 5.00 point scale. Following his excellent performance at Ph.D Admission Interview, he was admitted for the programme, and he successfully defended his Doctoral Dissertation on 3rd February, 1993.

Working Experience

Prof. E.N. Onyeike taught in Primary Schools as an Auxillary Teacher in the Imo State School System in 1977 and 1978 before he gained admission into the University of Port Harcourt as an undergraduate in October,

1978. He taught at Government Secondary School, Lemu, Niger State during his NYSC programme (1982-1983). From September 1983 to October 1991, Prof. Onyeike taught as Senior Mathematics and Chemistry Teacher in many secondary schools in Anambra and Imo States, and was at a time Acting Vice-Principal, Ahiazu Secondary School, Lude Ahiara, Mbaise. In the various secondary schools, he was also the Head of Science Department among other responsibilities. During his M.Sc and Ph.D programmes, he was for 5 years (1987-1991), a part-time Laboratory Demonstrator and Teaching Assistant. He was a Senior Master I awaiting promotion to the Principal Cadre when he joined Uniport in November 1991 as an Assistant Lecturer in Biochemistry on a salary that was about 48% less than what he was earning in the secondary school. Professor Onyeike consistently rose through the ranks to become Lecturer II on review of appointment (1993), Lecturer I (1996), Senior Lecturer (1999), Associate Professor (2003) and attained the rank of full Professor of Biochemistry with effect from 19th March, 2007; a chair he occupies till date.

Professional Activities

The professional activities of Professor E.N. Onyeike include

(i) National Treasurer, Nigerian Society of Biochemistry and Molecular Biology (NSBMB) from 2003 to 2007.

(ii) Associate Editor and Member of Editorial Board of
  (a) Global Journal of Pure and Applied Sciences (1999 till date)
  (b) Scientia Africana – An International Journal of Pure and Applied Sciences (2001 to 20th February, 2011).
  (c) Global Journal of Medical Sciences (2007 till date).

(iii) Editor, Book of Abstracts of the First South East Zonal Conference of the NSBMB held in Uniport in June, 2002.

(iv) South East and South South Zonal Co-ordinator of NSBMB (2007-2011).

(v) Editor, Scientia Africana (2011 till date).

(vi) Editor, Research Techniques in Biological and Chemical Sciences (ISBN 978-8020-84-4). Springfield Publishers Limited, Owerri, 412pp. This is an authoritative text contributed by 33 scientists

spread across nine tertiary institutions in Nigeria, and used in many Nigerian Universities.

University/Public Service

Vice-Chancellor Sir, Professor E.N. Onyeike has served as External Examiner for the B.Sc, M.Sc and Ph.D degrees and as External Assessor of candidates for professorial positions in many Nigerian Universities including the Rivers State University of Science and Technology, Nkpolu Port Harcourt; Imo State University, Owerri; Ebonyi State University, Abakaliki; Michael Okpara University of Agriculture, Umuahia; University of Nigeria, Nsukka; University of Benin, Benin City; Federal University of Technology, Owerri and Abia State University, Uturu. Records show that he has till date successfully assessed two candidates for professorial positions, and has examined a total of 5 Ph.D dissertations, 36 M.Sc theses and 624 B.Sc research projects in Biochemistry and Biochemistry-related area of Environmental Management.

Professor Onyeike has served the University of Port Harcourt in various capacities as

- Assistant Examination Officer, Faculty of Science (1996-1999).
- Member, Department of Biochemistry Committee on Direct Teaching and Laboratory Cost, DTLC (2004-date).
- Member of Senate (3rd January 2006 – 5th January, 2008).
- Member, Senate Appeals Committee on Certificate Verification (21st April, 2006 – 28th February, 2010).
- Senate Representative on the Board of University Demonstration Primary School, UDPS (2006-2008).
- Member, Board of Basic Studies Unit (2006-2008).
- Permanent Member of Senate of the University of Port Harcourt (19th March, 2007 till date).
- Chairman, Senate Appeals Committee on Certificate Verification (ACCV) (1st March, 2010 until further notice).
- Dean, Faculty of Science Nominee at oral M.Sc and Ph.D examinations (2007 till date).

- Chairman, International Foundation for Science (IFS) Equipment and Project Monitoring and Evaluation Sub-Committee, University of Port Harcourt (2009 till date).
- Patron, Purple House, UDPS (2009-2011).
- Chairman, Committee on Admission of Students/Employment of Staff, Department of Biochemistry (2010 till date).
- Chairman, Postgraduate Studies Committee, Department of Biochemistry (2011 till date).
- Senior Consultant to the Committee on Review, Production and Sale of the Department of Biochemistry Practical Manual (16th April, 2012 until further notice).
- Member, Research Ethics Committee, University of Port Harcourt (3rd May, 2012 until further notice).

In this University, Professor Onyeike is a member of the Boards of the: (i) Department of Biochemistry (ii) Faculty of Science (iii) Faculty of Basic Medical Sciences (iv) College of Health Sciences Academic Board, (v) Member of Faculty of Science Graduate Studies Committee, and (vi) Member, Faculty of Science Appointments and Promotions Committee (Academic).

Administrative Experience

Prof. Onyeike has served as Departmental Co-ordinator of Students' Industrial Work Experience Scheme (1992-1999); Undergraduate and Postgraduate Seminar Co-ordinator (1999-2004); Secretary to Group G of Strategic Planning Workshop organized by the Strategic Planning Committee of Uniport in April 2003; Chairman, Departmental Welfare Committee (2000-2006); Welfare Officer/Chairman Welfare Committee, Academic Staff Union of Universities, (ASUU) University of Port Harcourt Branch (2002-2004).

Professor E.N. Onyeike was Acting Head, Department of Biochemistry, Faculty of Science, Uniport (2006-2008). During his Headship, the Department recorded tremendous achievements in quality teaching, research and community service, had full programme accreditation by the National Universities Commission (NUC), improvement in infrastructure, increase in academic staff strength from

the long standing 14 to 25. Prof. Onyeike was adjudged one of the best and lucky Heads of Departments as he also had at that time on his staff list among others, Emeritus Prof. Emmanuel .O. Anosike, FAS (the first University Valedictorian); Prof. Gabriel .I. Ekeke, FAS (now Late) (the Biochemist who formulated "Ciklavit" endorsed by the World Health Organization and produced commercially by Neimeth Pharmaceutical Company for the management of sickle cell disease), Prof. Edward .O. Ayalogu FNSBMB (the Deputy Vice-Chancellor - Administration) and Prof (Mrs.) Bene W. Abbey (Dean, School of Graduate Studies), but today she is the Deputy Vice-Chancellor (Research and Development), University of Port Harcourt.

Membership of Professional Bodies

Our masquerade today is a member of the following bodies among others

- Nigerian Society of Biochemistry and Molecular Biology (NSBMB).
- Nigerian Society for Experimental Biology (NISEB).
- Federation of African Societies of Biochemistry and Molecular Biology (FASBMB).

Academic Leadership

Prof. Onyeike has for many years (1991 till date) taught courses to both undergraduate and postgraduate students in Biochemistry Department and in the Faculties of Science, Agriculture, Pharmaceutical Sciences, Basic Medical Sciences and the College of Health Sciences, distinguishing himself as an outstanding professional teacher and a mentor to many younger academic and professional colleagues. He has shown leadership in teaching and research activities, and has already supervised more than 120 B.Sc Projects, 20 M.Sc Theses and 6 Ph.D Dissertations of candidates whom he has also mentored, and can therefore be seen to have successfully replicated himself academically. The Ph.D candidates he has produced are Dr. Emmanuel N. Agomuo, Dr. Eucharia O. Nwaichi, Dr. Kingsley C. Patrick-Iwuanyanwu, Dr. (Mrs.) Catherine C. Ikewuchi (nee Okaraonye), Dr. Benjamin A. Amadi and Dr. Jude C. Ikewuchi. Each of them scored 'A' grade in the defense of his/her dissertation, attesting to Prof. Onyeike's dexterity in research design and execution, and in editing

of his students work before they are presented for final defence. Currently, he is supervising 5 Ph.D and 8 M.Sc candidates among others.

Research Publications

Vice-Chancellor Sir, research is part of Professor Onyeike's life, and he has published widely, and the publications which started in foreign journals are highly commendable. From 1991 till date, this productive Research Biochemist has to his credit, a total of 68 articles published in local, international and foreign journals. He has published 1 book which he edited, 10 chapters in refereed books and has presented 26 papers at local and international conferences. In most of his foreign publications, he received letters of commendation from organizations, one of which was from American Journal Experts – An Association of Ph.D, Graduate Students from America's Top 10 Research Universities in 2006.

Current Areas of Research Interest

With an array of his current Ph.D and M.Sc supervisees at various levels of their works, Professor Onyeike is actively involved in research in Nutritional Biochemistry and Toxicology, Environmental Biochemistry and Pharmacological Biochemistry.

Part of on-going and future research include:

(i) Studies on the effect of processing on the amino acid profile, minerals, vitamins and fatty acid composition of selected indigenous foods in the Niger Delta, Nigeria.

(ii) Formulation and industrial production of ENOLAC – a conceived infant weaning formula from available raw materials in Nigeria.

Listing

Professor E.N. Onyeike is listed in the 1999 16th Edition of "Marquis Who's Who in the World," a publication which is limited to those individuals who have demonstrated outstanding achievement in their own fields of endeavour, and have hence made significant contribution to the betterment of contemporary society.

Awards/Honours

Our Inaugural Lecturer has received the following awards and honours:

- National Association of Biochemistry Students (Uniport Branch) Honorary Patron Certificate Award dated 15th November, 1997, in recognition of his remarkable and invaluable contributions in the human struggle towards a better living.
- Recipient of the 2002 Global Journal Award of Certificate of Commitment to the growth, sustenance and maintenance of high quality of Global Journal through prompt reviews of manuscripts and promotion of the Journal.
- National Association of Biochemistry Students, Imo State University, Owerri, Certificate Award dated 2nd June, 2011, in recognition of his meritorious service as The Most Outstanding External Examiner in the Department of Biochemistry, Imo State University, Owerri.
- Procurement, Installation, Service, Maintenance and Use of Scientific Equipment (PRISM) Certificate of Participation Award in On-Site Training Programme, PRISM Scientific Institutions in Nigeria and Madagascar organized by the International Foundation for Science (IFS), NIPRD, Abuja Nigeria (6th November to 16th December, 2011).

Private Life

Professor E.N. Onyeike is a Christian of the Roman Catholic Faith. He is happily married to Dr. (Mrs) Victoria Chinasa Onyeike (Nee Nwosu) – a Senior Lecturer in the Department of Educational Management, Faculty of Education, Uniport; a God-given help mate and the most beautiful wife, Prof. Onyeike's eyes can see – beauty in outlook, in character and mind/heart. They are blessed with three children Chidinma, Nzubechukwu and Nneoma. Outside the University, Prof. Onyeike has participated in, and contributed significantly to the development of his community at home. He is a member of (i) Umuokpueze Family Association, Oparachi; (ii) Udokamma Age Grade, Oparachi Ihitte which he formed in 1979; (iii) Mbaukwu Ihitte Development Union Federated, (iv) Ihitte Development Union (IDU), Port Harcourt Branch; (v) Friendship Train Mbaise; and (vi) Oganihu Mbaise, Port Harcourt. At present, he is Chairman Education Committee, Oganihu Mbaise, Port

Harcourt. He is current Chairman, Mbaise Senior Staff Association, University of Port Harcourt.

Hobbies

Prof. Onyeike takes delight in designing and conducting research activities, travelling to places and in listening to good music. He loves soccer which he played well in the early 1970's in the then East Central State.

Vice-Chancellor Sir, distinguished audience; I present to you an accomplished Academic, a worthy Alumnus of the University of Port Harcourt, a kind-hearted and Focused Teacher a principled man of impeccable integrity who is firm in what he believes to be the right thing, a Research Biochemist and Scholar of International repute, an embodiment of academic excellence, a Mentor and a Role Model. I present to you a Gentleman and Sportsman par excellence, a Seasoned Administrator, a loving Husband and good family man, a peace maker and fearless crusader for quality control and assurance.

Distinguished Ladies and Gentlemen, please join me to welcome Professor Eugene Nwaogwugwu Onyeike to deliver the 99th Inaugural Lecture of the University of Port Harcourt.

Professor Augustine A. Uwakwe
(University Orator)

Appendices

Plates 16 -36 Food samples, plant materials and sawdust/poultry manure

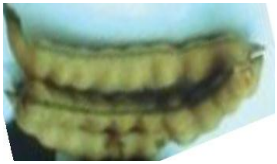
which have been investivated.

Gourd containing the seeds

Leaves

Plate 16. Fluted pumpkin (*Telfairia occidentalis*)

Plate 17. Avocado pear (*Persea americana*)



African yam bean Pod

African yam bean Seeds (Marble variety)

African yam bean Seeds (Miiky variety)

Plate 18. African yam bean (*Sphenostylis stenocarpa*) Varieties

Crude Oil Polluted Fishes

Unpolluted Fishes

Plate 19: Crude oil polluted and unpolluted fishes

Adult

Larvae

Plate 20 a Oil palm weevil *(Rynchophorus phoenicis*)

Adult

Larvae

Plate 20 b Oil palm beetle (*Oryctes rhinoceros*)

Cashew Fruits
(*Anacardium occidentale)*

Roasted Cashew nuts

Salted Cashew nuts

Plate 21 Cashew Fruits and processed Cashew nuts

Seeds

Leaves and flowers

Plate 22. Mucuna bean (*Mucuna pruriens*)

Leaves

Brown variety

White variety

Plate 23. Bambara groundnut (*Vigna subterranean*)

Plate 24. Ring worm plant *(Senna alata* (L.) Roxb.)




Plate 25. African Mistletoe (*Tapinanthus bangwensis*)

***Acalypha wilkesiana* Muell Arg (Acalypha)**

***Tridax procumbens* L. (Coat buttons)**

Plate 26

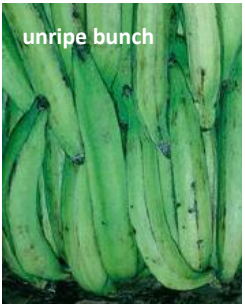
Sansevieria liberica Gerome and Labroy **(Sansevieria)**

Sanseviera senegambica **Baker (Sansevieria)**

Plate 27

Plate 28. Cocoyam (*Colocasia esculenta*)

Banana (*Musa species*)



Plantain (*Plantago major* Linn.))

Plate 29 Musa species

Plate 30 a Cowpea (*Vigna unguiculata*)

Plantain (*Plantago major* Linn.)

Plate 30 b Cray fish Millet

Groundnut seeds

Dikanut seeds

Melon seeds

Castor seeds

Coconut

Palm kernel

Plate 31 a

Oil bean seeds

Plate 31b

Pod

Seeds

Plate 32 *Tetrapleura tetraptera* (Uhiorkirihio)

Plate 32b *Monodora myristica* (Ehuru)

Bitter leaf
(*Vernonia amygdalina)*

Water leaf
(*Talinum triangulare*)

Green vegetable (*Amaranthus spp*)
Plate 33

Yam tubers

Rice grains

Cassava tubers

Maize cobs

Plate 34 Staple Foods

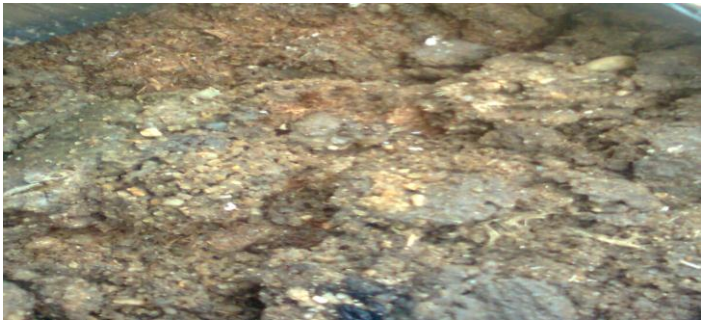


Plate 35 Saw dust and poultry manure

Aerial parts

Seeds

Plate 36. Centrocema pubescen Benth