ADEQUATE NUTRITION FOR GOOD HEALTH – IS OUR ENVIRONMENT NUTRITION FRIENDLY?

BY

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The Vice-Chancellor
Principal Officers
Fellow Academics
Distinguished Guests
Lions and Lionesses
Ladies and Gentlemen

PREAMBLE

I consider it a big privilege and honour to be given the opportunity to deliver this inaugural lecture in my alma mater, the University of Nigeria, Nsukka. I have had opportunities to deliver lectures at different national and international meetings and conferences, however this presentation which expound on the work and activities that culminated in my becoming a Professor of Public Health Nutrition is the Zenith of it all. Mr. Vice-Chancellor Sir, I thank you for this wonderful opportunity.

I came to University of Nigeria, Nsukka in 1974 after my West African School Certificate examination to pick up a clerical job in the Central Registry. I worked directly with Mr. A.E. Oradubanya, the then Registrar of the University and Mrs. G.I. Adichie, the Administrative Officer attached to Central Registry but later became one of the Registrars of this University. Mr. Dan Chibuzo of blessed memory was then the Personal Secretary to the Registrar. I acquired a lot of administrative experiences from these seasoned administrators. In the course of my service as a clerical officer, I took entrance examinations to different Universities and secured admission to University of Nigeria, Nsukka (UNN), University of Ibadan, Ibadan (UI) and University of Benin, Benin-City (UNIBEN) all in Nigeria. I however accepted the offer to read Food and Home Science in UNN because of its proximity to my family's residence.

The Department of Food and Home Science offered three degree options namely- Food Science and Technology, Nutrition and Dietetics, and Home Science. I registered in the Home Science option and worked closely with Dr. (Mrs.) Nancy Ohuche, who inspired me to develop great interest in Child Development. I graduated in 1981 with the desire to continue with a Masters' programme in Child Development. Unfortunately, the Department had not established the degree in the area. With a burning desire to further my education I registered for a Post Graduate Diploma in Education (PGDE) in 1982 and graduated in 1983. In the course of the programme and with the passion to continue in Child Development, I met Dr. (Mrs.) Theresa Ikeme of blessed memory who encouraged me to register in Guidance and Counseling. This was to give a window of opportunity to study special education. On completing my PGDE programme, I registered immediately for a Masters' degree in Guidance and Counseling under the supervision of Late Dr. (Mrs.) Theresa Ikeme. Mr Vice Chancellor sir, permit me to give honour to this great woman who undoubtedly would have been proud to be in attendance. She was a mother, a great motivator, with amiable character who encouraged me to actualize my ambition. I graduated in 1985, thought briefly at University of Nigeria Secondary School, Nsukka before joining the services of Federal College of

Education, Eha-Amufu. At Federal College of Education, Eha-Amufu, I thought Food and Nutrition in the Department of Home Economics. This marked another turning point in my academic career as my employment was based on my first degree despite the fact that I submitted two applications- one for Home Economics and the other for Guidance and Counseling. In due course, I figured that I could still work with children in Human Nutrition with maternal and child nutrition option. I registered for another masters' degree in Human Nutrition and subsequently a Ph.D. in the same area. In my Ph.D. work, I had opportunity to develop some products from indigenous food crops in the environment for young child feeding. The products were tested on children and their nitrogen and mineral balances were assessed. The work made me develop interest in locally available food crops and their utilization in the fight against the different forms of malnutrition, which is a major threat to good health. Shortly after acquiring Ph.D. in 1994, I joined the services of University of Nigeria, Nsukka and my research focus was in the use of locally available food crops to improve on the nutritional and health status of individuals. Mr. Vice-Chancellor Sir, once more thank you for this opportunity given me to present my research output over the years. At the end of this presentation, I must have answered the one question it is hinged on which is- whether our environment is nutrition friendly to provide adequate nutrition for good health.

The presentation for this inaugural lecture would be made under the following sub-topics

- Nutrition, nutrients and other substances in food – an overview; nutritional status
- Nutrition and health
- Nutrition and environment

- Documentation, nutrients and phytochemical composition of some known and lesser – known foods in the Nigerian ecosystem.
- Improving nutritional quality of locally available food crops through household – level food technology.
- Formulation of complementary foods and other food products from locally available food crops and their nutritional evaluation
- Improving nutritional status of individuals and nutritional quality of foods through food supplementation, biochemical studies.
- Conclusion.

NUTRITION

Human nutrition is a complex multifaceted scientific domain indicating how substances in foods provide essential nourishment for the maintenance of life (Vorster and Hautvast, 2002). It is a science of food, the nutrients and substances therein, their actions, interactions and balance in relation to health and diseases. It also covers the process by which the human organism ingests, digests, absorbs, transports, utilizes and excretes food substances. The study and practice of Human Nutrition involve a spectrum of other basic and applied scientific disciplines. These include Molecular Biology, Genetics, Biochemistry, Chemistry, Physics, Food Science, Microbiology, Physiology, Pathology, Immunology, Psychology, Sociology, Political Science, Anthropology, Communications and Economics. The multidisciplinary nature of the science of Nutrition, lying in both the natural (biological), physical and social scientific fields, demands that Nutritionists should have a basic understanding of many branches of science and should be able to integrate different concepts from these disciplines. Human nutrition is a complex scientific domain and not “cooking food” as perceived by some people. Food preparation and service is only an aspect of the programme.

NUTRIENTS

Nutrients are essential dietary factors or substances in foods that provide nourishment for the maintenance of life. Their absences in the diet have been experimentally or epidemiologically demonstrated to be associated with the development of poor health in man or domestic animals. On a genetic level it is now accepted that nutrients dictate phenotypic expression of an individual’s genotype by influencing the process of transcription, translation or post-translational reactions. In other words, nutrients can directly influence genetic (DNA) expression, determining the type of RNA formed (transcription) and also proteins synthesized (translation). Details of the role of nutrients in gene expression are treated extensively in Nutrigenomics (genetic nutrition). There are six classes of nutrients, which include carbohydrates, proteins, fats, minerals, vitamins and water.

Carbohydrates are compounds containing carbon, hydrogen and oxygen. They are significant sources of energy for cellular metabolism. Major food sources of carbohydrates are cereal grains (corn, sorghum, millet, wheat, hungry rice) roots and tubers (yam, cocoyam, cassava, potatoes), legumes (pulses-cowpea, pigeon pea, African yam bean) and starchy fruits (plantain and banana).

Proteins contain nitrogen, carbon, hydrogen and oxygen. Some proteins contain sulphur while a few may contain phosphorus or other elements such as iron, zinc, and copper. Proteins furnish amino acids which are important in the synthesis of many biological active molecules including hormones, enzymes and structural components. All animal foods such as meat, fish, milk and egg are rich in protein. Some plant foods especially legumes and nuts are also rich in protein. Foods of animal origin are nutritionally better protein source than those from plant sources because of their amino acids pattern. However, if plants are judiciously combined, they can produce amino acid pattern, which is equal to or better than that of animal foods.

Fats include heterogeneous group of substances soluble in organic solvents such as ether, chloroform and carbon tetrachloride, but usually insoluble in inorganic solvents such as water. They are made up of carbon, hydrogen, oxygen and some contain phosphorus and nitrogen. Fats are the concentrated source of energy and are essential for the absorption of the fat soluble vitamins. Sources of fats include palm oil, all the vegetable oils, margarine, butter, cheese and oil seeds (soybean, groundnut, sesame, African oil bean seed, melon seed, *ogbono* seed, fluted pumpkin seed, African walnut, locust bean seed).

Minerals are inorganic elements, which are essential for the normal functioning of the body. Minerals are divided into two groups as follows: macro and micro–elements. The macro - elements occur in reasonably large quantities in the body (approximately 0.5 to 2.0% of the body weight) and include calcium, phosphorus, potassium, sulphur, sodium, chlorine and magnesium. The micro - elements occur in very small quantities but have important functions in the body. Iron, copper, zinc, iodine, fluorine, cobalt, selenium, molybdenum and manganese are examples of micro-elements. As a group, minerals play vital roles in the functioning and structure of the body even though they are needed in far smaller amount in the diet than carbohydrates, fats and proteins. Some minerals are concerned with maintenance of acid-base balance (pH regulation) in the body. Some examples include chlorine, sulfur, phosphorus, calcium, magnesium, potassium and sodium. Sodium and potassium are osmoregulators. Calcium, phosphorus and magnesium provide structural components of the bones and teeth. Some minerals are constituents of essential compounds like thyroxine (iodine), haemoglobin (iron), insulin (zinc), thiamin (sulfur), vitamin B_{12} (cobalt), xanthine oxidase (molybdenum), hydrochloric acid (chlorine), carbonic anhydrase (zinc) and cytochrome system (iron). Some minerals play a catalytic role in many chemical reactions either in an enzyme system or as an ion in numerous reactions in the body. Magnesium is required for metabolism of carbohydrate, fat and protein. Copper, calcium, potassium, iron, zinc and other minerals catalyze various metabolic reactions. Zinc is an integral component of almost 100 different enzymes and vital to about 200 different enzymes as a metalo-enzyme. The formation of a variety of different substances in the body is catalyzed by the presence of iron e.g. the conversion of pro-vitamin A to vitamin A is effected with Fe serving as catalyst. Some minerals act as antioxidants e.g. selenium, iron, zinc and copper. Selenium is one of the most important antioxidant, which protects the cells from harmful effects of rancidification. Selenium counteracts cancer and chromosome damage as well as increasing resistance to viral and bacterial infections. Iron is important for its antioxidant effect, production of red blood corpuscles, oxygen transportation and the functioning of many enzymes. Dietary diversification is imperative to supply both the macro - and micro - elements needed for normal body functioning.

Vitamins are organic compounds that are required for the maintenance of normal health and metabolic integrity. Vitamins are required in very small amounts, of the order of milligrams or micrograms per day and thus can be distinguished from the essential fatty acids and the essential amino acids, which are required in larger amounts of grams per day. The body is not itself capable of producing sufficient quantities of vitamins. There are about 13 known vitamins of which 4 are fat soluble and 9 water soluble. Fat soluble vitamins include vitamins A, D, E and K while the water soluble vitamins are vitamins C and B complex group (thiamin, riboflavin, niacin, pyridoxine or B_6, pantothenate, cyanocobalamin or $B_{12,}$ folic acid and biotin). Some vitamins participate in enzyme systems as coenzymes to catalyze certain chemical reactions in carbohydrate, protein and lipid metabolism such as the B-complex vitamins. A number of vitamins act as antioxidants or are part of the antioxidant system to protect the cells from rancidification and production of free radicals. Some examples include vitamins A, C, E, thiamin, riboflavin, niacin and panthotenate. Some vitamins like Vitamins A and C play a vital role in strengthening the immune system, which is responsible for neutralizing invading microorganisms such as bacteria, viruses and carcinogens. Vitamins C and E have a delaying influence in the ageing process and thus inhibit senile decay. They have a prophylactic effect on cancer and could be used as supplementary treatment for the disease. Vitamin A is important for maintenance of normal vision. Vitamin D functions like a hormone in maintaining calcium and phosphorus homeostasis. Vitamin K plays a role in building up the capacity of blood to coagulate. It participates in a number of coagulation factors including prothrombin. Ascorbate (vitamin C) is a powerful antioxidant and a very good iron enhancer. Varied diets rich in fruits and vegetables are needed to meet the vitamin needs of the body.

Water is the most abundant constituent of the human body accounting for about 60-70% of the body weight, 70-80% of which exist in soft tissues while about 20% is found in bones. Water is the milieu for all chemical processes and is involved in such activities as the maintenance of acid-base balance, proper buffering and electrolyte balance of body fluid, digestion of food, regulation of body temperature, excretion of toxic waste from the body and transportation of food nutrients to cells of the body. A 65kg man contains about 46.43kg of water, 32.5kg of which is distributed inside the cells of tissues (intercellular water). Another 10.35kg of the body water is found outside the tissues (extra cellular water) and the rest in other fluids. The extra cellular water is found in blood plasma, in tissue spaces, in lymph and lymphatic spaces and in other minor areas like the eye. Water can be obtained by the body in the form of drinking water or as water contained in alcohol and non-alcoholic beverages, in foods, or as water arising from the oxidation of carbohydrates, fats, and proteins. Except for a few common foods like sugar, common salt, and cooking oil, foods generally contain reasonable quantities of water. The percentage of water in foods and the state in which it occurs (free or bound) are important factors in determining the storage life of different foods. Fresh fruits, roots and vegetables have high percentage of free water and so have a much shorter shelf life than grain cereals and legumes which have lower contents (mostly in bound form).

OTHER SUBSTANCES IN FOODS

In addition to nutrients, food contain other chemical substances, which could either help protect the body against diseases, chelate nutrients or have toxic effect on the body. Such substances include phytochemicals, antioxidants, anti-nutrients and anti-physiological factors.

1. Phytochemicals

Phytochemicals are natural bio-active non nutrient compounds found in vegetables, fruits, legumes, cereals and other plant foods. They fight to protect the body against diseases. Phytochemicals have complementary and overlapping mechanisms of action in the body, including antioxidant effects, antibacterial and antiviral effects, stimulation of immune system, modulation of detoxification enzymes and hormone metabolism. They help reduce the risk of certain types of cancer and coronary heart disease, improve lung function and reduce complications associated with diabetes. Phytochemicals include saponins, tannins, flavonoids cardiac glycosides, terpenes, alkaloids, deoxy-sugars, anthraquinones, carotenoids hydroxycinnamic acid, steroids, phenols, inulin and philobatanin. Cardiac glycosides, saponins, flavonoids, terpenes and alkaloids are known to protect the body by decreasing the risk of heart diseases, stroke and certain types of cancers. Saponins have the potential to lower cholesterol levels due to their hypocholesterolemic effect. They form complexes with cholesterol to reduce plasma cholesterol levels. Terpenes and flavonoids seem to battle against certain cancers and heart diseases due to their antioxidant effects and their action to increase the activities of the enzymes that detoxify carcinogens.

2. Antioxidants

Antioxidants are substances or chemical compounds, which prevent oxidation or rancidification. The antioxidants attach themselves chemically to oxygen free radicals and substances, which produce free radicals and protect the cells by reacting with the oxidizing factors and neutralizing them. Many fats and especially vegetable oils contain naturally occurring antioxidants, including Vitamin E, which protect them against rancidity for some time. Oxidation can damage polyunsaturated fats, proteins, the DNA and RNA in cells. Tissue damage by radicals is one of the theories of the biochemical basis of cancer and atherosclerosis. Vitamin E is the only chain breaking lipid-soluble antioxidant, which protects the cells from damage caused by free radicals and peroxides. Vitamin E is especially important in limiting radical damage resulting from oxidation of polyunsaturated fatty acids (PUFA) by reacting with the lipid peroxide radicals (radical-trapping) before they can establish a chain reaction. This property is reinforced by the selenium enzyme, glutathione peroxidase. The tocopheroxyl radical formed from vitamin E is relatively unreactive and persists long enough to undergo reaction to yield nonradical products.

Selenium, zinc, β-carotene, vitamins A, E, C, ubiquinone, flavonoids, phytochemicals and some of the B vitamins are natural dietary antioxidants.

3. Antinutrients

Antinutrients are substances in food which can compete bio-chemically for active sites for nutrient activity. They limit the absorption and bioavailability of nutrients. Some of the antinutrients include phytates, tannins, oxalates and trypsin inhibitors.

Tannins

Tannins are polyphenolic compounds found in plant foods. They are known to reduce the availability of proteins, carbohydrates and minerals by forming indigestible complexes with the nutrients (tannin – protein, tannic acid – starch and tannin – iron complexes). The complexes are resistant to enzyme hydrolysis, thus inhibiting the digestibility and absorption of nutrients. Tannin – protein complexes are reported to be responsible for growth depression, low protein digestibility, decreased amino acid availability, decreased N retention and increased faecal nitrogen in humans and experimental animals (Obizoba and Nnam. 1992; Nnam 1999a) Tannins are found in cereals, legumes, nuts, fruits and vegetables. They are present in large quantities in the coloured or pigmented varieties of seeds. Fermentation, soaking and germination could decrease tannin levels of foods.

Phytates (inositol hexaphosphate)

Phytate is present in cereals, particularly in the bran, dried legumes, some nuts and vegetables. Phytates are the principal source of phosphorus in dry seeds. They play a significant role in limiting the nutritive value of food by interacting with minerals and proteins to form complexes. Nutritionally, phytate is unavailable to humans due to the lack of an endogenous enzyme system that can catalyze the hydrolysis of the molecules to its moieties. During digestion, phytates interfere with absorption of nutrients by interacting with metals to form insoluble metal complexes. Phytates chelate with the multivalent cataions such as Ca^{++}, Mg^{++}, Zn^{++}, Fe^{++} and Fe^{+++} and form insoluble phytate - metal complexes (calcium - phytate, magnesium – calcium - phytate, iron - phytate, zinc - phytate, and zinc – calcium - phytate). The complexes reduce the availability of the metals for absorption. The acid ester, phytic acid or myo - inositol 1, 2, 3, 4, 5, 6-hexakis (dihydrogen phosphate) can form simple salts with a metal or complex salt with several metals all within the same molecule. Phytate may be chemically hydrolysed (under heating) or enzymatically with phytase. The enzyme dephosphorylates phytic acid on successive steps terminating with the formation of inositol and phosphoric acid. Certain metals are released in the process. Fermentation, germination, soaking and other autolytic treatments reduce or eliminate phytate in plant foods.

Oxalates

Oxalates are naturally-occurring substances found in plants, animals and in humans. They belong to the group of molecules called organic acids. Oxalates form insoluble complex with calcium (calcium oxalate) and thus limit the availability of the mineral. Oxalate is present in cocoa, black tea, leek, celery, green beans, cashew, peanuts, tangerine, plums, okra, soybean, grapes, figs and spinach. Boiling could help reduce the oxalic acid content of foods.

Trypsin Inhibitors

Trypsin inhibitors are low molecular weight proteins found in leguminous seeds. They are most frequently located in the outer layer of the cotyledons of such legumes as soybeans, cowpeas, kidney beans and mung beans. Trypsin inhibitor impairs the digestion of protein by combining with the digestive enzyme trypsin to form an inactive complex. Adequate heat treatment has been shown to completely eliminate the presence of trypsin inhibitor in legume seeds.

4. Toxicants

These are toxic substances found in food. They include lectins (haemagglutinins) and cyanogenic compounds.

i. Lectin

Lectin is one of a series of proteins found especially in legume seeds. Lectins act to agglutinate cells especially red blood cells, hence the old names haemagglutinin and phytoagglutinin. The toxic effect of lectins is due to its agglutinating property of the red blood cells (RBC). *Phaseolus vulgaris* (kidney bean) contains about the highest lectin content of all the edible legumes. Consumption of raw kidney beans has been reported to cause gastroenteritis, nausea, vomiting and diarrhea within 2hour. The toxic effect of the lectins can be inactivated by boiling for about 10min to denature the protein.

ii. Cyanogenic Glycosides

Cyanogenic glycosides are organic compounds of cyanide found in a variety of plants like cassava, lima beans and other members of the legume family. They are toxic through liberation of the cyanide when the plants are cut or chewed. Hydrolysis of cyanogenic compounds yields hydrocyanic acid (HCN) and other compounds. The cyanogenic glycosides which are important with regard to human toxicity include amygdalin, dhurrin, linamarin and lotaustralin. Processing like crushing of foods before soaking in water could detoxify the cyanogenic glycoside. This is accomplished through the action of the enzyme present in the plant tissue. It breaks down the glycosides to yield free hydrogen cyanide.

NUTRITIONAL STATUS

The nutritional status of an individual is greatly influenced by the individual’s dietary pattern. An individual could be in a state of

- Optimal or adequate nutrition
- Malnutrition

Optimal or Adequate Nutrition

Optimal or adequate nutrition is attained when an individual has adequate intake of food. This means that the food eaten in a meal contains the food nutrients (protein, carbohydrate, fat, mineral, vitamin and water) and other substances (phytochemicals, antioxidants among others) in proper quantity and proportion to one another to ensure maintenance of good health. Adequate nutrition could be achieved through the use of food guide pyramid in meal planning. This will help in making healthy food choice and combination. Variety of foods should be taken in a meal in moderation. **Fig. 1** shows the food guide pyramid while **fig. 2** shows the new food pyramid, which is a modification of the food guide pyramid.

The beauty of the food guide pyramid is that the proportion of each food group is represented by the position of the food group in the pyramid for example cereals, roots and tubers are at the base and are required in greater proportion than the other foods in the other food groups. Oils and fats are at the tip. This means that the proportion of fats and oils to be taken in a meal should be very small relative to other foods. Fats and oils should be taken sparingly. The key word is **variety, proportionality and moderation.** Variety is ensured by selecting foods in adequate proportion from each of the food group (adequate diet).

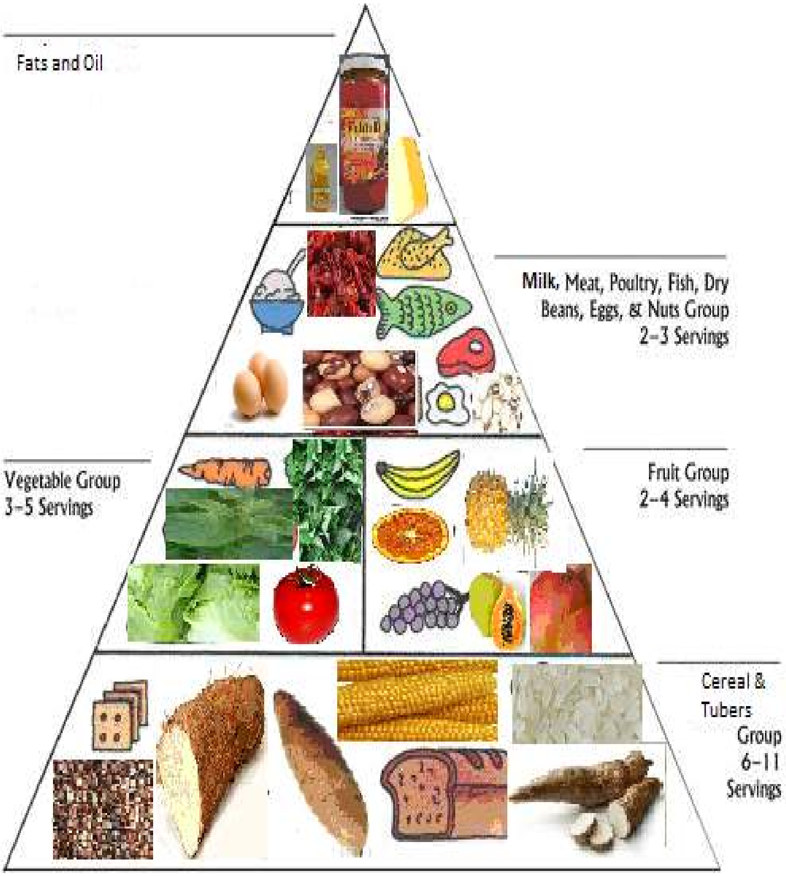


Fig 1: The Food Guide Pyramid

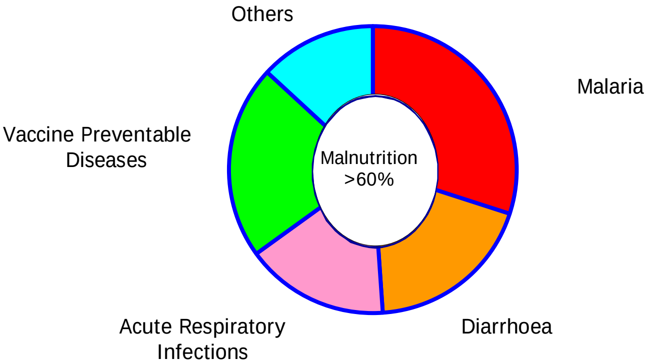
Fig. 2: New Food Pyramid

Again the new food pyramid presents the same information in a different way based on the key words – variety, proportionality and moderation. Proportionality is shown by the different widths of the food group bands. The widths suggest the quantity of food a person should choose from each group. The bands are wider for grains, than vegetables and fruits since these groups should form the bulk of the diet. The narrowest band is for oils and fats, indicating that these should be eaten sparingly. All the widths are a general guide and not exact proportions. Moderation is represented by the narrowing of each food group from bottom to top. The wider base stands for foods with little or no solid fats, added sugars or caloric sweeteners and salt. These should be selected more often to get the most nutrition from calories consumed. Variety is ensured by selecting foods from the five food groups in the pyramid. Physical activity is represented by the steps and the person climbing them showing the importance of physical activity together with adequate nutrition in maintaining good health. Eat varied diet selected from foods in the different food groups in adequate proportion and in moderate amount to ensure adequate nutrition and good health.

Malnutrition

Malnutrition is the disturbance of form or function of the body arising from deficiency or excess of one or more nutrients.

Malnutrition results from inadequate food intake, which leads to too little or excess nutrient absorption and utilization. Other factors, which could precipitate malnutrition include inadequate care practices, poor sanitation and inadequate health services among others. Malnutrition is a serious threat to physical, mental and social wellbeing of an individual. Profile (2001) analysis showed that malnutrition is responsible for more than 60% of child mortality in Nigeria.



Malnutrition and child mortality

Malnutrition could manifest as under-nutrition or over-nutrition. Low intake of nutrients from food, their poor utilization, diarrheal disease, infectious diseases and other diseases lead to undernutrition, which could manifest as protein-energy malnutrition (PEM) (kwashiorkor and marasmus) or micronutrient deficiencies.


Children suffering from kwashiorkor

Child suffering from Marasmus

Undernutrition in children is assessed using the three anthropometric parameters of weight for age, height for age and weight for height and by comparing them with internationally accepted reference standards. According to the World Health Organisation (WHO) classification:

- Appropriate height for age of a child reflects linear growth and can measure long-term growth faltering or stunting
- Appropriate weight for height reflects proper body proportion or the harmony of growth. Weight-for-height is partially sensitive to acute growth disturbances and is useful to detect the presence of wasting
- Weight for age represents a convenient synthesis of both linear growth and body proportion and can thus be used for the diagnosis of underweight children.

Excessive intake of nutrients from food leads to over-nutrition, which manifests as overweight, obesity and diet-related non communicable diseases (diabetes, hypertension and coronary heart diseases).

The world is currently faced with both under as well as over-nutrition leading to "**Double Burden of Malnutrition**". The transition towards the double burden of malnutrition is associated with changes in food consumption patterns, changes in physical activity levels and life style associated with modernization, urbanization, industrialization, economic development and market globalization. The co-existence of stunting, wasting, underweight, micronutrient deficiencies, overweight, obesity and other diet-related non-communicable diseases within the same countries, in the same communities and even in the same households throughout the world today pose one of the greatest challenges to good health and national development. Having overweight parents (typically mothers more than fathers) and underweight children in the same household is a paradox.

NUTRITION AND HEALTH

WHO defined health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Adequate nutrition is essential for good health. This is because inadequate diet leads to malnutrition, which affects all aspects of health. Malnutrition as either under-or over-nutrition negatively affects the physical, mental and social well-being of an individual. PEM presents a broad array of clinical conditions. There is mild PEM at one end, which manifests itself mainly as poor physical growth in children to kwashiorkor, which is characterized by the presence of oedema and nutritional marasmus, characterized by severe wasting. PEM weakens the immune system of children and reduces their ability to fight infection and diseases. A child suffering from kwashiorkor has poor mental and social well-being. The child experiences poor brain development and mental retardation as a result of inadequate intake and utilization of protein, iron, iodine and other nutrients. The same child is usually apathetic about her surrounding and irritable when moved or disturbed and subsequently withdraws to himself, thus experiencing poor social well-being.

Micronutrient malnutrition or hidden hunger has an important impact on health. Iodine deficiency manifests as goiter, which causes serious health problems. Studies have shown that 3% of babies born to iodine deficient women suffer from cretinism and present severe mental and physical retardation, 10% suffer from moderate to severe mental retardation and the remaining 87% suffer from some form of mental impairment. Vitamin A deficiency causes defective eye sight, impairment of the immune system and increased mortality from childhood diseases. Iron deficiency and anemia are associated with increased susceptibility to certain infections and to decreased physical and mental performance. Deficiencies of the antioxidant nutrients (selenium, vitamins A, C, E and the B-complex vitamins) increase oxidative stress and accumulation of toxic substances in the body and thus make the individual susceptible to diet-related non-communicable diseases. Low levels of vitamins A, C, iron, panthotenate and some of the B-complex vitamins lowers the immune response and predisposes the individual to opportunistic infections. In some instances, the symptoms of micronutrient deficiencies are not always visible hence micronutrient malnutrition is often referred to as “hidden hunger”.

Over-nutrition precipitates obesity and other diet-related non communicable diseases like coronary heart disease, diabetes and hypertension while adequate nutrition could lower the incidence. Consumption of an adequate diet (meal that contains all the nutrients and food substances in proper quantity and proportion to one another) could reduce the occurrence of nutrition-related chronic diseases. High intake of fat, sugar, salt and low intake of dietary fiber, antioxidant and phytochemical rich foods are risk factors for diet-related chronic diseases. Including foods that contain adequate quantities of phytochemicals in a meal could help reduce the incidence of coronary heart diseases (CHD). For example saponins form complexes with cholesterol to reduce plasma cholesterol levels. Cholesterol is implicated in the development of atherosclerosis and CHD. Terpenes and flavonoids seem to battle against certain cancers and heart diseases due to their antioxidant effect and their action to increase the activities of the enzymes that detoxify carcinogens.

It is important that individuals consume nutritionally adequate diet to be in a state of optimal nutrition and good health. One of the keys to good health is adequate nutrition.

NUTRITION AND ENVIRONMENT

The free online dictionary defines environment as the circumstances or conditions that surround one - the surroundings. Global fora have acknowledged in broad terms that adequate nutrition and environment are interconnected (World Declaration on Nutrition, International Conference on Nutrition, Convention on Biodiversity, Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetics, Resources for Food and Agriculture). Writing on Nutrition and Environment, Johns and Eyzaguirre (2000) stated that “Unless the environment is used in sustainable ways, it will become progressively more difficult to feed the world’s population. Health of humans intrinsically connects with the health of the ecosystem in which they live. Disruption in environmental integrity in turn affects pattern of human health, disease and nutritional status. Unless local communities protect the environment around them, they have limited hope to thrive beyond the short term". In Nigeria, the ecosystem has rich bio-diversity of foods across the agro-ecological zones. Some of these foods are currently very close to the point of extinction due to modernization, urbanization, industrialization, acculturization, economic development and market globalization. Documentation of these foods is imperative to help promote their consumption and utilization. Evidence based studies are needed to highlight their nutrient potentials and ways of increasing their utilization. These observations form the background to my research focus.

Table 1a: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	Cu (mg)	References
LEGUMES (PULSES)												
Sphenostylis stenocarpa (African yam bean, *ijiriji, azaakuru, okpodudu, azama*)	21.25	60.35	3.00	3.00	12.20	DM	32.50	125.00	1.85	ND	ND	Nnam (2002a)
Cajanus cajan (Pigeon pea)	19.25	68.91	2.69	3.95	3.19	DM	104.59	ND	4.15	2.46	1.25	Nnam & Uzoechina (2006)
Vigna unguiculata (cowpea - *potiskum* variety)	22.15	73.40	2.17	2.29	ND	DM	22.50	116.00	0.65	0.38	0.14	Nnam (1995)
Vigna subterranean (Bambara groundnut, *okpa*)	13.35	64.01	3.87	3.03	6.81	4.73	170.40 (PPM)	296.91 (PPM)	18.54 (PPM)	ND	4.60 (PPM)	Nnam (2001a)

Key: ND – Not determined, DM – Dry matter basis

Table 1b: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrat %	Fat %	Ash %	Fiber %	Moisture %	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	Cu (mg)	References
(OIL SEEDS)												
Arachis hypogaea (groundnut)	28.46	18.28	39.92	2.14	ND	11.20	60.00	ND	1.80	1.72	0.72	Nnam (2001d)
Glycine max (soybean)	42.18	31.08	18.60	5.02	3.12	DM	ND	ND	6.25	0.03	ND	Nnam & Baiyeri (2008)
Pentaclethra macrophylla (African oil bean)	26.40	20.98	38.95	7.60	1.20	4.87	ND	ND	4.42	0.06	0.26	Nnam & Madu (2002)
Sesame indicum (sesame)	27.56	17.85	49.81	4.78	ND	DM	16.10	873.67	5.14	1.44	0.27	Nwokocha & Nnam (2000)
Mucuna pruriens (Mucuna beans)	31.44	52.56	6.73	4.11	5.16	DM	31.37	ND	7.03	0.61	0.67	Nnam (2011)

Key: ND Not determined, DM Dry matter basis

Table 1c: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydra %	Fat %	Ash %	Fiber %	Moisture %	Ca mg	P mg	Fe mg	Zn mg	Cu mg	References
CEREALS												
Zea mays (Maize)	6.36	84.47	4.43	1.54	6.25	DM	3.50	602.33	1.85	1.60	0.02	Nnam and Okafor (1999)
Sorghum bicolour (Sorghum)	8.70	82.51	2.07	1.34	6.50	DM	217.63 (PPM)	83.17	ND	ND	ND	Nnam (2001a)
Digitaria exilis (hungry rice, *acha*)	7.84	86.31	11.94	1.73	2.18	DM	6.27	58.20	ND	ND	1.42	Nnam (2000c)
Pennisetum typhoides (millet)	11.33	74.70	5.62	1.91	6.44	DM	18.00	ND	ND	6.33	4.33	Nnam & Madu (2002)
Oryza sativa (rice)	6.61	90.63	1.22	1.54	ND	DM	0.43	620.33	2.81	0.26	0.03	Nnam and Obiakor (2003)

Key: ND – Not determined, DM – Dry matter basis

Table 1d: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate	Fat %	Ash %	Fiber %	Moisture %	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	Cu (mg)	References
OTHER OIL SEEDS												
Hibiscus sabdariffa (sorrel seed)	22.35	66.57	2.16	4.53	4.39	DM	332.00	690.67	4.40	3.37	7.40	Nnam & Onyeke (2010)
Adensonia digitata (baobab seed)	25.45	48.07	18.87	7.61	ND	DM	0.50	326.33	0.63	1.29	0.02	Nnam & Obiakor (2003)
Colocynthis citrallus (melon seed)	19.83	20.34	49.98	3.65	6.20	DM	0.93	ND	0.03	0.53	0.05	Nnam & Okafor (1999)
Irvingia gabonensis (ogbono seed)	9.10	23.10	58.00	1.40	8.40	DM	0.80	ND	0.02	0.02	0.06	Nnam & Nwofor (2001)
Cucurbita moshata (pumpkin seed)	38.75	12.07	36.73	5.38	7.07	DM	0.15	ND	0.17	0.10	0.02	Nnam & Okafor (2001)

Key: ND – Not determined, DM – Dry matter basis

Table 1e: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	Cu (mg)	References
NUT												
Juglans regia (wall nut)	4.80	14.78	12.60	1.80	6.50	60.32	ND	ND	4.02	2.70	1.68	Nnam (2011)
ROOT AND TUBERS												
Ipomea batatas (sweet potatoes)	3.17	89.44	1.43	1.53	4.43	DM	101.12	ND	0.95	ND	0.54	Nnam (2001a)
Colocasia esculenta (taro)	4.02	92.56	1.31	2.21	ND	DM	26.42	ND	0.72	ND	ND	Nnam (2001b)
Dioscorea dumetorum (African bitter yam, three leaved yam, trifoliate yam, *ona* (Yellow variety)	4.52	93.82	0.46	1.20	ND	DM	18.73	ND	2.66	0.64	ND	Nnam & Nwachukwu (2007)
White variety	4.72	94.53	0.52	0.23	ND	DM	19.30	ND	0.80	0.17	ND	Nnam & Nwachukwu (2007)
Dioscorea bulbifera aerial yam, air potato yam, bulbil bearing yam, turkey liver yam, *adu* (green variety)	3.14	96.03	0.23	0.60	ND	DM	19.33	ND	1.73	0.18	ND	Nnam & Nwachuwku (2007)
Brown variety	6.20	90.80	1.50	1.50	ND	DM	3.15	ND	3.93	0.43	ND	Nnam & Nwachukwu (2007)
MUSHROOM												
Pleurotus tuber regium (ero)	9.51	52.11	0.38	1.07	8.02	28.86	0.77	0.58	0.09	0.31	0.05	Nnam & Okafor (2001)

Key: ND – Not determined, DM – Dry matter basis

Table 1f: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate ($_{mg}$)	β-carotene (RE)	Ca $_{(mg)}$	P $_{(mg)}$	Fe $_{(mg)}$	Zn $_{(mg)}$	References
VEGETABLES													
Mucuna pruiens leaf (fresh)	3.14	11.47	0.65	1.25	3.82	79.67	26.16	3.62	23.48	ND	7.45	2.86	Nnam (2011)
Phellantus niriri leaf (fresh)	3.87	15.47	1.08	3.02	3.20	73.67	20.13	3.65	34.71	ND	11.27	1.83	Nnam (2011)
Ficus carpensis leaf (fresh)	2.18	14.48	3.42	10.57	8.91	60.44	8.52	27.94	2.65	1.42	1.70	0.42	Nnam & Omaekwe (2010)
Vitex doniana leaf (fresh)	4.44	45.73	1.88	2.05	11.45	34.44	27.45	67.83	1.45	28.63	1.38	1.65	Nnam & Omaekwe (2010)
Adansonia digitata (baobab leaf flour)	12.40	66.50	4.30	6.90	9.90	DM	ND	ND	147.00	203.00	0.02	0.02	Nnam & Nwofor (2001)
Hibiscus sabdariffa (sorrel leaf flour – red calyx plant)	3.68	82.03	2.57	5.90	5.52	DM	11.90	365.86	24.31	23.64	8.56	0.03	Nnam & Onyeke (2010)
Sorrel leaf flour-yellow calyx plant	1.56	78.99	6.06	4.34	9.05	DM	10.84	340.01	62.10	23.03	6.34	0.69	Nnam & Onyeke (2010)
Sorrel red calyx flour	6.40	79.25	5.13	6.52	2.70	DM	53.00	285.29	3.00	22.00	8.33	1.17	Nnam & Onyeke (2010)
Sorrel yellow calyx flour	9.08	76.96	4.92	6.08	2.95	DM	56.83	281.28	3.00	23.33	8.00	1.37	Nnam & Onyeke (2010)

Key: ND – Not determined, DM – Dry matter basis

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	β-caroten (RE)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	Reference
VEGETABLES													
Telferia occidentalis (fluted pumpkin, *ugu* leaf) Fresh leaf	1.80	8.10	0.90	2.40	2.80	84.00	ND	ND	ND	ND	ND	ND	Nnam & Ogbu (2009)
Fresh leaf flour	23.08	61.75	8.98	2.99	3.47	DM	28.00	41.09	2.95	ND	9.86	ND	Nnam & Ogbu (2009)
Fresh leaf curd	6.24	14.56	0.72	0.83	1.38	76.24	ND	ND	ND	ND	ND	ND	Nnam & Ogbu (2009)
Fresh leaf curd flour	19.75	76.99	0.94	1.21	1.29	DM	16.00	14.56	ND	3.75	ND	ND	Nnam & Ogbu (2009)
Portulaca oleracea (nti-oke, water leaf) fresh leaf	3.44	5.39	0.20	3.55	2.87	84.55	155.88	150.00	1686.55	ND	ND	ND	Nnam & Onyeanwu (2009)
Leaf flour	22.26	34.87	1.29	22.96	18.57	DM	1002.85	970.05	10911.98	ND	ND	ND	Nnam & Onyeanwu (2009)
Boerhavia diffusa (azu igwe, Hog weed) fresh leaf	3.53	5.96	0.22	3.18	2.66	84.45	170.22	150.00	1725.11	ND	ND	ND	Nnam & Onyeanwu (2009)
Leaf flour	22.69	38.32	1.41	20.44	17.10	DM	1094.51	964.50	11092.45	ND	ND	ND	Nnam & Onyeanwu (2009)
Stellaria media (Nri okuku, chickweed) Fresh leaf	3.48	7.57	0.22	3.27	2.58	82.88	158.31	300.00	1801.22	ND	ND	ND	Nnam & Onyeanwu (2009)
Leaf flour	20.32	44.21	1.28	19.09	15.06	DM	922.72	1752.00	10542.48	ND	ND	ND	Nnam & Onyeanwu (2009)

Key: ND – Not determined, DM – Dry matter basis

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	β-carotene (RE)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	References
VEGETABLES													
Amaranthus spinosus (inine ogwu) fresh leaf	3.92	5.97	0.20	3.44	2.82	83.65	180.10	150.00	1081.33	ND	ND	ND	Nnam & Onyeanwu (2009)
Leaf flour	23.95	36.47	1.22	21.02	17.23	DM	1100.41	916.50	10272.93	ND	ND	ND	Nnam & Onyeanwu (2009)
Amaranthus hybridus (inine nri) fresh leaf	3.88	4.71	0.21	3.38	2.77	85.05	160.45	600.00	1833.05	ND	ND	ND	Nnam & Onyeanwu (2009)
Leaf flour	25.95	31.51	1.40	22.61	18.53	DM	1073.41	4014.50	12265.10	ND	ND	ND	Nnam & Onyeanwu (2009)
Ficus elasticoides *Ogbu ike*, fig tree leaf (fresh)	4.60	18.90	0.70	2.90	2.10	68.80	32.90	ND	101.60	375.40	2.90	4.30	Nnam (2011)
Corchorus olitorius *Ariraolegule*, jute leaf (fresh)	3.30	17.90	0.80	1.00	1.80	70.20	3.60	ND	238.00	128.20	1.60	6.90	Nnam (2011)
Ficus vogeliana *Ogbu* leaf (fresh)	2.80	28.70	0.40	3.70	2.30	61.60	6.50	ND	240.60	73.40	6.20	2.90	Nnam (2011)
Ceiba pentandra *Akwukwo akpu* (fresh)	2.70	25.40	0.10	0.90	1.20	69.70	12.20	ND	261.50	154.10	3.60	5.30	Nnam (2011)
Daniella oliveri Leaf (fresh)	3.90	18.00	0.40	0.90	1.70	71.10	3.64	ND	281.90	187.90	2.00	1.30	Nnam (2011)
Pterocarpus santalinoides *Uturukpa* leaf	4.20	26.10	0.40	4.20	4.30	60.80	11.20	ND	343.40	85.00	3.10	1.80	Nnam (2011)
Psychotria viridis *Anyazu* leaf	1.40	23.50	1.30	1.80	0.60	66.40	29.90	ND	116.20	134.60	14.80	7.0	Nnam (2011)

Key: ND – Not determined, DM – Dry matter basis

Table 1g: Nutrient sComposition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	-carotene (RE)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	References
FRUITS													
Musa spp													
Plantain hybrid flour	3.64	89.83	2.76	3.84	0.29	DM	0.03	1.27	ND	ND	7.05	3.05	Naam & Baiyeri (2008)
Plantain landrace flour	4.56	87.65	1.61	3.06	3.12	DM	0.05	1.19	ND	ND	3.44	3.10	Naam & Baiyeri (2008)
Musa acuminate Banana flour	5.64	87.56	0.77	3.54	2.49	DM	ND	ND	0.85	35.50	ND	ND	Oly-Alawuba & Naam (2010)
Magnifera inidica L.													
Normal mango pulp fresh	0.33	13.04	0.17	1.53	0.33	84.60	42.40	24.30	23.00	ND	1.03	Trace	Naam &Ajugwe (2003)
Normal mango pulp flour	4.22	86.92	2.63	3.53	2.70	DM	48.10	16.30	23.00	ND	1.03	Trace	Naam & Ajugwe (2003)
Normal mango epicarp fresh	0.53	20.03	0.33	1.80	0.90	76.40	42.66	68.00	13.80	ND	1.00	ND	Naam & Odigwe (2010)
Sweet mango pulp fresh	0.87	8.17	0.33	1.57	0.17	88.90	40.40	18.00	14.00	ND	Trace	Trace	Naam & Ajugwe (2003)
Sweet mango epicerp fresh	0.57	20.80	0.17	2.30	1.33	74.80	43.33	16.00	18.00	ND	Trace	Trace	Naam & Ajugwe (2003)
Lycopersicon esculentum (tomato flour)	8.67	74.91	4.91	4.65	6.86	DM	44.33	55.00	18.43	ND	5.43	0.40	Naam (2011)

Key: ND – Not determined, DM – Dry matter basis

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	-carotene (RE)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	References
FRUITS													
Curcurbita moschata (pumpkin pulp fresh)	0.72	5.56	0.98	3.42	4.67	84.65	ND	266.67	15.57	ND	0.82	3.06	Nnam & Uzoechina (2006)
Pumpkin pulp flour	12.04	66.51	1.75	3.31	1.92	12.47	ND	29.40	36.10	ND	1.95	6.55	Nnam & Uzoechina (2006
Artocarpus altilis flour Seedless bread fruit	8.20	55.33	11.7 1	18.87	5.89	DM	1.03	ND	0.52	651.00	61.10	7.02	Nwokocha & Nnam (2000)
Olax viridis fresh	6.52	5.30	2.25	12.52	13.58	59.83	40.22	3.99	3.25	39.42	1.43	1.29	Nnam & Onuekwe (2010)
Ficus carpensis fresh	6.53	19.54	0.46	6.59	3.49	63.39	13.68	36.00	18.03	20.13	1.04	0.42	Nnam & Onuekwe (2010)
Napoleana imperialis (*Odure* fresh)	3.00	12.76	0.46	10.48	8.91	61.15	48.87	11.99	4.60	11.46	1.29	1.42	Nnam & Onuekwe (2010)
Afromomium daniella (*ose ohia*) fresh	0.27	26.50	0.27	0.65	1.01	71.30	17.40	0.29	16.63	44.66	3.50	ND	Nnam (2011)
Gongronema sp fresh	2.60	20.69	Trace	0.66	1.30	75.40	14.84	0.25	3.02	3.85	1.48	0.02	Nnam (2011)
Hippocretae myriat (wild kola) fresh	0.30	26.37	0.10	0.55	0.28	72.40	22.70	Trace	13.04	20.00	9.60	ND	Nnam (2011)

Key: ND – Not determined, DM – Dry matter basis

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	[illegible]	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	References
FRUITS													
Nauclear diderrichii (*uvuru*) fresh	1.01	36.61	0.41	0.80	1.47	59.70	13.40	ND	9.20	9.00	4.80	1.70	Nnam (2011)
Icacina trichatha O. *Urumbia* fresh	0.90	24.39	0.37	0.73	0.11	73.45	4.90	ND	20.70	13.00	2.10	2.80	Nnam (2011)
Vitex doniana (mbembe) plack plum	1.30	30.95	2.50	2.79	0.76	61.70	14.29	ND	12.16	19.00	3.40	ND	Nnam (2011)
Spondian monbin Echikara (Hog plum)	1.20	26.38	0.20	3.00	2.02	67.20	9.30	ND	17.91	39.00	2.12	ND	Nnam (2011)
Ficus elasticoides (utu *nkilisi*)	0.31	25.62	0.47	0.44	0.36	72.80	8.60	Trace	14.71	18.00	3.80	ND	Nnam (2011)
Myristicaceae spp	1.20	35.77	0.52	0.68	0.93	60.90	14.90	ND	19.09	12.00	6.40	2.30	Nnam (2011)
Olasiviridis spp (*aziza ohia*)	0.72	25.08	0.39	0.71	0.39	73.10	2.40	ND	18.47	14.00	3.60	0.01	Nnam (2011)
Solanum melongera Garden egg white variety fresh	0.45	25.76	0.22	2.27	2.20	69.10	6.47	1.43	1.48	ND	8.03	0.55	Nnam & Ajugwe (2003)
Garden egg green variety fresh	2.23	21.23	0.14	2.28	1.68	72.80	9.58	1.75	1.62	ND	12.50	0.85	Nnam & Ajugwe (2003)
Dennettia tripetala (*mmi-mmi*) pepper fruit fresh	3.87	0.36	1.84	3.04	6.84	84.05	8.40	305.22	ND	ND	Trace	Trace	Nnam (2011)

Key: ND – Not determined, DM – Dry matter basis

Table 1h: Nutrients Composition of Some Known and Lesser-known Food Crops

	Protein %	Carbohydrate %	Fat %	Ash %	Fiber %	Moisture %	Ascorbate (mg)	β-carotene (RE)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)	References
HERBS, SPICES, SEASONINGS AND OTHERS													
Allium cepa Onion flour	10.50	69.32	11.43	5.00	3.75	DM	ND	ND	180.00	202.00	16.60	1.20	Nnam et al. (2009)
Zingiber officinate Ginger flour	4.81	68.80	17.14	3.00	6.25	DM	ND	ND	173.70	213.20	20.60	1.70	Nnam et al. (2009)
Carcina kola (*aku ini*) bitter cola	3.54	21.12	4.84	0.90	5.10	64.50	12.10	50.60	ND	ND	6.10	2.64	Nnam (2011)
SEA FOODS													
Littorina saxatili Periwinkle fresh	12.60	53.60	1.00	2.40	1.40	29.00	ND	ND	418.90	166.80	61.90	15.40	Nnam & Nwabueze (2006)
Macrobrachium vollenhovenii Prawn, *uporo* fresh	14.00	48.84	1.20	2.53	1.43	32.00	ND	ND	412.80	102.60	12.60	16.70	Nnam & Nwabueze (2006)

Key: ND – Not determined, DM – Dry matter basis

Table 1 documents some known and lesser-known food crops in Nigerian ecosystem and their nutrients composition. The table shows that there are a lot of underutilized lesser-known food crops in Nigerian ecosystem. They have promising nutrient potentials, which could be utilized in the food based approach to fighting malnutrition. Malnutrition with its “double burden” is still a public health problem in Nigeria and poses a serious threat to the health of individuals. Dietary diversification using locally available food crops in the ecosystem should be used to address malnutrition especially among the vulnerable groups (infants, children and women). Increased utilization of the wild uncultivated fruits and vegetables in the ecosystem could help to ensure food and nutrition security, which is further threatened with the adverse effect of global climate change.

Table 2 presents the phytochemical constituents of some known and lesser- known food crops in Nigeria. The data show that the food crops contained most of the phytochemicals examined in high and moderate quantities. Some foods however have trace amounts of the phytochemcials. The nutrient composition and phytochemical constituents of the food crops are of interest. The food crops could make significant contribution in the dietary diversification programme to combating malnutrition and ensuring nutrition security of individuals.

Table 2a: Phytochemical constituents of some known and known-lessercrops food

		Phenol	Tannins	Cardiac Glycosides	Terpenes	Deoxy Sugar	Flavonoids	Alkaloids	Phlobatannins	Anthraquinones
FRUITS										
Dennetia tripetala (pepper fruit, *mmimi*)	++	+++	ND	ND	ND	+	ND	++	ND	ND
Hyppocretiae myriu (wild kola fresh)	+++	ND	++	++	+	+++	+	++	++	+++
Nauclea diderrichii (*Uvuru* fresh)	++	ND	++	++	++	++	+++	+++	+	++
Icacina trichatha O. (*Urumbia* fresh)	+++	ND	+	++	+	++	++	++	+	++
Napoleana imperialist (*Ukum*) fresh	++	ND	+	++	++	++	+	++	+	++
Spondias mombin (*echikara*) Hog plum fresh	+	ND	+++	++	++	+++	++	+++	++	++
Vitex doniana (*mbembe*) Black plum	+	ND	+++	++	++	+++	++	+++	++	++
Afromomium daniella (*Ose ohia* fresh)	++	ND	+	++	++	+	++	+	+	+++
Bridelia wild (fresh)	++	ND	+	++	+	++	+	+	+	+++
Myristicaceae spp (fresh)	++	ND	++	+++	+	++	++	++	+	++
Olaxviridis spp (fresh) (*aziza ohia*)	+	ND	+	++	++	++	+	++	+	++

Sources: Nnam et al. (2009) and Nnam (2011)
Key: +++ highly present, ++ moderately present, + trace amount

Table 2b: Phytochemical constituents of some known and known-lessercrops food

	[illegible]	Phenol	Tannins	Cardia Glycosides	Terpenes	Deoxy Sugar	Flavonoids	Alkaloids	Phlobatannins	Anthraquinones
VEGETABLES										
Mucuna pruriens (fresh)	+	ND	++	++	++	+	++	++	+	++
Phylantus niriri (fresh)	+++	ND	+++	+++	++	+++	++	+++	+	++
Vitex doniana	+++	ND	+++	++	+++	+++	+	+++	+	+
Ficus elsticoides (ogbuike, ifg tree leaf fresh)	+++	ND	+++	+++	++	+++	+++	++	+	++
Corchorus olitorius (*Arira/Ekgule*, jute leaf fresh)	++	ND	++	+	+++	+++	+++	++	++	+
Ficus vogeliana (*ogbu* leaf fresh)	+	ND	++	+	++	+++	+++	+	+	+
Ceiba pentandra (*Akwukwo akpu* fresh)	+++	ND	++	+++	+++	+++	+	++	+	++
Portulaca oleracea (nti akei) water leaf fresh	+	ND	++	++	++	++	++	+++	+++	++
Daniella olivera (*Agba* leaf fresh)	++	ND	++	+	+++	+++	+++	+	+	+
Pterocarpus santalinoides (*Uturukpa* leaf fresh)	++	ND	+++	++	++	++	++	+++	+	++
Psychotria viridis (*Anyanu* leaf fresh)	++	ND	++	+	+++	+++	++	+++	+++	+
Boerhavia diffusa (*Azuigwe*) Hog weed	++	ND	++	+	++	+++	++	+++	++	+
Veronomia amygdalina(onugbu)	+++	ND	++	+	++	+++	++	+++	++	+
Ociumgratissimum(nch anwu)scent leaf	++	ND	++	+	++	+++	++	+++	++	+

Sources: Nnam et al. (2009) and Nnam (2011)

Key: +++ highly present, ++ moderately present, + trace amount

IMPROVING NUTRITIONAL QUALITY OF LOCALLY AVAILABLE FOOD CROPS THROUGH HOUSEHOLD-LEVEL FOOD TECHNOLOGY

Some household-level food technologies like fermentation, germination and boiling are known to improve nutritional quality of plant foods by increasing the levels of some nutrients and their bio-availability, decreasing bulk and antinutrients level, increasing nutrient density, imparting antibacterial property to improve food safety, improving flavour and converting inedible plant items to edible plant foods. Table 3 shows the effect of household- level food technology on some plant foods.

Table 3: Effect of household-level food technology on nutrient composition of plant foods

Plant food	House hold-level food technology	Nutrients that increased	References
*Vigna unguiculata (*Cowpea-potiskum variety)	Fermentation (24 – 144h)	Lipids, ash, Ca, Pa, Mg, Zn & Cu	Nnam (1995; 1999b)
Sphenostylis stenocarpa (African yam bean)	Fermentation (24 – 144h)	Protein, soluble sugar, Ca, Mg &Fe	Nnam (1999b; 2002)
Vigna subterranea (Bambara groundnut)	Sprouting (48h)	Protein, lipid & Ca	Nnam (2001a)
Adansonia digitata (Baobab seeds)	Fermentation (24 – 72h)	Fat & Zn	Nnam & Obiakor (2003)
Hibiscus sabdariffa (Sorrel seed)	Fermentation (4 – 6d)	Protein, Ca, P & Fe	Nnam & Onyeke (2010)
Sorghum bicolor (Sorghum)	Sprouting (48h)	Protein, CHO & P	Nnam (2001a)

Digitaria exilis (Hungry rice)	Sprouting (24 – 60h)	Protein, ash, crude fiber, P, Ca, Mg, Fe, Cu & ascorbate	Nnam (2000)
Oryza sativa (Rice)	Fermentation (24 – 72h)	P, Zn & Cu	Nnam & Obiakor (2003)
Ipomea batatas (Sweet potatoes)	Fermentation (48h)	Protein, lipid & Cu	Nnam (2001a)
Dioscorea dumetorum (Bitter yam- white variety)	Fermentation (24 – 72h)	Protein, ash, Ca, Zn & Fe	Nnam & Nwachukwu (2007)
Dioscorea dumetorum (Bitter yam- yellow variety)	Fermentation (24 – 72h)	Protein, fat, ash, Ca & Fe	Nnam & Nwachukwu (2007)
Dioscorea bulbifera (Aerial yam-green skinned variety)	Fermentation (24 – 72h)	Protein, fat, ash & Fe	Nnam & Nwachukwu (2007)
Dioscorea bulbifera (Aerial yam-brown skinned variety)	Fermentation (24 – 72h)	Protein, ash & Ca	Nnam & Nwachukwu (2007)
Dioscorea dumetorum (Bitter yam- white variety	Fermentation (24 – 72h) and Boiling (90min)	Protein, fiber & ash	Nnam & Nwachukwu (2008)
Dioscorea dumetorum (Bitter yam – yellow variety)	Fermentation (24 – 72h) and Boiling (90min)	Protein, fat, fiber & ash	Nnam & Nwachukwu (2008)
Dioscorea bulbifera (aerial yam – green skinned variety)	Fermentation (24 – 72h) and Boiling (35min)	Protein, fat, fiber & ash	Nnam & Nwachukwu (2008)
Dioscorea bulbifera (aerial yam – brown skinned variety)	Fermentation (24 – 72h) and Boiling (35min)	Protein, fat & fiber	Nnam & Nwachukwu (2008)

The increases in nutrients observed during the household-level food technologies were due to increased microbial enzyme activities and losses in dry matter. Complex changes occur during fermentation due to the release by the fermenting microflora of protease, lipase, amylase, phytase, phosphotase and pectinase enzymes, which lead to dry matter reduction and apparent increases in proximate values.

Effect of household-level food technology on amino-acid

Saccharomyces sp. were inoculated separately or mixed with *Lactobacillus delbruckii* and *Lactobacillus coryneformis* into cassava mash and fermented with or without dewatering for 24, 48, 72, 92 and 120h. At the end of the fermentation period, the mash was converted to *garri*. The lysine content of the mash was highest when all three organisms were mixed and it tended to increase with increasing length of fermentation of the mash (Okafor et al. 1998).

Effect of household-level food technology on nutritional quality of plant foods

The nutritional quality of blends of fermented or unfermented corn, African yam bean and cowpea were evaluated in ten children 5.2 ±0.5 years old. The children fed the fermented diets had higher nitrogen and mineral (Ca, P, Fe, Zn) balances (Nnam, 1999a).

Cream and brown varieties of African yam bean were sprouted for 36 – 72h. Sprouting increased protein levels and calcium retention in rats fed the cream variety (Obizoba and Nnam, 1992).

Twenty-four rats (95 – 102g) were used to determine the bio-availability of minerals (Ca, Zn and Fe) in unprocessed and processed sorghum, bambara groundnuts and sweet potatoes flour mixture. Processing lowered fecal and urinary losses of Ca, Zn and Fe in most of the groups. This in turn improved the bioavailability of the nutrients in the animals (Nnam, 2008).

The increased level of protein and micronutrients in the plant foods as well as their improved bioavailability observed with household-level food technologies are of interest particularly as regards the emerging trends observed with climate change. The increase in atmospheric carbon dioxide (CO_2) concentration observed with climate change may lower the protein and micronutrients composition of some staple foods. Some cereal and forage crops have lower protein levels under elevated CO_2 conditions. This is because the extra CO_2 is often converted to carbohydrate such as starch and this is likely to decline the level of other nutrients particularly protein. The simple household-level food technologies like fermentation and or germination of food crops could be useful in bridging the nutrient gap and the burden of micronutrient deficiency or hidden hunger that might increase as a result of climate change. These technologies are useful particularly in rural communities who depend mainly on plant foods as their main source of protein and micronutrients as animal foods are very expensive and unaffordable.

Effect of household-level food technology on antinutrients

Fermentation reduced the levels of some antinutrients (phytates, tannins and oxalates) in some plant foods (Nnam, 1992; 1999a; 2000a; 2001c; 2002a; Nnam and

Obiakor, 2003; Nnam and Nwachukwu, 2007). The decreases in tannins and phytates due to fermentation could improve the bio-availability of nutrients due to breakdown of tannin-protein, tannin-iron, tannic acid-starch and mineral-phytate complexes to release free nutrients.

Effect of household-level food technology on oligosaccharides

The effect of fermentation on the oligosaccharides constituents of imitation milk made from fermented and unfermented cowpea and cowpea corn blends were studied (Nnam 2001c). The oligosaccharides (Stachyose and raffinose) decreased during fermentation due to the activities of the amylolytic enzymes (α-galactosidases), which predigested the galactosidosucrose molecules of the complex sugars. The decrease in oligosaccharides would reduce flatulence and increase the level of available carbohydrates (the soluble sugar). This is important especially in young child feeding. It has been observed that even in those parts of the world where the average per capita consumption of cowpea is considerably high, that of children is usually low. Flatulence has been identified as a major factor that hinders the utilization of cowpea for food.

Effect of household-level food technology on bulk and nutrient density

Sprouting of cereals and legumes led to decreased bulk and increased nutrient densities of porridge made from their multimixes (Nnam 2001a; Nnam and Odigwe, 2010). The viscosities of the porridges made from the sprouted flour were thinner than that of their control. The low viscosities of the porridges have important nutritional implications for young child feeding. Dietary bulk (bulkiness) or high viscosity (consistency) or high volume of porridges has remained a major constraint in providing young children with enough food to meet energy and nutrient requirements. When the porridges are made energy and nutrient dense, they become thick, sticky, high in viscosity and unacceptable to the child who cannot consume such thick solids. On dilution, the porridge becomes voluminous and the child's small stomach is filled without adequate energy and nutrient intake. The high energy requirement of young children coupled with their limited stomach capacity make it impossible for them to have sufficient food intake, particularly if the number of meals per day is low.

Effect of household-level food technology on food safety

Fermentation of cereals and legumes decreased pH with corresponding increases in titratable acidity (TA). (Nnam, 2000a; 2002a; Nnam and Obiakor, 2003). The accumulation of acid is desirable particularly in the use of the fermented flours as ingredients for the formulation of complementary food. The acidic medium developed as a result of the hydrolytic activities of the amylolytic and proteolytic enzymes provides unfavourable condition for the proliferation of most of the pathogenic organisams that could cause food spoilage and poisoning.

Fermentation of African yam bean for 144h (Nnam, 2002a) showed changes in total viable count (TVC) of microorganisms. The TVC ranged from 4.15×10^{14} to 2.14 to 10^{11} c.f.u. g^{-1}. Fermentation increased the TVC up to 72h; thereafter there was a sharp decrease (**Fig. 3**).

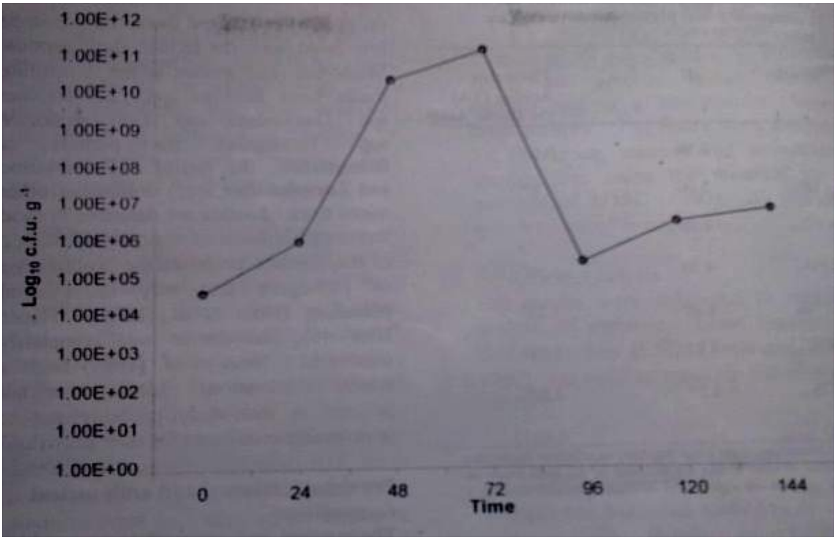


Fig. 3: Changes in total viable counts of microorganisms during the fermentation of African yam bean flours

Acid accumulation has been known to reduce the number of less acid tolerant microorganisms as a normal sequence of microbial succession in fermenting system. Major bacterial species in the fermenting media were *Bacillus spp, Lactobacillus spp, Leuconostoc spp* and *Aerobacter spp*, which was completely eliminated after 48h fermentation. The disappearance of *Aerobacter spp* at 48h fermentation is significant because its presence is indicative of possible presence of enteric pathogens, which may cause diarrhoea and other gastro intestinal diseases in humans. Throughout the periods of fermentation, the lactics *(Leuconostoc and Lactobacillus spp*) dominated other micro flora (**Fig. 4**). Lactics are desirable in food fermentation because their acidiphication of the medium prohibits the proliferation of pathogens that may cause food poisoning.

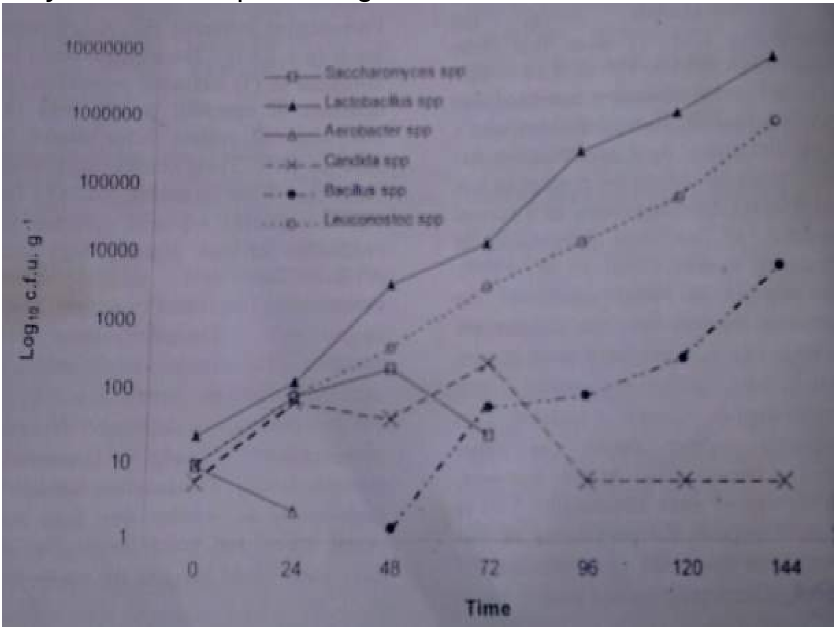


Fig. 4: Changes in viable counts of organisms isolated from fermentation of African yam bean flours

Microbial changes during the fermentation of cowpea were studied (Nnam, 2000a). The TVC ranged from 2.02 x 10^3 c.f.u.g^{-1} in unfermented sample to 2.23 x 10^9 c.f.u.g^{-1} in the fermented sample. The counts increased and peaked at 72h of fermentation. Thereafter, there was a sharp decrease (**fig. 5**). The *Lactiobacillus* species isolated were *Lactobacillus acidophilus* and *Lactobacillus plantarum* (**fig. 6**). Other bacterial species isolated were from the genera *Bacillus* and *Aerobacter*. Their population remained very low throughout the fermentation periods due to dominance of the fermenting mash by the lactics. *Aerobacter spp* was completely eliminated at 24h of fermentation.

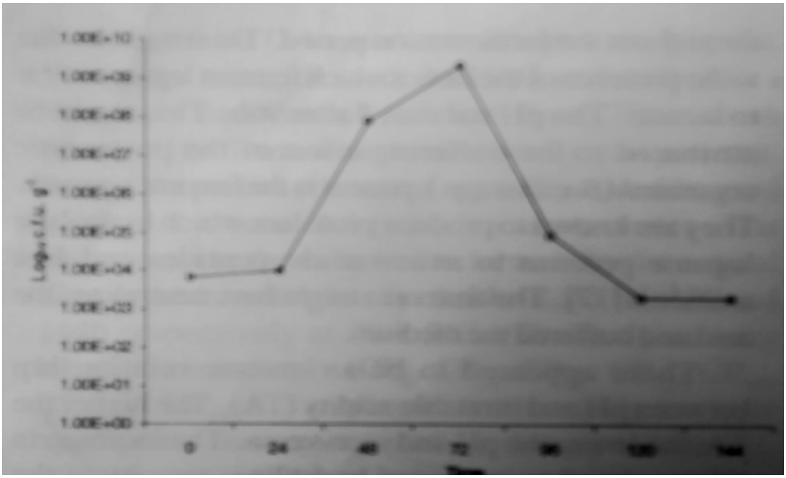


Fig. 5: Changes in total viable counts of microorganisms during the fermentation of cowpea

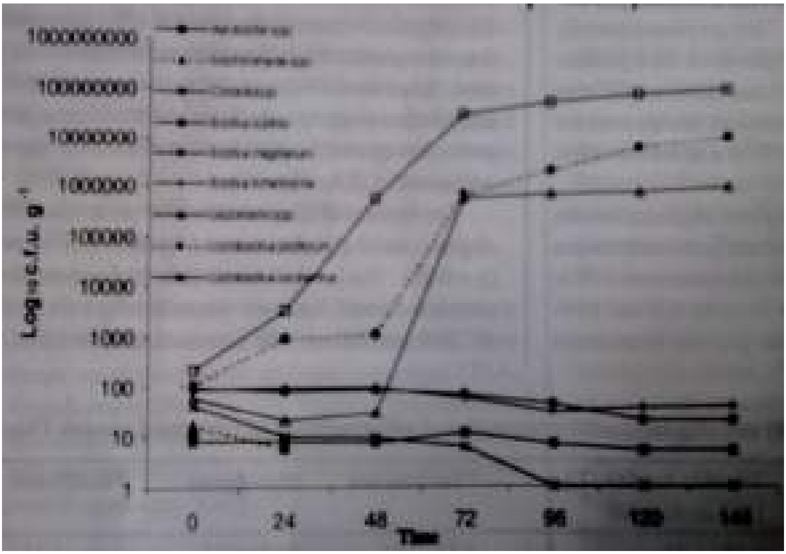


Fig. 6: Changes in viable counts of organisms from fermentation of cowpea

Effect of household-level technology on flavour

The flavor of food products (imitation milk and porridges) made from fermented cereal and legume flour (24h fermentation) were preferred over their controls from unfermented flour (Nnam, 1997; 1999c, 2003). The preference of the flavour of the products made from fermented flour over those of the unfermented could possibly be due to formation of desirable flavouring substances e.g. diacetyl produced by lactics (*Leuconostoc ssp*) during fermentation. Another possible reason may be due to lipolytic enzyme activities during fermentation to release more free fatty acids. The fatty acids might react with alcohol to form a mixture of esters, which provide a pleasant flavor. The improvement of flavor during fermentation is one of the reasons for the use of fermentation to convert inedible plant item to edible plant food.

FORMULATION OF INFANT COMPLEMENTARY FOODS, MULTIMIXES AND OTHER FOOD PRODUCTS FROM LOCALLY AVAILABLE FOOD CROPS AND THEIR NUTRIENT AND SENSORY EVALUATION

Nnam and Odigwe (2007) studied the nutrient adequacy of complementary food formulated from blends of sprouted millet, baobab seed and pulp from either baobab or mango. The result showed that the formulated complementary food could meet the protein, vitamin A and iron requirements of infants 6 – 9m.

Porridges were made from blends of fermented maize and African yam bean (Nnam, 2003c), fermented maize, cowpea and plantain (Nnam, 1999c). The porridges had good nutritional attributes and were accepted by mothers for feeding their young children.

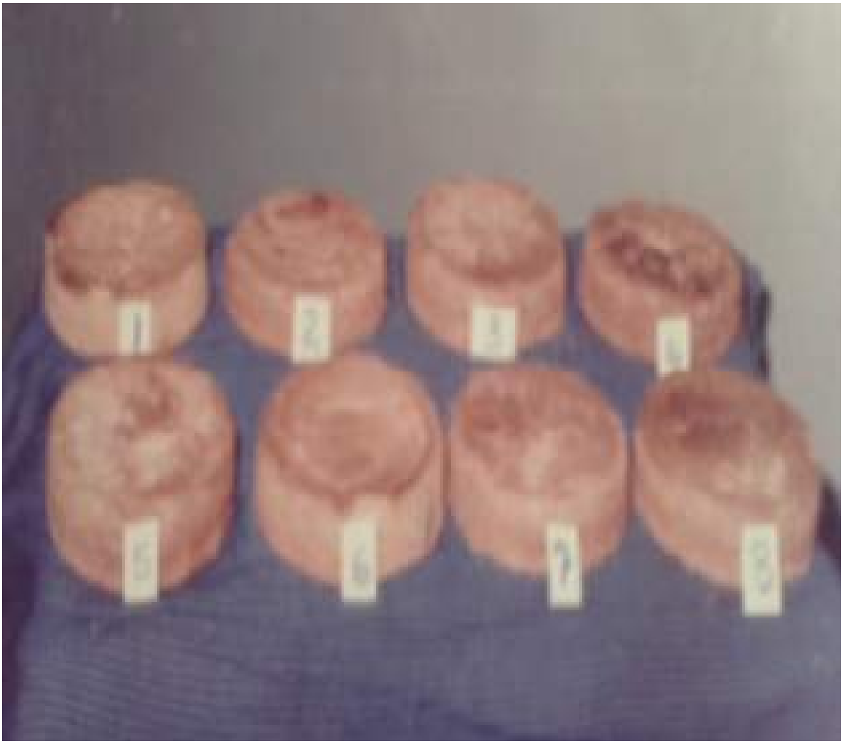
Eight multimixes were formulated from some locally available food crops (soybeans, cowpeas, maize, sorghum, yams, cocoyams, plantains and sweet potatoes) using a ratio of 65% cereal, 30% legume and 5% starchy staple (65: 30: 5) (protein basis) for use as infant complementary foods. The foods were processed by sprouting, cooking and fermentation. The protein and energy levels of the mutimixes were higher than those of some commercial infant complementary foods in Nigeria. The multimixes contained fair quantities of calcium and phosphorus and an adequate amount of some of the essential amino acids. The amino acid scores, protein scores and net protein values compared favourably well with the FAO provisional amino acid scoring pattern (Nnam, 2000b).

Multimixes for use as infant complementary food

Multimixes were made from blends of fermented maize, roasted groundnuts and paw-paw or mango pulp (Nnam, 2002b); sprouted maize, boiled soybean and plantain pulp (Nnam and Baiyeri, 2008) for possible use as infant complementary food. The nutrient levels of the multimixes were compared with the Codex Alimentarius Standard for formulated supplementary food for infants and young children. The composites met the Codex specification for some of the nutrients and showed nutritional superiority over the maize traditional complementary food in terms of protein and mineral nuriture. Porridges made from the multimixes were acceptable by mothers for feeding their young children.

Snacks were prepared from blends of some locally available food crops. Jellof agidi for feeding young children was made from fermented African yam bean (AYB) or cowpea and corn blends combined in the ratio of 70% corn and 30% AYB or cowpea (Nnam, 1999d). Snacks were made from blends of melon or pumpkin seed and mushroom supplemented with maize flour in the ratio of 70: 28: 2 (protein basis) (Nnam and Okafor, 2001). Cookies and muffins were prepared from composite flour of fermented sorghum, cowpea and banana pulp formulated in ratios of 60: 30: 10 (protein basis) (Nnam, 2003b). Biscuits were made from mixtures of hungry rice (acha), sesame and breadfruit combined in different ratios (Nnam and Nwokocha, 2003). The snacks had rich nutrient potentials and the sensory properties were acceptable to the judges.

Biscuits made from blends of locally available foods



Cakes developed from blends of locally available foods

Bread developed from blends of locally available foods

Imitation milks were made from some oil seeds (Nnam, 2003), pulses and cereals or their combinations (Nnam, 1997; 2001c). The milks were acceptable with promising nutrient potentials. This is of interest as the imitation milks could provide varied alternatives for individuals who cannot afford animal milk due to high cost. Furthermore, large proportion of the world's population has hypolactasia (low level of lactase in the intestinal mucosa) resulting to lactose intolerance. Use of the vegetable milks is an economic method of providing nutritious foods and supplying the compatible milk needs of lactose-intolerant families.

Imitation milk developed from some oil seeds

Fruit juices were produced from some citrus fruits (orange, lime, lemon and grape) (Nnam and Njoku, 2005) and other commonly consumed fruits (Obizoba et al. 2004). The juices were rich in micronutrients particularly ascorbate and potassium. Consumption of the juices could be useful in bridging the micronutrient malnutrition, which is still a major public health problem in Nigeria. It could also help reduce post-harvest losses and increase utilization of the fruits. In Nigeria, consumption of some citrus fruits like grape (*citrus paradisi*), lime (*citrus aurantifolia*) and lemon (*citrus lemon*) is limited. The fruits are found in some villages and towns producing and wasting. The high ascorbate levels of the fruit juices is of interest because when a food rich in ascorbate is part of the meal, iron absorption is significantly improved.

Recipes were developed and used to formulate sorrel jelly and cordial juice from the calyx, sorrel seasoning from the leaf, and sorrel food condiment from fermented seed. The products had promising nutritional attributes and were accepted by the judges (Nnam and Onyeke, 2010).

Jelly developed from sorrel calyces

Juice develop from sorrel calyces

Food condiment developed from sorrel seeds

Oil developed from sorrel seeds

Food seasoning developed from sorrel leaves

These products are in use locally. Efforts are in progress to obtain patent right for their wider usage.

IMPROVING NUTRITIONAL STATUS OF INDIVIDUALS AND NUTRITIONAL QUALITY OF FOOD CROPS THROUGH FOOD SUPPLEMENTATION, BIOCHEMICAL STUDIES

Leaf curd was developed from fluted pumpkin leaf and added to rat chow for a 28-day study period to determine the effect on hematolological indices of rats (Nnam and Ogbu, 2009). The control group was fed rat chow alone. Blood samples were collected before and after the feeding trials for determination of haemoglobin (Hb), serum iron (SI), serum ferritin (SF), serum β-carotene (SBC), serum ascorbate (SA) and serum zinc (SZ) levels. The hematological indices increased in the rats fed the pumpkin leaf curd. Addition of the leaf curd into the traditional infant complementary food could help address micronutrient malnutrition or hidden hunger and reduce dietary bulk associated with consumption of green leafy vegetables. This is of particular interest because infants have limited stomach capacity (250ml).

Leaf extracts of *Jatropha aconitifolia* were fed to rats to determine the effect on haematological indices. Anemia was induced in all the rats for 7 days. One group was fed a combination of rat chow and *Jatropha aconitifolia* leaf extract, another group was fed rat chow supplemented with ferrous sulphate and the third group was fed rat chow alone (control group) for a study period of 28 days (7-day acclimatization, 7-day inducing anemia and 14-day feeding trial) (Nnam and Ngwa, 2009). The group fed combination of chow and *Jatropha aconitifolia* extract had comparable iron status as those fed combination of ferrous sulphate and chow. These two groups had an edge over the group fed rat chow alone in terms of iron and vitamin A utilization. *Jatropha aconitifolia* leaf or the extract could be incorporated into the local diets and infant complementary foods in the dietary diversification programme to fight iron deficiency anemia and vitamin A deficiency, which often co-exist as public health problems in Nigeria.

One hundred and sixty young children aged 2 – 3 years were randomly selected from a rural community nursery school and used for 8 weeks intervention study with boiled pumpkin fruit puree (*Cucurbita pepo L.*) (Nnam, 2005). The children were divided into two groups – the control group (CG) and the test group (TG). The TG was fed soymaize porridge with added boiled pumpkin fruit puree to constitute 10% of the diet while the CG was fed only the soymaize porridge. The TG had improved serum retinol (SR) and HB levels (10.78g/dl to 11.92g/dl). There were no significant changes in the CG (**fig. 7**). Pumpkin fruit puree could be incorporated into the traditional infant complementary foods to diversity diet and improve iron and vitamin A nutriture.

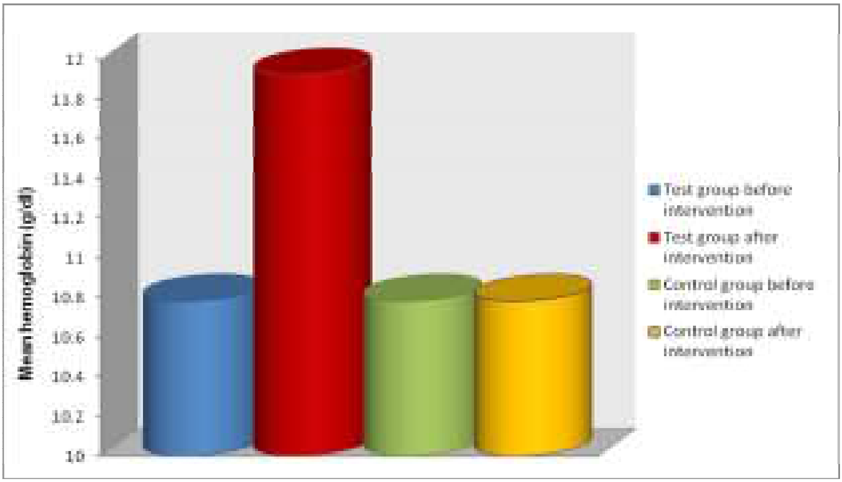


Fig. 7: Mean hemoglobin concentration of the children

The leaf of *Moringa oleifera* plant (wonder plant) was used to supplement the traditional maize infant complementary food. Infants 6-12 months were fed the maize traditional complementary food with added *Moringa oleifera* leaf powder to provide 3.67mg of iron a day for four weeks (TG). The CG was fed only the traditional maize infant complementary food (Nnam, 2009). The mean Hb of the infants in the TG was 10.65gdl^{-1} at baseline and rose to 12.98gdl^{-1} at the end of the intervention period, the mean SF concentration rose from 10.64µgl^{-1} to 36.82µg l^{-1} and SR concentration rose from 18.62ugdl^{-1} to 27.40µgdl^{-1}. There were no changes in the haematological indices of the control group (**fig. 8, 9, 10**).

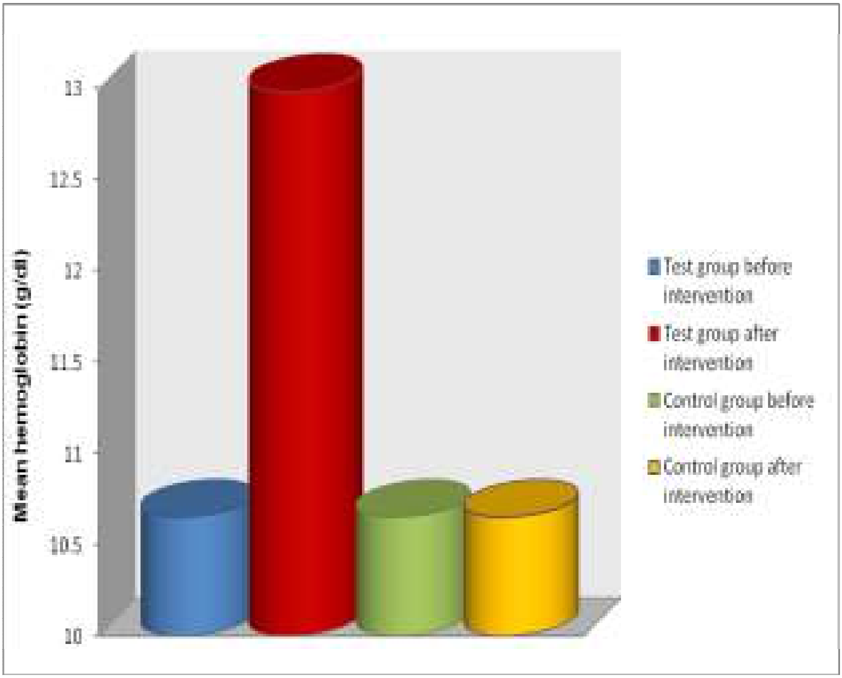


Fig. 8: Mean hemoglobin concentration of the infants

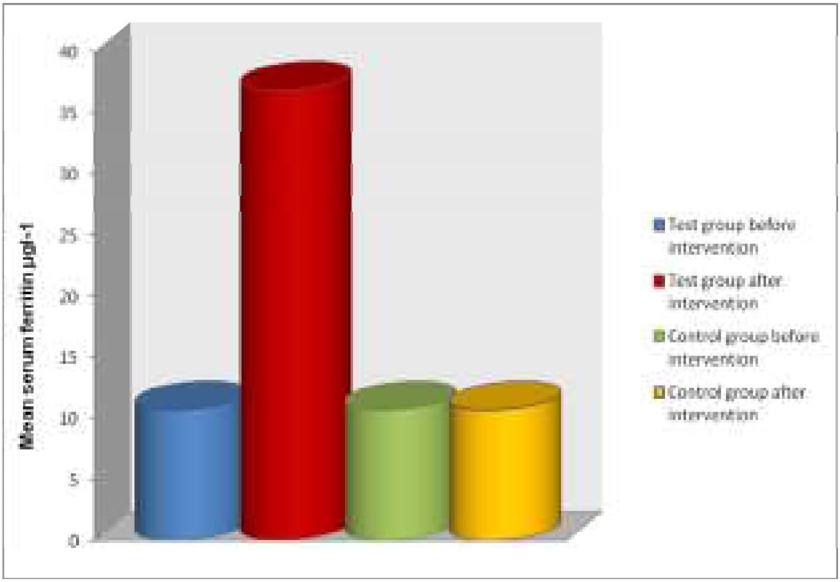


Fig. 9: Mean serum ferritin concentration of the infants

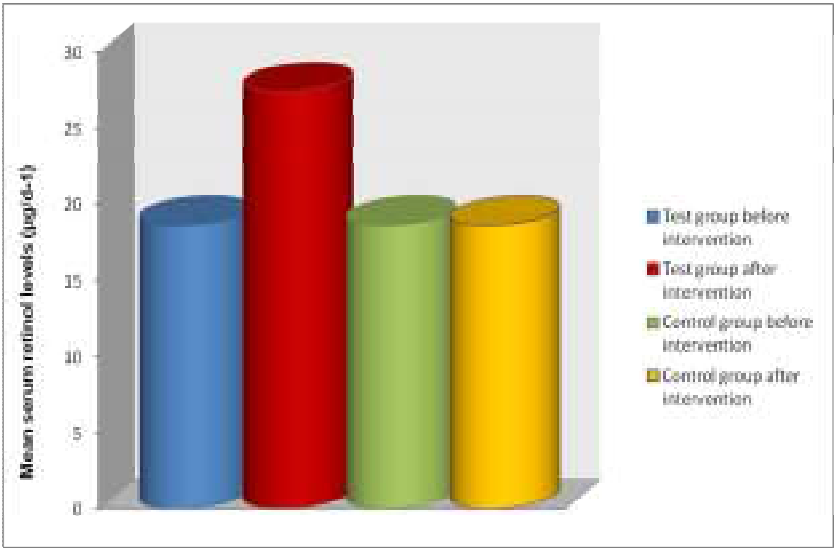


Fig. 10: Mean serum retinol concentration of the infants

The significant increase in Hb, SF and SR concentrations of infant fed the *Moringa Oleifera* supplemented diet is indicative of improved iron and vitamin A status. Serum ferretin represents “iron bank” and the high level is much likely to be an indicator of iron saturation. *Moringa Oleifera* leaf is rich in multiplicity of nutrients, which could interact positively to enhance iron metabolism and red cell formation. The leaf is a powerhouse of nutrients. *Moringa* leaf is very rich in β-carotene (vitamin A 15620 IU), ascorbic acid (773 mg), iron (28 mg), phosphorus (267 mg) and calcium (1,924 mg) per 100g on dry matter basis. The leaf is richer in iron than beef meat, contains 7 times the vitamin C in oranges and 4 times the β-carotene in carrots. The nutrients interact to improve iron absorption and utilization. There is a strong link between vitamins A, C, E, B, B_{12}, folic acid and riboflavin with iron in preventing anemia. Ascorbate promotes iron absorption possibly by chelating or reducing the iron III ions (Fe^{+++}) to ferrous (Fe^{2+}) state. β-carotene improves absorption of iron possibly by forming a complex with iron, keeping it soluble in the intestinal lumen and preventing the inhibitory effect of phytates and polyphenols on iron absorption. Vitamin A improves iron status possibly by reducing levels of infection, improving production and proliferation of red blood cells in bone marrow, increasing the absorption of iron from food in the intestine and mobilization from store. The improved iron status of the infants fed *Moringa Oleifera* leaf powder supplemented diet is of interest in the formulation of complementary food. This is because iron deficiency anemia is still one of the widespread public health problems experienced by infants in the developing countries during the introduction of complementary food. The deficiency is partly due to the fact that infants are introduced to nutritionally inadequate complementary foods, which are poor in bio-available iron. The poor level of iron in breast milk, which leads to depletion of infant's iron from birth stores by 6-months, further predisposes the infant to iron deficiency anemia. *Moringa Oleifera* leaf is readily available and grows wild in many rural communities in sub-sahara Africa. The leaf could serve as an ingredient in complementary food formulation and could be incorporated into many traditional dishes to diversify diet and improve nutritional status.

Baobab fruit pulp drink (BFPD) (250ml) was served as part of a meal based on cereal/legume/vegetables for 3 months to school children 6 – 8years in a rural community primary school in Nsukka (TG). The CG received only the meal (Nnam, 2004a). The mean Hb increased from 10.85g/dl to 12.92g/dl and the percentage children with serum ferritin less than 12µg/L dropped from 64.79% to 22.54% in the TG. The CG had slight increase in Hb (10.86 vs 11.01g/dl) with no change in SF (**fig. 11**).

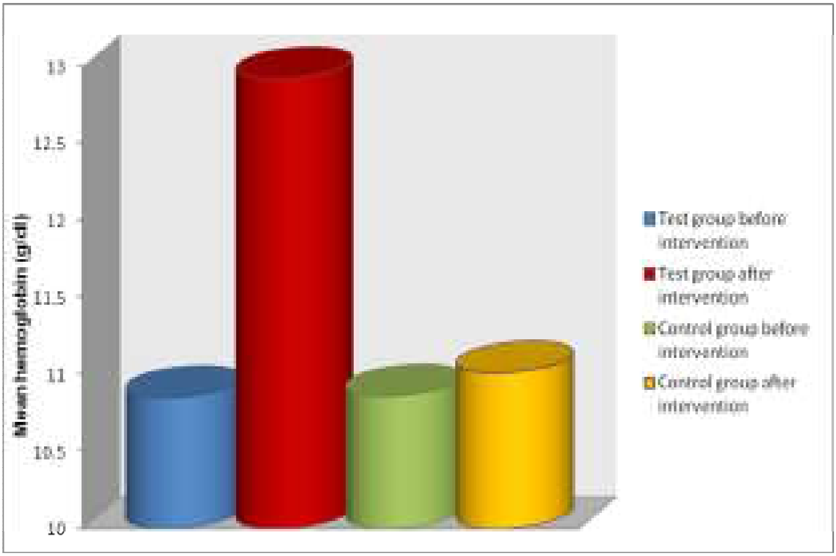


Fig. 11: Mean hemoglobin concentration of the children

The result is of interest as iron deficiency anemia rates in children are as high as 50% in some regions in Nigeria. The deficiency in most cases is due to low bio-availability of dietary iron rather than low intake. This is because the dietary supply of iron in Nigeria is mainly from plants (about 90%) which contain nonheme iron that is poorly absorbed. Baobab fruit pulp is rich in ascorbate (337mg ascorbate/100g), which enhances iron absorption.

A similar study was carried out with baobab leaf powder (BLP) using 160 children randomly selected from a rural community primary school in Nsukka (Nnam, 2004b). The children in the TG were fed diet containing baobab leaf powder for 6 weeks. The children in the CG did not receive BLP in their diet. For the TG, the proportion of children with serum retinol levels below 20µg/dl fell significantly from 21.25 to 10.00%, serum β-carotene increased from 6.8µg/dl to 14µg/dl while there were no changes in that of the control group (**fig. 12**). Baobab leaf is rich in micronutrients, which interact with each other for their effective utilization. There is need to tap the potentials of this underutilized and lesser-known plant food in the dietary diversification strategies to controlling malnutrition particularly vitamin A deficiency.

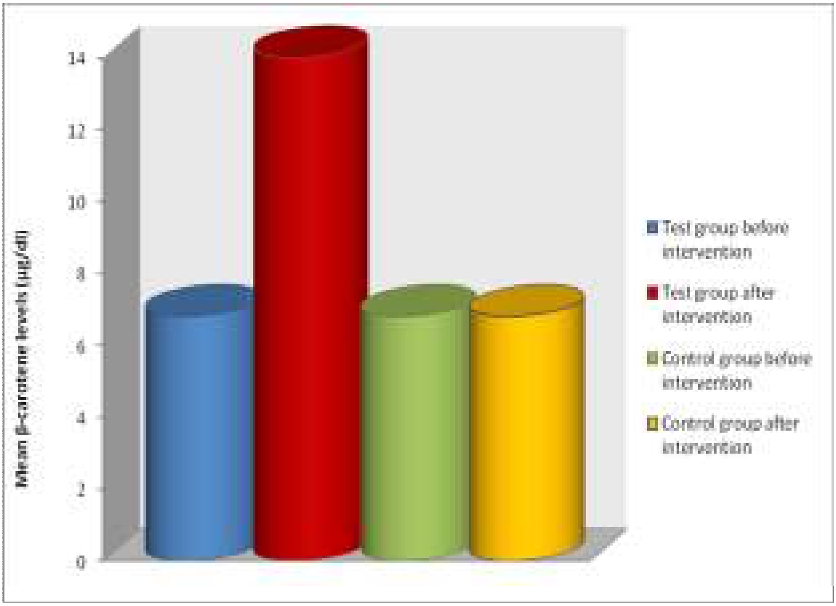


Fig. 12: Mean serum β-carotene concentration of the children

Another study was carried out using 120 school children 5 – 10years in Nsukka rural community primary school to test the effectiveness of sorrel calyx in improving their vitamin A status (Nnam and Onyeke, 2004). The children in the TG were fed diet supplemented with sorrel calyx to provide 2.9mg of β-carotene daily for 4weeks. The CG received only the diet. The test subjects had no symptoms of VAD, higher Hb and serum retinol than the CG. Sorrel calyx is available in many rural communities in Nigeria and could be incorporated into the traditional diets to help control vitamin A deficiency.

The home grown school feeding and health programme practiced in some schools in Nigeria is a good way of introducing new dietary habit to children to prevent hunger and malnutrition. *Mucuna pruriens* was cultivated in the school garden of a rural primary school in Enugu State of

Nigeria. The leaf was used as an intervention to tackle micronutrient malnutrition in school children (Nnam and Udofia, 2009). One hundred and sixty four primary school children, 7 – 8 years were used for the study. The TG received their school meal with 100ml of *Mucuna pruriens* leaf extract while the CG consumed only the school meal. The children in the TG had increase in all the haematological indices examined. Large scale cultivation of the crop should be encouraged to help tackle micronutrient malnutrition.

The effect of daily consumption of periwinkle on the iron status of pregnant women was studied using 120 pregnant women in their second trimester at Bishop Shanahan Hospital Nsukka (Nnam and Udofia, 2010). Women in the TG consumed 50g of periwinkle daily for six weeks with their normal diet while those in the CG consumed only the normal diet. The mean Hb and SF concentrations of the pregnant women increased from 10.87 to 12.24gdl^{-1} and 11.21 to 19.67µgl^{-1}, respectively in the TG with no significant change in the CG. There were no significant change in the mean Hb (10.41 vs 10.46gdl^{-1}) and SF (11.34 vs 11.36µgl^{-1}) concentrations of the women in the CG (**Fig. 13 & 14**).

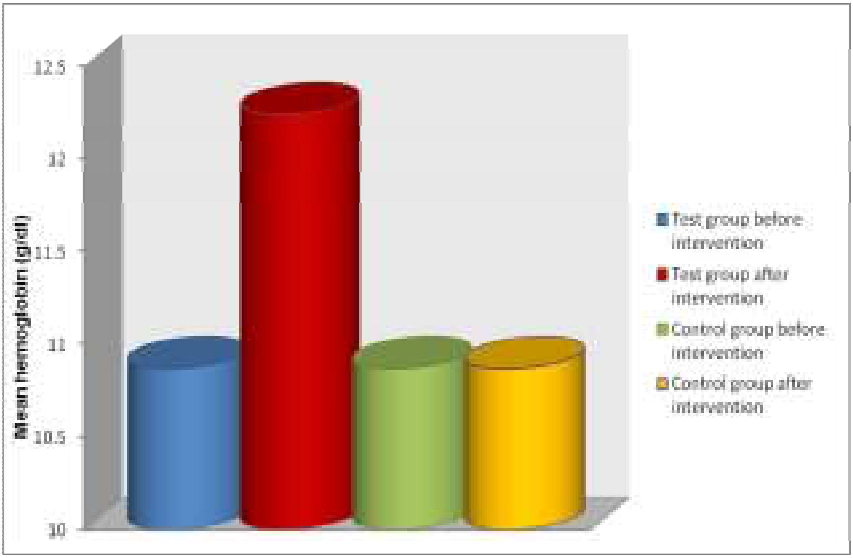


Fig. 13: Mean hemogbobin concentration of the pregnant women

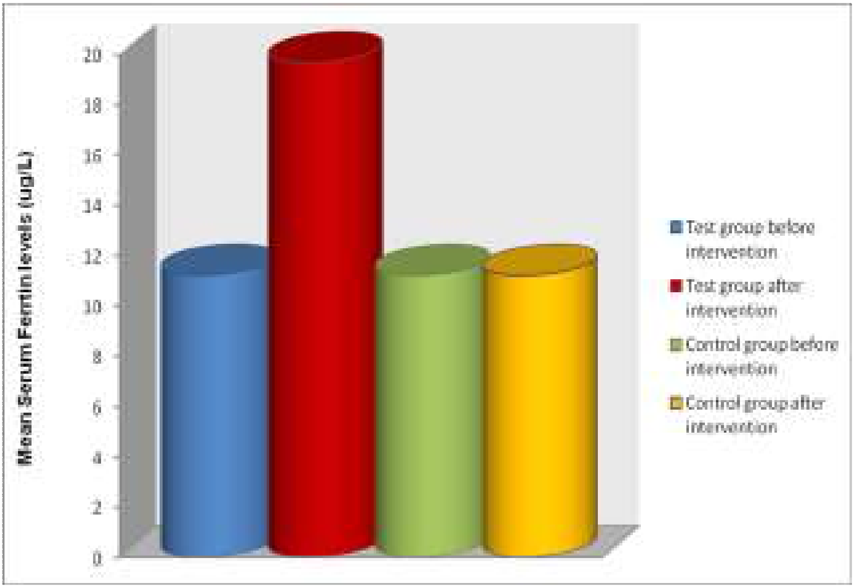


Fig. 14: Mean serum ferrtin concentration of the pregnant women

Periwinkle is rich in micronutrients particularly iron, copper, B_{12} and magnesium and the iron is in the haem form, which is readily absorbed.

The nutritional quality of plant foods could be upgraded by adequate processing and blending. The protein quality of four food blends based on sprouted sorghum, bambara groundnuts and fermented sweet potatoes was evaluated by rat feeding experiments (Nnam, 2001). Casein served as a reference protein. The test proteins were incorporated to make up 1.6% total nitrogen. There was an inverse relationship between % nitrogen digestibility and the proportion of sorghum protein in the blend; being highest in the diet based on sorghum; bambara groundnut; sweet potatoes with protein ratios of 52: 46: 2. This blend proved to be optimum when the biological value (93.6%) and net protein utilization (84%) were used as protein indices. Foods with good protein quality could be formulated from a blend of sorghum, bambara groundnut and sweet potatoes provided appropriate processing and blending are taken into consideration.

CONCLUSION AND RECOMMENDATIONS

Adequate nutrition is the cornerstone of good health and is essential for normal functioning of the body – you are what you eat. Our environment is nutrition friendly. The ecosystem has rich biodiversity of food crops with promising nutritional potentials for addressing the problem of malnutrition. Dietary diversification to incorporate the wide diversity of food crops in adequate amount in the food menu is strongly recommended for all age groups. Keeping vegetable gardens and orchards around the homes could help in the dietary diversification programme to ensure adequate nutrition. Some food crops are going into extinct and could be lost forever. There is need to re-introduce such foods into the food menu. This involves intersectoral approach to ensure increased production, adequate processing, preservation and combination of the food crops.

There is need for intensive Nutrition Education programme to enlighten the populace on principles of nutrition and selection of adequate diet. The Federal Ministry of Education is developing curriculum for teaching Nutrition in the basic education programme (from primary I through primary six to JSS 3). This is of interest because most dietary habits are formed during the early years. It is good to catch the children young for adequate nutrition. The school meal and health programme for primary schools should be strengthened and introduced in all primary schools. This is because the programme offers a good opportunity for introducing new dietary habit and diversifying diet for children. Schools should be encouraged to have school gardens and farms. Both male and female students should be encouraged to study Nutrition and build capacity for adequate diet. In tertiary institutions, Nutrition should be given adequate allocation in general studies curriculum. This would help to consolidate knowledge on principles of nutrition for informed food choices. Consuming large amounts of two or three staple foods like *garri* and rice as is the habit in most families will not provide the nutrients necessary for a healthy and productive life. There is need to consume these staples with a lot of fruits and vegetables to make for nutritionally adequate diet. In order to ensure an adequate supply of all nutrients and substances essential to human growth and development, a varied diet richly provided from our environment is the key.

ACKNOWLEDGEMENTS

Vice-Chancellor Sir, permit me to acknowledge some of the people who supported me in the course of my career but before then I want to first and foremost appreciate the Almighty God.

I kneel in reverence and thank the Almighty God, the Omniscience God, the Awesome God, the Omnipresence God for His love, protection, mercy, kindness and favour on me and my family all these years. May His name be praised for ever in Jesus Name – Amen.

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