INAUGURAL LECTURE SERIES 294

# A FINGER ON THE PULSE OF EATING WELL: MOST WONDERFUL CURE AND PREVENTATIVE

By

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## PREAMBLE

The Vice Chancellor,
Principal Officer of the University,
Provosts, Deans and Directors,
Members of the Senate,
Head of Departments and Programmes,
Institute of Agricultural Research and Training Staff,
My Lords, Spiritual and Temporal,
Ladies and Gentlemen of the Print and Electronic Media/Press
Great Ifes,
My Esteemed Guests and Audience,

I consider myself privileged to be permitted to deliver this Inaugural Lecture, the fourth of its kind from the Institute of Agricultural Research and Training, in this unrivalled and imperial-building University in which 293 Professors have delivered their Inaugural Lectures and many are still awaiting the opportunity to perform this academic and intellectual ritual.

It is a privilege to share and make public pronouncements of my contributions to knowledge through research with all facets of the community that has nurtured me since birth. Though a privilege, it is as well an obligation worthy of being fulfilled by every Professor in the University system.

In addition, I am honoured because I am able to use this inaugural lecture to mark the 15years of glorious exit to eternity of my brother, friend, lover, husband and mentor, Dr Charles 'Rotimi' Obatolu, who aroused and nurtured my interest in academia. My successes and the fulfilment of my academic career, that has made it possible for me to stand before this audience today, was the solid foundation laid by my Guardian Angel, Charles Rotimi Obatolu, of blessed memory. His wish was to nurture me to this day and sit amidst the audience. I'm certain that he is here in the spirit. All glory and honour to God for making this day a reality.

Mr Vice-Chancellor Sir, it is my humble desire at this inaugural lecture to take a cursory look at a finger on the pulse of eating well, the most wonderful cure and preventative and a must for any nation's economic growth. These thoughts are based on practice and proficiency of food and nutrition science acquired over 20 years of my research activities.

## 1. INTRODUCTION

The most important and obvious act of all living things is eating. Foods are complex blends of various components, which supply varying qualities and quantities of macronutrients (proteins, carbohydrates, lipids and water) and micronutrients (vitamins, minerals and other trace elements) crucial for metabolic processes.

Foods are converted into energy, which is measured in calorie. Protein provides essential amino acids that are essential for key body functions and development. Micronutrients are needed in relatively small quantities for proper functioning of the body system.

The body cannot produce most nutrients. Studies have shown that no single food contains all the nutrients needed by the body in the right proportion. Hence, nutrient must be consumed in adequate amount by consumption of a variety of foods in order to carry out day-to-day activities and to stay healthy

Mr Vice Chancellor Sir, achieving a healthy status with good nutrition depends on using appropriate processing and utilization technologies for any food to improve its nutrient digestibility and absorptivity for nourishing of the body.

## 2. MALNUTRITION

Malnutrition is defined by World Health Organization (WHO) as a faulty diet due to imbalance between intake of nutrients and the body's demand to ensure specific functions for maintenance and growth. Eating patterns that do not provide adequate nutrient, or provides more nutrients than needed, can lead to malnutrition.

About 795 million people of the 7.3 billion world population never get enough food to meet even their minimum energy and nutrient needs triggering chronic undernourishment in them (FAO, 2015). Malnutrition contributes to the death of nearly 13 million children under the age of five (FAO, 2013) and is capable of hindering peoples' ability to earn and provide for themselves.

Malnutrition is caused by a complex array of conditions such as: dietary inadequacy, (excesses or imbalances in energy, protein and micronutrients), infections, environmental and socio-cultural factors. The major forms of

malnutrition are under-nutrition and over-nutrition (Shakir, 2006).

Under-nutrition is mostly in the form of marasmus, kwashiorkor or protein-energy malnutrition (PEM). PEM is the most deadly form of malnutrition that always receives the most attention. These conditions are response of the body to insufficient calorie, protein or protein-energy intake resulting in body depletion disorders and cumulative process of growth failure.

Over-nutrition occurs when the diet contains more nutrients than the body demands especially nutritionally empty calories. Eating high-calorie fatty food is a common factor in over-nutrition. The major nutritional problem of over-nutrition in Nigeria is over-weight and obesity.

Vitamin and mineral deficiencies are other forms of under- nutrition that are often *hidden hunger* and inconspicuous with enormous consequences for economic growth and human development.

WHO (2013) estimated 26% of global under-five children as stunted, 31% with vitamin A deficiency and1.4 billion people as overweight, of which 500 million are obese.

In a study by Obatolu and Cole (1999), on the prevalence of under nutrition among under-five children in western Nigeria, 43.6% of the studied population were stunted, 26.1% wasted and 52.2% were underweight (Table 1). The children's level of urine aminoaciduria was higher while the haemoglobin (Hb), blood protein, growth hormones and electrolyte were lower than normal level (Figure 1). This implies that chronic and acute malnutrition is of high prevalence within our society.

Table 1: Percentage distribution of children according to stunting, wasting and underweight status (NCHS Standard)

| STUNTING | % | WASTED | % | UNDERWEIGHT | % |
|---|---|---|---|---|---|
| Moderate | 20.4 | Moderate | 17.1 | Moderate | 24.7 |
| Severe | 23.2 | Severe | 9.0 | Severe | 26.5 |
| Total | 43.6 | Total | 26.1 | Total | 51.2 |
| Not stunted | 56.4 | Not Wasted | 73.9 | Not stunted | 48.8 |

Source: Obatolu and Cole (1999).

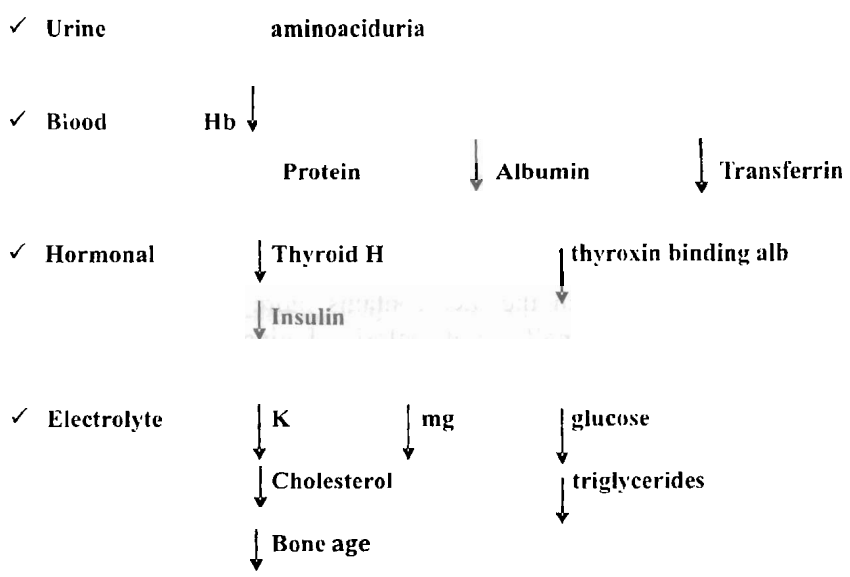


Figure 1: Biochemical changes in PEM Children

## 3. HUNGER, POVERTY AND FOOD AND NUTRITION INSECURITY

Hunger is an uncomfortable or painful feeling caused by lack of food, or recurrent and involuntary lack of access to food. Extreme poverty is the basis for under-nutrition while hunger and malnutrition are in turn the main roots of poverty.

Food security, according to the 1996 World Food Summit, exists 'when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). This definition has four linked dimensions as illustrated in Figure 2 namely: food availability, access to food (physical, economic), stability of supply and safe, healthy food utilization. The absence of one or more of these dimensions suggests food insecurity. The 1996 World Food Summit identified hunger and food insecurity as a serious manifestation of extreme poverty, and committed herself to reduce the world food hunger to half by 2015 through the Millennium Development Goals (MDGs) declaration of year 2000.

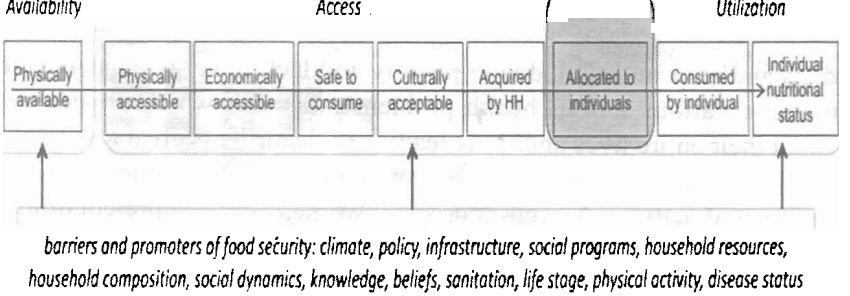


Figure 2: Conceptual pathway linking domains of Food Security (***Source: Jones et al. 2013***)

The year 2015 marked the end of the monitoring period for the MDGs targets, with the level of hunger in developing countries reduced by 27%. There was a decline in prevalence of undernourished people in all regions of the world from 18.6% between 1990 and 1992 to 10.9% in 2014–16 (Table 2). Despite this decline, 836 million people globally, still live on less than $1.25/day (Figure 3) and a considerably high number of people still lack the food necessary for an active-healthy life. For example, the state of hunger in Nigeria remained critical with a Global Hunger Index (GHI) score of 32.8% (IFRI 2015).

It is apparent that addressing food security is vital, but not adequate for nutrition security. It is possible that a food secured person is nutrition insecure due to the inability to adequately use the food ingredients to meet the needs of the body. Nutrition insecurity, as presented in Figure 4, encompasses poverty, under-nutrition, hunger and food insecurity on one hand and on the other hand, over nutrition and food security. That is, a person who is chronically undernourished is captured in a hunger trap of low productivity, chronic poverty and food insecurity. In the same vein, a person who is food-secured but over-nourished is captured in an unhealthy and low productivity trap. To be nutrition secured, the body must be able to appropriately utilize the food consumed and make the person more capable health wise, to earn income to escape poverty and hunger.

Mr Vice Chancellor Sir, in my own words, ***nutrition security*** is a state when every person in any community has physical or economic access at all times to adequate

sufficient nutritional value for a person to live a healthy and active life

Poor diets and poor nutrition, due to poverty and lack of knowledge, have been seen to cause various serious health problems, many of which impede people throughout their entire lives and some leading to death. This great loss of human potential is of significant consequence on social and economic costs of any community and nation. A well-nourished workforce is a pre-condition for sustainable human development. Human beings are unable to attain full potential without good nutrition because of its role as a driver of sustainable development. Thus, a productive economy requires the majority of its population to be of a good nutritional and health status.

**Table 2:**Number of World undernourished (millions) and prevalence (%) of undernourishment

| | 1990–92 | | 2000–02 | | 2005–07 | | 2010–12 | | 2014–16* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | No | % | No | % |
| **WORLD** | **1010.6** | **18.6** | **929.6** | **14.9** | **942.3** | **14.3** | **820.7** | **11.8** | **794.6** | **10.9** |
| **Developed Regions** | **20.0** | **<5.0** | **21.2** | **<5.0** | **15.4** | **<5.0** | **15.7** | **<5.0** | **14.7** | **<5.0** |
| **Developing Regions** | **990.7** | **23.3** | **908.4** | **18.2** | **926.9** | **17.3** | **805.0** | **14.1** | **779.9** | **12.9** |
| **Africa** | **181.7** | **27.6** | **210.2** | **25.4** | **213.0** | **22.7** | **218.5** | **20.7** | **232.5** | **20.0** |
| Northern Africa | 6.0 | <5.0 | 7.0 | <5.0 | 5.1 | <5.0 | 5.1 | <5.0 | 4.3 | <5.0 |
| Sub-Saharan African | 175.7 | 33.2 | 203.6 | 30.6 | 206.0 | 26.5 | 205.7 | 24.1 | 220.0 | 23.2 |
| Eastern Africa | 103.9 | 47.2 | 121.6 | 43.1 | 122.5 | 37.8 | 118.7 | 33.7 | 124.2 | 31.5 |
| Middle Africa | 24.2 | 33.5 | 42.4 | 44.2 | 47.7 | 43.0 | 53.0 | 41.5 | 58.9 | 41.3 |
| Southern Africa | 3.1 | 7.2 | 3.7 | 7.1 | 3.5 | 6.2 | 3.6 | 6.1 | 3.2 | 5.2 |
| Western Africa | 44.6 | 24.2 | 35.9 | 15.0 | 32.3 | 11.8 | 30.6 | 9.7 | 33.7 | 9.6 |
| **Asia** | **741.9** | **23.6** | **636.5** | **17.6** | **665.5** | **17.3** | **546.9** | **13.5** | **511.7** | **12.1** |
| **Latin America/ theCaribbean** | **66.1** | **14.7** | **60.4** | **11.4** | **47.1** | **8.4** | **38.3** | **6.4** | **34.3** | **5.5** |
| Oceania | 1.0 | 15.7 | 1.3 | 16.5 | 1.2 | 15.4 | 1.3 | 13.5 | 1.4 | 14.2 |

**Source: FAO:** Data for 2014–16 refer to provisional estimates

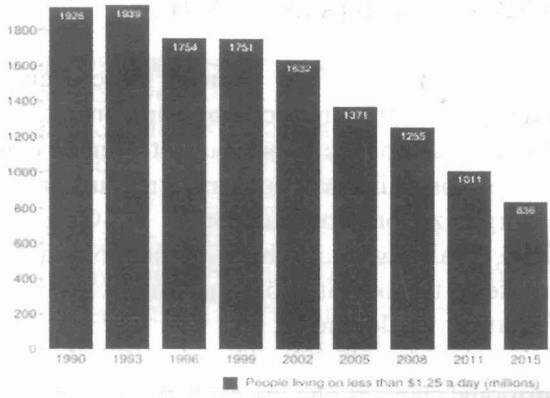


Figure 3: Global number of people living on less than $1.25/day from 1990-2015 (millions)
*(Source: MDGs report2015)*

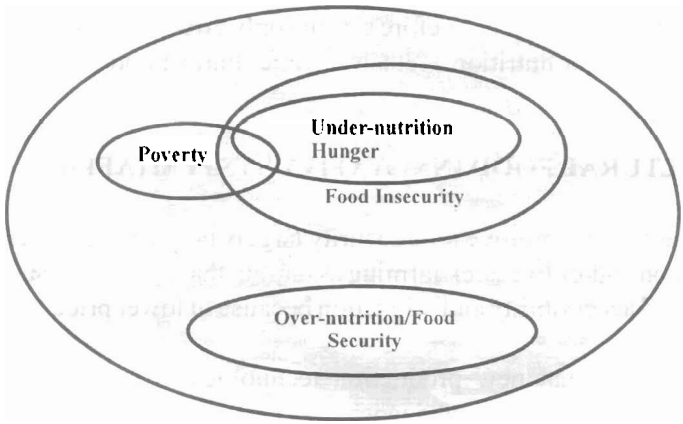


Figure 4: Concept of Nutrition Insecurity

Of recent, nutrition has also been recognised to have the ability to significan contribute to the success of the recently adopted 17 Sustainable Development Goals (SDGs), which is the successor to the MDGs. Nutrition can contribute to the success of SDGs in many ways, some of which include,

- Improving women nutritional status for enhanced labour productivity in agricultural work for higher earned income.
- Reducing overweight and obesity to alleviate prevalence of non-communicable diseases.
- Improving cognitive development especially in the first 1,000 days after birth.

## 4. COMBATING FOOD AND NUTRITION INSECURITY

Agriculture has great potential to impact food security for especially poor populations because agriculture is their primary sector of employment. Also food expenditure occupies the largest share of the poor's budget. Hence, combating malnutrition should entail integration of interventions in agriculture and the food system in general. The Organization for Economic Co-Operation and Development (OECD, 2009), realising that, there is no solo agricultural component suitable as a strategy to combat food and nutrition security and advocate for innovative agricultural development.

Mr Vice Chancellor Sir, nutritional status is one visible major way by which the impact of any program targeted at improving food and nutrition security can be measured. Good nutrition indicates the fulfilment of people's rights to food and health (Obatolu *et al* 2004). I therefore say, the only effective approach to food and nutrition security is a nutrition inclusive Agricultural Food Innovative System (AFIS).

## 5. AGRICULTURAL FOOD INNOVATIVE SYSTEM (AFIS)

Historically, efforts to improve food security largely target on activities to increase crop production and/or livestock farming assuming that increase in supply leads to increase in food accessibility and utilization because of lower prices.

There is no doubt that new production technology is crucial to agricultural productivity by providing rural income and affordable food for most of the population. Not withstanding, with increase in food availability and accessibility, one out of three people are still malnourished worldwide due to either under or over nourishment. Can we eat soil??? Soil is only relevant when quality crops (breeding) are planted (production) on it and which, in turns give good yields that are adaptable and adoptable (agronomy) and could be marketed (extension). Similarly these good quality farm produce (plant/animal) do not translate to food and nutrition security except they are processed and consumed to nourish the body.

The implication of this is that, just as the human body, an *agricultural system* is a group of components connected by some forms of interaction and interdependence. Obatolu (2011) reported that the only fundamental and direct

way by which food production can translate into better food and nutrition security is through appropriate food processing and utilization. Food and nutrition security can only be achieved if these components are adequately recognised and leveraged with consideration given to indirect sectors like environment, social, policy, economics and health (Figure 5).

What I'm saying in essence is that each of the agricultural components function within a given borderline to attain a precise agricultural objective for overall benefit of the entire system. Hence, combating food and nutrition insecurity is changing and implementing the slogan 'improved farming practises for increased crop yield" to "improved farming practises for improved nutrition".

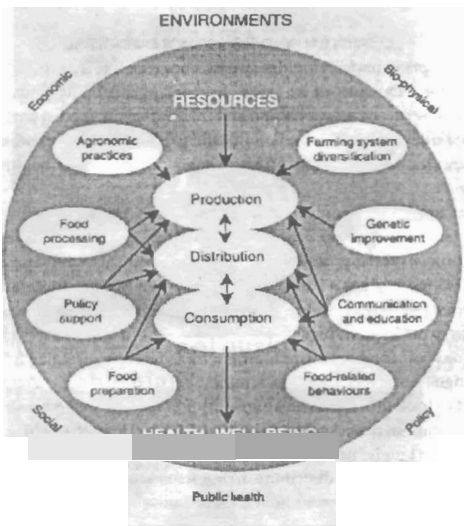


Figure 5: Agricultural System (*Source:* Combs *et al, 1996)*

## 6.0 THAT THEY MAY LIVE HEALTHY

Mr Vice Chancellor Sir, early in my career as a Research Scientist, the reality of 'hunger and poverty' (Plate 1)dawned on me; that there are many, especially children and women, who suffer and die because of lack of food and/or knowledge of what they have. Being a Graduate Assistant with an externally funded International Development Research Centre (IDRC) project on soybean utilization, took me to many rural communities in Nigeria and neighbouring

countries. The project aimed at introducing improved soybean utilization technologies for alleviating under-nutrition in Nigeria and some selected West African countries (Plate 2). The livelihoods of these vulnerable groups were found in agriculture with monthly income far below N5000 ($50) (Lanipekun, Obatolu and Oyekan, 1993). The low purchasing power of these groups resulted in inadequate consumption of appropriate nutrients for healthy living (Obatolu and Cole, 1999) because they lacked the knowledge in converting their resources to nutritious foods. This corresponded with the observed and recorded high prevalence of protein-energy malnutrition (Plate 3) during the baseline survey study.

Plate 1: Hunger: A co

Plate 2: Poverty and Malnutrition

Plate 3: High prevalence of protein energy malnutrition in especially children and women

The widespread of hunger and malnutrition in all communities visited during my active nine years participation in the IDRC project is a total contradiction to my view of world hunger. Six months into the project years, I was spurred to search for how humans can make use of available resources within their environment to fight hunger and under-nutrition for a healthy living. My attention was especially drawn to exploring legume crops processing in alleviating food and nutrition insecurity by the popular concept of gastronome, Jean Brillat-Savarin; "Tell me what you eat, and I'll tell you who you are".

Mr Vice Chancellor Sir, in my search to answer the question: ***"How can I overcome under and over nourishment?" (Plate 4),*** the thrust of my research activities focused on identifying and processing cheap underutilized legume food crops, soybean to be precise, as a source of quality protein and calorie. This begins with the development of adaptable high quality novel foods that would be stable in terms of appropriateness, availability, accessibility and safety for an enhanced nutritional and healthy status of rural people in Nigeria.

Plate 4: Under and Over Nourishment

### *6.1 Underutilized agricultural crops*

Underutilized agricultural crops are sometimes referred to as unexploited crops. They are classified into cereals, roots and tubers, leafy vegetables and legumes. It is possible that a community could have used a particular crop in the past but gradually loses local knowledge resulting in increased ignorance among the new generation. Making the crop to be seen as new or underutilized. They varied from one global region to another. For example; cowpea (*Vigna unguiculata*) that is a major staple in Nigerian diets is an underutilized crop in some Mediterranean countries. Chickpea (*Cicer arietinum*) is considered as underutilized by many Nigerian Scientists but a major legume crop in Syria. Obatolu *et al* (1992) survey showed that soybean was an underutilized crop before 1990s in Nigeria, with just 17% of farmers cultivating it and less than 5% household consumers. Many of these crop species are rich nutritionally and have great potential to:

- Contribute to dietary diversification,
- Increase income source of the poor,
- Alleviate food and nutrition insecurity and
- Reduce 'hidden hunger'

Hence their elimination from diet could have food and nutrition insecurity consequences on particularly, the poor.

In our series of studies (Obatolu *et al* 2000; Obatolu and Cole, 2000; Obatolu 2002; Obatolu *et al,* 2006) as shown in Table 3, legumes' protein content ranges from 20-40% and are used mainly as source of protein in human nutrition. They are significant sources of vitamins (folic acid and vitamin B) and minerals (calcium, zinc, iron). Legumes are low in low-density lipoprotein cholesterol (LDL) and, except for soybean and groundnut, are also low sources of fat in the human diet. In this regard, legumes have been highlighted as an effective substitute to animal protein in terms of amino acid quality (Table 4) as well as being cost effective.

Mr Vice Chancellor Sir, it is right to consider legumes as the most cost efficient protein sources, for alleviating food and nutrition insecurity. However, legumes contain some components called *'anti-nutrient factors'*, which limit their applicability in alleviating food and nutrition insecurity.

Table 3: Overview of Nutritional profile of some under utilized legumes (g/100g)

| Legume | Protein | Fat | NFE* | Dietary fibre | Riboflavin µg | Folate µg | Ca mg | Zn g | Fe mg |
|---|---|---|---|---|---|---|---|---|---|
| Soybean | 39.4 | 19.7 | 27.8 | 9.0 | 275 | 247 | 258 | 3.9 | 13.4 |
| Groundnut | 23.8 | 46.9 | 17.5 | 3.2 | 115 | 121 | 71 | 2.4 | 3.9 |
| Kidney bean | 25.8 | 2.5 | 50.5 | 3.2 | 219 | 205 | 25 | 0.9 | 7.6 |
| Lima | 24.5 | 1.4 | 62.7 | 6.2 | 286 | 295 | 82 | 1.8 | 6.2 |
| Chickpea | 23.2 | 5.7 | 61.1 | 5.9 | 100 | 187 | 72 | 1.6 | 4.7 |
| Pigeon pea | 22.4 | 1.8 | 59.8 | 2.5 | 203 | 164 | 115 | 2.5 | 3.6 |
| Lentil | 20.9 | 1.4 | 59.1 | 4.8 | 102 | 279 | 37 | 1.8 | 5.30 |
| African yam bean | 22.3 | 2.4 | 54.8 | 6.0 | ND | ND | 68.5 | 3.2 | 8.2 |
| Bambara | 20.3 | 5.8 | 58.51 | 4.4 | 120 | 140 | 41.21 | 5.2 | 5.0 |

*NFE= Nitrogen Free Extract *ND =Not Determined

Source: Compiled from Literature (2016)

Table 4: Selected Under Utilized Legumes essential Amino acid profile compared to Egg Protein (g/16gN)

| Amino Acids | Soybean | Ground nut | Kidney | Lima | Chick pea | Pigeon | Lentil | Africa n Yam | Bambar a | Egg |
|---|---|---|---|---|---|---|---|---|---|---|
| Threonine | 4.3 | 4.2 | 3.3 | 4.5 | 3.6 | 2.7 | 3.2 | 3.8 | 2.5 | 4.8 |
| Valine | 5.8 | 5.2 | 4.1 | 1.2 | 5.4 | 5.5 | 4.9 | 4.5 | 3.9 | 6.1 |
| Methionine | 1.6 | 0.8 | 1.7 | 1.5 | 1.4 | 1.1 | 0.7 | 0.8 | 2.8 | 3.3 |
| Leucine | 7.7 | 9.1 | 7.0 | 5.5 | 7.2 | 6.4 | 7.7 | ND* | 6.7 | 8.6 |
| Isoleucine | 4.9 | 5.4 | 3.0 | 4.3 | 4.4 | 3.3 | 3.9 | 3.6 | 3.2 | 4.4 |
| Typtophan | 1.4 | ND | ND | ND | 0.8 | ND | 0.6 | ND | ND | 1.5 |
| Tyrosine | 3.4 | 3.0 | ND | 0.8 | ND | ND | ND | 3.7 | 3.4 | ND |
| Phenylalanine | 5.1 | 4.8 | 4.4 | 5.2 | 5.3 | 5.8 | 4.3 | 5.2 | 4.1 | 5.2 |
| Lysine | 6.9 | 5.7 | 7.0 | 6.4 | 6.0 | 7.7 | 6.9 | 7.9 | 2.7 | 6.8 |
| Histidine | 2.5 | 3.2 | 2.9 | 6.8 | 2.6 | 3.6 | 2.2 | 4.2 | 2.4 | 2.2 |

*ND –Not Determined Source: Compile from Literature (2016)

### *6.2: What are Anti-nutrient factors?*

Anti-nutrient factors are nature's immune system of plants to enhance their effective reproduction. They offer protection from the radiation of the sun. foraging by animals and invasion by bacteria, viruses, or fungi (Khattab and Arntfield, 2009). But interfere with optimum availability/utilization of some nutrients in human nutrition. Aside from nature, anti-nutrient factors may also be produced in large amounts as a direct result of some adverse environmental conditions. The most important anti nutrient factors in legumes include:

i. Protease inhibitor: interferes with nutrient absorption. Proteases are enzymes in human gastric juices that break down proteins and peptides. The most characterised protease inhibitor in legume is trypsin inhibitor (Krogdahl *et al* 1994).

ii. Phenolic Substances: such as tannins,are found primarily in the seed coat and interfere with protein digestibility and protein quality. Tannin binds and precipitates protein. In addition, it inhibits the proteolytic enzymes such as trypsin and chymotrypsin (Akande *et al.* 2010).

**iii.** Lectins: like haemaglutinins, theseare proteins in some plant and animal foods that bind themselves to the sugar part of carbohydrate molecules (Olguin *et al.*, 2003).

iv. Phytate: is a phosphorous-containing organic acid that binds cat ion minerals (such as copper, iron, magnesium, calcium and zinc) and prevents their absorption. *Phytate* even though an anti-nutrient, is also a valuable phytonutrient (Obatolu, 2008; Farinde Madushini, 2002).

v. Goitrogens: are substances that can block the production of thyroid hormone as well as cause goitre formation (Barbara, 2009).

vi. Oligosaccharides: raffinose, verbascose and stachyose are major oligosaccharides in many food legumes, associated with the feeling of flatulence after legume consumption (Madushini, 2002; Obatolu and Osho, 2006).

Mr Vice Chancellor Sir, anti-nutrient factors are not something to be alarmed about because most food groups aside from legumes typically have one or more anti-nutrients. Furthermore, most of these anti-nutrients could be reduced or eliminated to safe level through various processing methods.

## 7.0 FOOD PROCESSING

Food processing is the use of series of mechanical or chemical operations to change or preserve food, which has been from the time of man's history on earth. Meat and fish were salted, smoked and dried; herbs were dried and stored for use as medicines; alcoholic beverages were processed from fruits and cereals. Food is processed for many reasons. Traditionally, food is mainly processed for extending shelf life, retaining sensory qualities and for availability of safe nutritious food year-round, especially in times of scarcity. As the world becomes a 'global village', food has also become a globally traded product with an increasing need for processing to create variety, convenience and wealth for all levels of processors. However, providing a safe nutritious diet in order to maintain health remains the major acceptable objective for food processing. Processing of food is similar whether at home or at an industrial level.

### *7.1 Food Processing Methods*

For utilization in human diets, several single or combinations of traditional food processing methods can be used in plant-based diets. Processing opportunities for legumes in either human or animal diet ranges from ordinary soaking and dehulling to series of heat cooking (Figure 6).

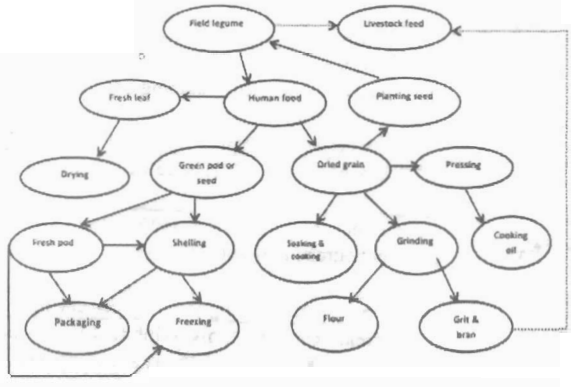


Figure 6: Processing opportunities for legumes

### *7.2 Anti nutrient removal in grain legumes, a must!*

The quality of food is determined by adequacy of its nutrient. Nutrient bioavailability is the major limiting factor in legume consumption due to the presence of anti-nutrient factors. The legume's full potential in contributing to food and nutrition security, can only be attained through processing in order to inactivate the anti-nutrients. Anti-nutrient inactivation in legumes will enhance their palatability, digestibility and increased nutrient bioavailability.

### *7.3 Anti-nutrient Removal*

Cooking methods for legume anti-nutrient removal can be characterized into two main types: dry heat cooking and moist heat cooking. Dry heat cooking heats food in the absence of water, and includes methods such as baking and roasting. Moist heat cooking uses water to heat food, and includes boiling and steaming. Heat processing particularly inactivates the anti-nutrient factors in legumes by unfolding the protein structure, making them more vulnerable to attack by digestive enzymes. Some physical processes for anti-nutrient removal in legumes are described in Table 5.

Table 5: Physical Processes for Legume anti-nutrients removal

| Physical Processing | Description |
|---|---|
| Autoclaving, Pressure cooking, Steaming | Heating at ultrahigh temperatures (.100 °C). Performance dependent on temperature, moisture, pressure relations. |
| Blanching | Mild boiling (75 °C – 95°C) to inactivate endogenous enzymes and avoid cooking |
| De-hulling, germination, fermentation | Usually preceded by soaking or another domestic processing |
| Extrusion | A form of high temperature short time (HTST) cooking that combines many operational units including pressure, mixing, kneading, shearing, shaping and forming. It reduces microbial contamination and inactivates enzymes. a combination of high temperature, pressure, and shear processing |
| Roasting | Dry heating at 120°C – 250°C |
| Soaking | Exposure to water and salt solutions with or without additive to encourage anti-nutrient loss |
| Micronization | Process of breaking into tiny or very fine grain |
| Chemical modification | Treatment with thiols, sulphite, Cu -salts (+ ascorbic acid). Chemical modification via acylation, succinylation. |

Table 6 gives an overview of effective ways to eliminate major anti-nutrients. Simple processing technique such as dehulling was used by Obatolu (2002) to reduce tannin and polyphenol level in soybean and African yam bean. In several of our other studies on African yam bean (Sphenostylis sternocarpa), lima beans (Phaseolus lunatus), soybeans (Glycine Max L.) and pigeon peas (Cajanuscajan), it was found that phytate, trypsin inhibitor, tannin, hemagglutinin and oligosaccharides were successfully eliminated using various dry and/or moist heat processing methods. Germination and fermentation similarly have reducing effect on the legumes' anti-nutrients, especially phytate and oligosaccharides. Obatolu et al (2003) reported phytate to be heat-stable, however, soaking before heating increased reduction as much as 60-85% in the different legumes. Equally, soaking soybean in 0.5% sodium bicarbonate minimizes phytic acid, tannin, trypsin inhibitor and hemagglutinin activities as well as losses of dry matter and minerals (Ca, Fe, Zn).

In all our search for the best method of inactivating legume trypsin, chymotrypsin, α-amylase inhibitors and hemagglutinin activities, extrusion cooking was the most effective in terms of retaining, improving protein quality and starch digestibility of legumes when compared to other processing methods such as dehulling, soaking and germination, microwave and boiling (Obatolu, 2002; Obatolu *et al*, 2000; Obatolu *et al*, 2005; Obatolu *et al*, 2006).

Table 6: Overview methods for major Anti-Nutrient Elimination

| Anti Nutrient | Methods of Elimination |
|---|---|
| Phytate/Phytic acid/Phytin | Soaking, sprouting, fermentation. |
| Protease Inhibitors | Soaking, sprouting, boiling/Cooking |
| Calcium Oxalate | Soaking, boiling/Cooking |
| Tannins | Soaking, boiling/Cooking |
| Lectins | Soaking, Fermentation, Heating, Boiling/Cooking |

For improved food and nutrition security, legumes are usually used as a supplement in meals or diets. Legume proteins are rich in lysine but low in sulphur-containing amino acids while cereal proteins are deficient in lysine but have adequate amount of sulphur amino acids. Combined processing and consumption of cereal and legume as food has practical implication to the overall intake of essential amino acids and could help to combat the world protein calorie malnutrition problem (Obatolu *et al*, 2006).

Examples of food legumes of practical implication for improved nutrition security include; cowpea (*Vigna unguiculata*), bambara nut (*Vigna subterranea*), fava bean (*Vicia faba L*), chickpea (*Cicer arietinum*), kidney beans (*Phaseolus vulgaris*), peanut (*Arachis hypogaea*), lima bean (*Phaseolus lunatus*), black bean, lentils (*Lens culinaris*), African yam bean (*Sphenostylis stenocarpa*), soybean *(Glycine max (L.) Merrill)* and many others (Plate 5).

Mr Vice Chancellor Sir, for the purpose of this inaugural lecture, emphasis would be on my extensive research findings on the practicability of soybean as a food legume for improved nutrition security.


Plate 5: Some food Legumes of practical implication for improve nutritional security

### *7.5 Soybean (Glycine max (L.) Merrill)*

Soybean originated from China where it has been cultivated for about 5000 years (Qiu and Chang, 2010). It has since been widely cultivated with a worldwide annual planting area of 102.77 million $hm^2$ and a harvest of 239.36t in the season of 2011/2012, generating an economic impact of $114 billion to farmers around the world (USDA, 2012). Soybean was introduced into Nigeria in 1908 and grown only as export crop mainly in Benue State and Zonkwa-Abuja areas (Oyekan 1984).Soybean is classified as an oilseed (FAO, 2013) and its oil was used for the main purpose of commercial production.Different varieties of colours (Plate 6) are also cultivated.

Soybean,among other legumes, is valued for its high protein (38–40%) and oil (20%) content. It is a good source of dietary fibre (9.3%) and minerals, especially calcium (USDA 2013). Also soybean products contain varying concentrations of phytoestrogens called isoflavones, which is of health benefits. Liu *et al*, (2012) isolated soybean isoflavones to as, genistein, daidzein, glycitein, and formononetin (Figure 7).

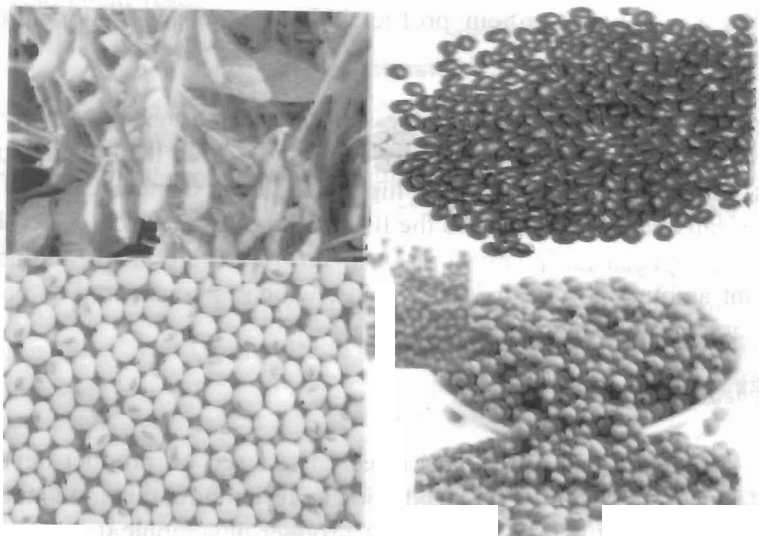

Plate 6: Soyabean in pod and Colour Varieties

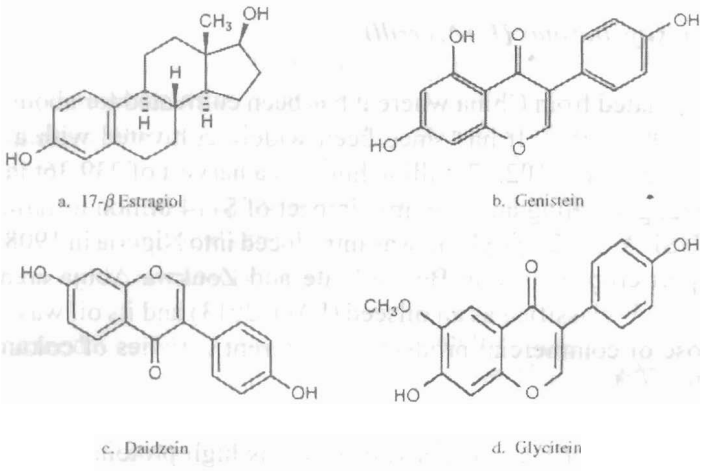


Figure 7: Chemical structures of Soybean Isoflavones (Source: Liu *et al*, 2012)

In addition to soybean quality, Ogundipe and Osho (1990) reported that one kilogram of soybean contained as much protein as 2kg of boneless meat or 45cups of cow's milk or 5 dozens of egg. Hence, soybean protein products can be good substitutes or replacements for animal products because, unlike some other beans. soy offers a 'complete' protein profile without requiring major adjustments elsewhere in the diet.

Mr Vice Chancellor Sir, I completely support that amino acids derived from animal based proteins are more readily and rapidly used than plant proteins by humans. However, aside from the high cost, they contain especially high-***saturated*** fatty acids, which cause the liver to produce more cholesterol. On the other hand, soybean fat is very high in ***unsaturated*** fatty acids and contains a significant amount of omega-3 fatty acids, which is considered as part of the healthy fat group (USDA, 2013).

### *7.6: Soybean Utilization*

Mr Vice Chancellor Sir, my initial research focused on product development directed at using soybean for value addition to agricultural raw food materials for improved nutritional value. Research in product development involves tightly overlapping activities such as efficacy of ingredients, safety assessment. processing, acceptability, output and storage (Figure 8) that must be motivated by the needs of the consumer.

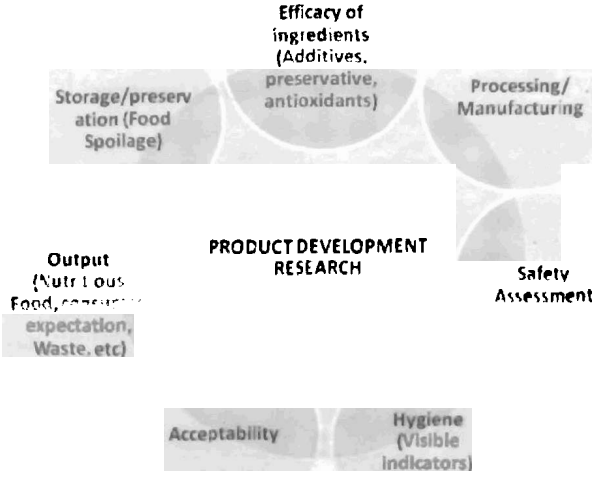


Figure 8: Product Development Research Chain

Product development research helps to discover the difficult balance between reformulating food products to reduce levels of unwanted components/ingredients such as salt and saturated/trans fats while retaining their functional roles. For instance, trans-fats play an important role in maintaining an acceptable texture in food products and salt could be useful in lowering water activity, prevent spoilage and increases dough stability in bread (Obatolu, 1995). Producing healthy and functional foods is of little benefit if consumers do not choose to eat them.

The astounding option for diversity of soybean utilization has earned it the title of **"The Wonder Bean" or "Golden Bean"**. Through processing, soybean is a very versatile grain that can yield a broad spectrum of products for numerous food applicationsthan one can imagine (Obatolu and Cole, 2000).

Soybean utilization options (Plate 7) in the human diet is based on the utilization of the whole grain as in milk and tofu, or used as a food ingredient in many cooked, baked and fried products (Obatolu, 1995). In Nigeria, soybean has been used to fortify many traditional foods of different ethnic groups such as soy-vegetable soup, soy-*gari*, soy-*moinmoin*, among many others. Soybean increased the

nutrient composition of these food products in which it forms part of the ingredients (Table 7).


Plate 7: Soybean Options in Human Diet

Table 7: Nutrient composition of food samples with Soybean as an ingredient (%)

| Components | Flour | Milk | Ogi | Eko | Moinmoin | Akara | Eba | Vegetable soup | Gari |
|---|---|---|---|---|---|---|---|---|---|
| Protein | 47.9 | 3.70 | 10.8 | 12.8 | 22.6 | 26.03 | 6.6 | 18.6 | 11.0 |
| Fat | 24.2 | 3.20 | 2.01 | 2.16 | 10.6 | 24.6 | 2.16 | 15.2 | 7.2 |
| Energy (kJ) | 485.2 | 68.6 | 214.09 | 147.9 | 213.8 | 343.9 | 148.2 | 241.6 | 381.6 |
| Moisture | 5.2 | 86.1 | 76.8 | 68.8 | 56.8 | 43.6 | 66.8 | 64.3 | 7.8 |
| Iron | 0.09 | 0.08 | 0.06 | 0.06 | 0.2 | 0.21 | 0.09 | 0.12 | 0.09 |
| Calcium | 0.10 | 0.03 | 0.04 | 0.08 | 0.03 | 0.08 | 0.34 | 0.08 | 0.02 |
| Magnesium | 0.42 | 0.01 | 0.21 | 0.18 | 0.14 | 0.20 | 0.18 | 0.32 | 0.31 |
| Phosphorus | 0.14 | 0.29 | 0.12 | 0.14 | 0.10 | 0.13 | 0.14 | 0.23 | 0.17 |

*Source: Obatolu (1995)*

Consumption of soy foods is increasing because of reported beneficial effects on human nutrition and health. Proteins from different sources have different amino acid compositions, which will affect their nutritional value to human diets. Soybean protein's Protein Digestibility Corrected Amino Acid Score (PDCAAS) of 1.0 is ranked the highest among vegetable proteins, and is equal to that of milk

(casein, whey protein) and egg proteins. This is far above the PDCAAS of 0.25 for wheat gluten, another popular plant protein commonly found in the vegetarian diet. This implies that soy protein provides complete amino acids to human nutrition (FAO, 2013). Hence, under conditions of normal dietary intake. properly processed soy protein ingredients are of good protein value for humans.

### *7.6.1 Soymilk*

Bringing soybean potential to use was my major goal. Due to the scarcity and high cost of cow milk, I used soybean products to overcome the high prevalence of protein deficiencies in especially the less privileged and among lactose intolerant children. In a child feeding experiment, Obatolu *et al* (2003) adjusted soymilk water content to that of cow milk and breast milk and recorded about two times more protein, 7.5% less calories, 13% less fat, 38% less carbohydrate and no cholesterol, when compared to both cow and breast milk (Table 8). But soybean adjusted milk had less calcium when compared to breast milk and cow's milk. This provides more choices for vegetarians and lactose intolerant individuals. My daughter is a living example oflactose intolerant individual that used soybean milk as a substitute to cow milk in her diet.

Table 8: Composition of soymilk, cow's milk and breast milk

| Nutrients | Soymilk (%) | Cow milk (%) | Breast Milk (%) |
|---|---|---|---|
| Moisture (g) | 85.8 | 85.8 | 85.3 |
| Protein | 3.6 | 2.1 | 1.8 |
| Fat | 3.4 | 3.9 | 4.1 |
| Carbohydrate | 2.8 | 4.5 | 6.9 |
| Ash | 0.5 | 0.7 | 0.30 |
| Calcium | 19.6 | 96.7 | 32.7 |
| Sodium | 2.7 | 33.5 | 13.6 |
| Iron | 1.3 | 0.2 | 0.4 |
| Thiamine | 0.06 | 0.1 | 0.04 |
| Riboflavin | 0.02 | 0.2 | 0.03 |
| Niacin | 0.7 | 0.3 | 0.2 |
| Calorie | 50 | 54 | 59 |

### *7.6.2 Soy Tofu (Cheese)*

In the quest for a suitable coagulant for soymilk in cheese production, Farinde *et al*, (2008) and Obatolu (2008) compared four indigenous coagulants namely: magnesium salt, lemon juice, alum and *'omi kan'* (steep water of fermented ogi) with calcium sulphate. The effect of these coagulants on chemical, textural, colour, and sensory attributes of the cheese products were analysed. Calcium and magnesium contents increased and decreased significantly ($P < 0.05$) in cheese coagulated with calcium sulphate and magnesium salt while cheese coagulated with lemon juice had increased vitamin C content and *'omi kan'* coagulated sample had higher vitamin B content. However, there were large amount of the B-vitamins in the soymilk whey that was discarded when compared to the curd. In this study, thiamine content in the curd decreased ($P<0.05$) after 5, 10 and 15 days of storage. The loss may be due to leaching since thiamine is a water-soluble vitamin. The riboflavin contents of tofu were more stable during storage especially in 'omi kan' processed curd. The high quality of tofu yield from steep water of fermented maize compared to calcium sulphate processed curd, prompted its introduction as the most suitable and cheap alternative soymilk coagulant in tofu making.

### *7.6.3 Soy-Gari*

Obatolu and Osho (1990) developed a processing technique for soy-gari by fortifying fresh grated cassava with 30% soybean paste. Desired organoleptic properties (colour, texture, taste, odour and appearance) achieved for soy-gari compared well to the 100% cassava gari with increase in especially protein and fat contents (Table 9).

### *7.6.4 Other Products*

Various other soy products such as concentrates, isolates and extruded-expanded products have been developed through advances in food technology resulting in increased utilization (Obatolu, 2010).

## *7.7 Importance of Soybean in Overcoming Chronic Malnutrition*

Mr Vice Chancellor Sir, as noted earlier, good health depends on the availability, affordability, and acceptability of the foods essential for a balanced diet. Obesity resulting from excess energy consumption is an extreme form of malnourishment, just as in the case of under-nutrition and starvation. In such situations, soybean often referred to as *"poor man's meat"*, can fill the gap (Obatolu, 1995).

Table 9: Proximate composition of Soy-gari from three processing centres in Ibadan compared to conventional gari.

| Nutrient | Orisunbare | Mokola | Orita | Unfortified Gari |
|---|---|---|---|---|
| Moisture | 9.9 | 10.5 | 10.3 | 10.5 |
| Protein | 10.1 | 9.5 | 9.2 | 0.85 |
| Fat | 10.6 | 10.5 | 10.1 | 1.2 |
| Ash | 1.6 | 1.4 | 1.4 | 1.6 |
| Carbohydrate | 67.8 | 68.1 | 66.9 | 85.7 |

*Source: Obatolu and Osho, (1990)*

### *7.7.1Complementary Feeding*

In pursuit of the effect of soybean, in complementary baby feeding mixture on nutritional status, liver function and infection, Obatolu *et al* (2006) fed 4 groups of albino rats for 28days with maize fortified with soybean and cowpea at the levels of 35% each. Similarly, 3 other groups of albino rats were either placed on casein, non-protein or rat pellet diet. Biochemical analysis, were done on blood samples of the rats. Table 11 gives the initial and final weight of the albino rats and protein quality of each of the experimental diet. Evidence from the rats' biochemical parameters showed the potential of soybean and cowpea to support growth with no harmful consequence. The serum aspartate aminotransferase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) level of rats on all diets were within normal range (Table 12). AST, ALT and ALP are liver enzymes in the cells that leak out into the blood when there is liver damage or there is some form of infection. Rats fed non-protein diet (NPD) had significant ($p<0.05$) lower Haemoglobin (Hb), White Blood Cell (WBC) and Mean corpuscular haemoglobin concentrate (MCHC) values when compared to other diets (Table 13). Also the significantly higher serum sodium values observed for rats fed NPD was an indication of inadequate feeding or having macro nutrient deficiency.

Table 11: Biological evaluation of protein quality of the experimental diets using rat bioassay

| Diets | Initial weight (g) | Final weight (g) | Weight gain (g) | PER | NPR | TD (%) | NPU (%) |
|---|---|---|---|---|---|---|---|
| MMS | 52.0±1.00 | 128.50±1.67 | 76.50±1.20 | 2.49±0.06 | 3.12±0.13 | 87.07±0.21 | 85.23±0.48 |
| UMS | 52.8±0.80 | 125.17±0.79 | 72.33±0.05 | 2.33±0.05 | 3.03±0.10 | 84.59±0.47 | 78.13±0.48 |
| MMC | 52.5±0.86 | 125.30±1.02 | 72.83±1.13 | 2.35±0.04 | 3.06±0.04 | 85.22±0.56 | 76.13±0.49 |
| UMC | 52.5±1.09 | 122.00±1.34 | 69.50±1.18 | 2.24±0.84 | 2.94±0.06 | 82.46±0.72 | 70.97±0.37 |
| NPD | 53.2±0.92 | 30.81±0.05 | 22.37±0.98 | - | - | - | - |
| RP | 52.6±1.98 | 130.83±0.45 | 74.17±0.79 | 2.41±0.07 | 3.01±0.16 | 86.69±0.49 | 89.23±0.80 |
| Casein | 52.3±0.87 | 129.83±1.10 | 77.33±1.28 | 2.42±0.05 | 3.18±0.13 | 91.18±0.36 | 92.01±0.88 |

*Mean values with the same superscript are not significantly different ($p < 0.05$)*
*Source: Obatolu et al (2006)*

MMS = Malted maize/malted soybean; UMS = Unmalted maize/unmalted soybean;
MMC = Malted Maize/cowpea; UMC = Unmalted maize/unmalted cowpea;
CD = Casein Diet RP = Rat pellet;
NPD = Non-protein Diet

Table 12: Mean serum enzymes concentration of rats on various diets

| Diets | AST (IU/l) | ALT (IU/l) | ALP (IU/l) |
|---|---|---|---|
| MMS | 63.17$^{ab}$ | 23.00$^{abc}$ | 92.28$^{a}$ |
| UMS | 51.00$^{bc}$ | 23.5$^{abc}$ | 93.83$^{ab}$ |
| MMC | 60.50$^{ab}$ | 24.50$^{ab}$ | 68.00$^{b}$ |
| UMC | 55.67$^{bc}$ | 20.17$^{bc}$ | 80.83$^{ab}$ |
| RP | 71.17$^{a}$ | 23.17$^{abc}$ | 67.67$^{bc}$ |
| CD | 75.50$^{a}$ | 26.67$^{a}$ | 62.50$^{bc}$ |
| NPD | 42.50$^{c}$ | 18.67$^{c}$ | 49.67$^{c}$ |

*Mean values with the same superscript are not significantly different ($p < 0.05$)*
*Source: Obatolu et al (2006)*

AST = Aspartate transaminase ALT = alanine transaminase;
ALP = Alkaline phosphatase;

Table 13: Haematological parameters of rats on all diets

| Diets | PCV(%) | Hb. g/100ml | RBC $10^{6/mm}$ | WBC $10^{3/mm}$ | MCV ($ug^3$) | MCH ($ug^2$) | MCHC (%) |
|---|---|---|---|---|---|---|---|
| MMS | 44.5±1.0$^{a}$ | 15.6±0.9$^{a}$ | 6.9 ±0.5$^{ab}$ | 6.6 ±1.1$^{a}$ | 7.4 ±0.2$^{a}$ | 2.3±0.1$^{ab}$ | 36.0±1.4$^{a}$ |
| MMC | 42.2±1.0$^{ab}$ | 14.6±0.7$^{a}$ | 6.6 ±0.2$^{ab}$ | 5.7 ±1.0$^{b}$ | 6.5 ±0.3$^{ab}$ | 2.07±0.1$^{b}$ | 36.1±1.4$^{a}$ |
| UMS | 43.8±0.8$^{ab}$ | 15.3±0.5$^{a}$ | 7.3 ±0.6$^{a}$ | 6.4 ±1.0$^{ab}$ | 6.2 ±0.4$^{ab}$ | 2.2±0.1$^{b}$ | 34.0±0.7$^{ab}$ |
| UMS | 43.3±1.1$^{ab}$ | 14.7±0.8$^{a}$ | 7.2 ±0.2$^{a}$ | 6.3 ±0.7$^{ab}$ | 6.0 ±0.2$^{a}$ | 2.0±0.1$^{b}$ | 33.1±1.9$^{bc}$ |
| RP | 42.3±1.5$^{ab}$ | 16.1±0.7$^{a}$ | 7.4±0.7$^{a}$ | 7.2±0.8$^{a}$ | 6.4±0.5$^{ab}$ | 2.1±0.5$^{ab}$ | 39.2±0.8$^{a}$ |
| CD | 43.5±1.0$^{ab}$ | 15.2±0.9$^{a}$ | 6.1±0.5$^{ab}$ | 7.8±1.0$^{a}$ | 7.3±0.6$^{a}$ | 2.6±0.3$^{a}$ | 35.1±1.7$^{ab}$ |
| NPD | 40.8±1.1$^{b}$ | 12.3±0.1$^{a}$ | 5.9±0.3$^{b}$ | 5.2±0.6$^{b}$ | 5.8±0.6$^{b}$ | 2.3±0.2$^{ab}$ | 29.41±1.4$^{c}$ |

*Mean values with the same superscript are not significantly different ($p < 0.05$)*
*Source: Obatolu et al (2003)*

MMS = Malted maize/malted soybean; UMS = Unmalted maize/unmalted soybean;
MMC = Malted Maize/cowpea; UMC = Unmalted maize/unmalted cowpea;
CD = Casein Diet RP = Rat pellet;
NPD = Non-protein Diet

### *7.7.2 Treatment of Malnourished Children*

In exploration to improve commonly consumed foods by the low socioeconomic groups, Obatolu *et al*, (2002) used soybean products for overcoming moderate to chronic under-nutrition in 224 children within selected rural households in Nigeria. A linear mixed model was used to estimate and compare weight gain among children fed on soybean products (milk, ogi, vegetable mixture, cheese, gari, bread) and cow milk supplements. Results showed nitrogen balance in all the supplemented diet. The clinical and biological tests showed enhanced nutritional status in both compared groups. Soybean products had an effect on weight gain (P= 0.04) with a mean weight gain of 1.06 (±0.5) kg body mass per week of feeding intervention.

In another study by Obatolu (2003), weight gain and low mortality were recorded for in- and outpatient malnourished children on soybean diet at the Oni-Memorial hospital, Ibadan, Nigeria. The children were moderately and severely malnourished with median baseline weight-for-age z-score as −3.0 to -4.0. Specifically, 14% of the children were underweight, 53% marasmic, 17% kwashiorkor, and 16% marasmic-kwashiorkor. Soybean fed children had a higher weight gain of 7.2g/kg body mass/day compared to control group with a weight gain of <5g/ kg body mass/day over the four weeks period of treatment. Majority (62%) of the soybean rehabilitated children became normal with a 0 z-score median weight-for-age, 23% achieved -1 z-score and others -2 z-score median weight-for-age. Calorie intake and haemoglobin concentration were equally higher in the soybean diet fed group than in the control group.

We similarly recorded improved values within normal range for serum albumin. haemoglobin and packed cell volume (PCV) of 16 protein-energy malnourished (PEM) children after intervention with soybean-fortified foods and mineral tablets for eight weeks. The protein content of soybean foods served during intervention ranged from 3.4% in liquid soymilk to 47.9% in soy flour. Protein contributed about 36% to the children's total daily calorie of 1100Kcal. The serum albumin improved from 3.1g/dl to 4.0g/dl; haemoglobin from 8.6g/dl to 11.5g/dl and packed cell volume (PCV) from 28% to 38% after intervention. The increase in serum albumin after treatment with soybean-fortified foods indicated a sign of recovery and an indication that supplementation of normal diets with soybean consumption has promising potentials to treat children with PEM.

Mr Vice Chancellor Sir, aside from soybean potential in alleviating prevalence of under nutrition, it had been found useful in the clinical management of obesity and type-2 diabetes. As a high fibre food with low glycaemic index, soybean delivers more bulk with less energy. This allows for a feeling of fullness in the intestine giving it the protective role against diabetes by enhancing sensitivity to insulin. Anderson *et al*, (1995) reviewed 43 primary studies and concluded that consumption of soybean protein rather than animal protein significantly decreased serum concentrations of total cholesterol, low-density lipoproteins (LDL) cholesterol and triglycerides. Heart attack risk is reduced with lower total cholesterol with higher proportion of high-density lipoprotein (HDL) cholesterol. ***Hence, I suggest from this profile, that legumes' protein and fat are safer for human consumption than animal protein.***

## 8. FROM LABORATORY RESEARCH TO COMMUNITY

In taking full advantage of any good research on development in whatever discipline. an inherent component is dissemination, or else, information and knowledge have the tendency to stay where they are generated. Research findings are rarely considered relevant until the results have been made widely available to end-users. Dissemination adds value to the research in development and prevents knowledge becoming 'ticklish' and completely lost.

My long and eventful research journey has numbers of positive evidence of the impact built through regular formal publications (over 50 journal publications), non-formal communications (over 40 technical reports) and knowledge, skill and capacity building programmes (Plate 8). Many of my findings and tangible products of research have had positive impacts on the poor and have encouraged public-private partnerships.

Plate 8: Household Training on appropriate food crop processing and utilization technologies

Obatolu and Ashaye (1999) expressed the effectiveness of the soybean utilization education in the prevention of malnutrition in terms of the difference between the final and initial under-nutrition prevalence. That is, the values of -3SD reference median as a percentage of initial value for the three nutritional indicators at the start and the end of a 3-year intervention study. A reduction of 72.5%, 55.0% and 65.8% in prevalence of PEM respectively for the weight-for-age, height for age and weight-for-height indicators among the beneficiary population (BP) was observed at end of study. On the contrary, negative signs for weight-for-age and weight-for-height indicators were observed for non-beneficiary population (NBP). These were populations left off from the knowledge transfer programme. This reduction and increase in prevalence of malnutrition between BP and NBP respectively is attributed to improved soybean processing knowledge of mothers within the BP, which consequently increase their soybean utilization and consumption.

At the onset of the IDRC project, less than 5% (Lanipekun *et al*, 1992) of the Nigerian population consumed the grain due to lack of knowledge and information on the 'hard-to-cook' phenomenon and negative assumptions (Osho and Obatolu, 1992). Soybean production and utilisation have been on the increase in Nigeria since 1992. This has been made possible by the interest and research sponsors by many national and international organisations, in particular, International Institute of Tropical Agriculture (IITA) and research activities of many scientists of which I played a prominent role. Our research findings have proved the adaptability (Table 14) of soybean to most households and industrial products (Ogunsumi *et al*, 2005). In addition, we have been able to publish a soybean recipe booklet with over 70 recipes.

Mr Vice Chancellor Sir, it is impossible to oppose the importance of soybean as a household food ingredient in Nigeria, Ghana and Cote d'Ivoire today. The reason for this and the availability of over 300 household and industrial soybean products in West Africa could be traced to the 9-year IDRC Soybean Utilization project for which I was a Principal Facilitator and Implementer.

Table 14: Overview of some developed soybean product and adoption rate

| Products | Year | Household & commercial Dissemination | Adoption (%) |
|---|---|---|---|
| ***Whole Soybean Product*** | | | |
| Flour | 1990 | 3,200 | 100 |
| Milk | 1990 | 15,080 | 100 |
| Cheese/Tofu | 1992 | 15,080 | 100 |
| Iru (Fermented Soybean) | 1992 | 4,600 | 100 |
| Vegetable | 2000 | 27 | 15 |
| Scramble | 1996 | 5,080 | 36 |
| Melon alternative | 1996 | 5,080 | 100 |
| Gbegiri | 2000 | 600 | 08 |
| Baked Soya | 2000 | 1,200 | 0 |
| Soy nut | 1995 | 2,357 | 20 |
| Soy Ekuru | 1989 | 450 | 15 |
| ***Maize+ Soybean*** | | | |
| Soy Ogi | 1992 | 23,689 | 89 |
| Soy Tortilla | 2001 | 20 | 02 |
| Soy Weaning Mix | 2002 | 7,089 | 100 |
| ***Wheat + Soybean*** | | | |
| Breads, Cakes and Biscuits | 1990 | 15 | 35 |
| ***Cowpea + Soybean*** | | | |
| Akara | 1992 | 5,080 | 05 |
| Moinmoin | 1993 | 5,080 | 05 |
| ***Tubers + Soybean*** | | | |
| Gari | 1990 | 135 | 35 |
| Elubo (Yam-soy four) | 2000 | 46 | 10 |
| Soy/cassava balls | 2004 | 15,080 | 0 |

*Source: Obatolu et al (2000)*

## 9. CONCLUSIONS

This inaugural lecture stressed the importance of diversifyingunder-utilized legumes utilization through food processing with focus on soybean for alleviating poverty-related underand overmalnutrition. Improper nutrition results into a vicious circle of malnutrition and poverty that could further lead to several adverse consequences. It cannot be disputed that nutrition plays an important role in promoting individual, national and global growth and development.

My research findings on the diversification of legume utilization, has alleviated food and nutrition insecurity and continues to make progress on alleviating poverty-related under and overnutrition.

Also, my research efforts have attracted many grants, awards and fellowships such as Recipient of the US National Marine Fisheries Services Post-doctoral Award, Research Award grant of US National Marine Fisheries Services for Crab waste utilization, Fellow of Phi Tau Sigma Award (USA), International Development Research Centre Research grants (3 consecutive times), Ford Foundation Research Grant, The Netherland Fellowship Programme (4 consecutive times), United Kingdom Department of International Development (DFID) grants among others.

I was the first African head of the Nutrition Group at Bournemouth University, UK, that led the development of Human Nutrition Curriculum for the Institute of Health and Community Studies for accreditation by the British Nutrition Accreditation Commission.

As a Research Fellow, I deep-rooted the extruding processing plant for developing value added seafood products from crab wastes, at the Department of Food Science and Human Nutrition, University of Maine, Orono, USA.

I was the only Nigerian representative in the UN- Habitat Partner University Initiative (HPUI) to the promotion of sustainable urbanization working on the thematic hubs, Food Security at Tampa, Florida, USA.

However, Mr Vice Chancellor Sir, the highest accolade to my intellectual adventure is giving the underprivileged the opportunity to explore potentials of agricultural food crops, particularly legume grains, to improve their nutrition and health status within a framework of sustainable environment.

## 10. RECOMMENDATIONS

i. A number of factors impinge on the efficacy of the power-that-be with Nigeria policies on food system. For any agrarian nation, it is important that attention is paid to promoting policy actions that support nutrition-enhancing Agricultural Food Innovative System (AFIS) in revitalizing economic growth within the existence of agricultural potential of such nation. There may be no better time than now when oil from the petroleum sector is failing and agricultural activities are loading with prospects for the economic growth of Nigeria.

ii. In the face of rapid change in global food and agriculture, there is an urgent need for nations to update policy actions focused on the potential of nutrition inclusive agricultural development to improve livelihoods through farm and off-farm income that will allow buying of healthy foods and access to education and relevant health care.

iii. The Federal Ministry of Agriculture in Nigeria should consider the establishment of a Food Nutrition Research Institute, being the only aspect of food system missing within the country's agricultural research institutions, which should support the role of facilitating product development, assured product integrity and provide supporting research and regulatory activities. Investment in product development research is vital for the sustainable agricultural food innovative system aimed at food and nutrition security for all.

iv. My heartfelt recommendation to all is, "eat well, to get well; for when diet is wrong, everything is wrong and medicine is of no use; but when diet is right, medicine is not needed but, can at best be a supplement".

Mr Vice Chancellor Sir, I would be an ingrate ending this inaugural lecture without publicly appreciating those whom God had used in making the person who stands before you today.

I thank everyone here for leaving so many other important things to be here to honour me today; I pray God will honour and bless you through our Lord Jesus.

My sincere appreciation goes to the Institute of Agricultural Research and training (IAR&T) and the International Institute of Tropical Agriculture (IITA), the foundation of my academic achievements. I thank the past and present Directors of these Institutions. I am particularly grateful to Prof. Tayo Ojo Atere of blessed memory and Professor Adebisi Adebowale for their invaluable support and encouragement in my career growth.

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My profound gratitude goes to the members of the planning committee both at Ibadan and home Campus, Ife, for this august event. They worked assiduously and tirelessly in pointing out every feature for the success of this inaugural lecture.

In a special way I acknowledge and appreciate all my subjects of studies, especially the nursing mothers, children and the rural women, who freely gave their consent to participate in my research studies.

I want to appreciate my church family; His Grace, Gabriel Leke Abegunrin; my baba, Archbishop Emeritus, Felix Alaba Job; Priests, Religious and Lay Faithful of the Catholic Archdiocese of Ibadan for your many years of support and Christian love; the Kizitan family (St Kizito Catholic Church, Oluyole Ibadan) in particular members of St Mary Society and the League of Lay Readers. In a special way, I appreciate the Spiritual guidance of Rev. Frs. Stephen Nwabuike, John Adio, Clement Emeruwe, and my Parish Priest Joachim Akee and all other Priests that have given me the sacrament of reconciliation. How can I forget all the support, inspirations and encouragement of my brother and friend, Very Rev. Fr. Felix Ethapemi? I cannot thank you enough for all you continue to do to help us get through the difficult and scary times.

To my friends, in particular Iyabo Olajide, Titi Fasanmi, Kehinde Famoroti, Bukola Oshinaya, Bisi Ogunsanwo, Kudi Ijaya, Iyabo Taiwo, Sekinat Farinde, Prof. Akin Oluwatosin and many others that I cannot mention. These are people

prayers and fasting if need be. You are indeed the best. Thank you all for accommodating and standing by me.

I profoundly appreciate my siblings, especially Chief Olusola Olusanya, Mrs Aderonke Abiola and Mrs Ayobola Akinyemi, cousins (in particular, Boda Dewale Oredipe, and Dr Tunji Oredipe) nephews (particularly Femi Olusanya), nieces (particularly Tope, Bunmi and Bukola) and extended family including Professor Akinloye Farinde's family and Omotayo Ethapemi-Abiola.

In my life's journey, I thought I was right and my parents were wrong. But life's harsh lessons made me realize that my father, mother and mother in-law (all of blessed memory) words were right all along and that there was no single second pass without you loving me unconditionally. Success has always been in my tread, because I have parents like them.

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I say thank you to Charles' siblings, Peter Taiye, Bimbo, Bernard Femi, Kofoworola, Stephen Tanimowo and others. Nothing that I do or say can show my gratitude for you, Suzan Iyadunni Fafemi, your husband and children for your steadfast love and care till today through thick and thin, since the demise of your brother, Charles Rotimi Obatolu. Thank you for being so incredibly compassionate. I could not have had better relations.

Again, eternal rest, O Lord, grant to *Charles Durotimi Obatolu*, and let perpetual light continually shine upon him.

Mr Vice Chancellor Sir, I cannot run off the precious Jewels of God out of my happiness, Oluwaseyi Mary, Oluwaseye David and Oluwaseni Charles. It is not normally easy for children to cope with a career mother and in particular a 'very strict and *would-not-let-go disciplinarian*' without a daddy to bail them out. Thank you for your love, patience and sacrifices. With all sincerity, your selfless understanding and support have helped in converting daddy's and my dreams to reality. Ronny and Elo, you are in my mind too.

acknowledgment that has in a way contributed to achieving this success. that the **ALMIGHTY GOD** bless you with good health and wisdom without measure through our Lord Jesus Christ..

Finally, Mr Vice Chancellor Sir, permit me to return all glory, honour and adoration to the Lord of lords, the ALMIGHTY who gives me the opportunity to go this far in life despite many challenges. I "THANK YOU LORD FOR MANY CHANCES" and I adore You with the song of our mother Mary.

1. My soul now glorifies
The Lord who is my Saviour,
Rejoice for who am I,
That God has shown me favour.

2. The world shall call me blessed
And ponder on my story,
In me is manifest
God's greatness and his glory.

3. For those who are his friends
And keep his laws holy,
His mercy never ends,
And he exalts the lowly.

4. But by his power the great
The proud, the self-conceited,
The kings who sit in state,
Are humbled and defeated

5. He feed the starving poor.
He guides his holy nation.
Fulfilling what he swore,
Long since in revelation.

6. Then glorify with me
The Lord who is my Saviour
One Holy Trinity
Forever and forever.

## REFERENCES


Akande, K. E., Doma, U. D., Agu, H. O. and Adamu, H. M. (2010). Major antinutrients found in plant protein sources: their effect on nutrition. *Pakistan Journal of Nutrition*, 9 (8): 827-832

Anderson, J.W., Johnstone, B.M. and Cook-Newell, M.E. (1995).Meta-analysis of the effects of soy protein intake on serum lipids.*The New England Journal of Medicine;* 333: 276–282.

Barrett,C. B. *(2010).Measuring food insecurity. Science; 327:825–8.*

Farinde, E. O., Obatolu, V. A., Fasoyiro, S. B., Adeniran, A. H. and Agboola (2008). Use of alternative raw materials for yoghurt production. *African Journal of Biotechnology. 7(18): 3339-33.*

Food and Agriculture Organization. (1983). World food security: a reappraisal of the concepts and approaches. Director General's Report. Rome, FAO

Food and Agriculture Organization (1996). Rome Declaration on World Food Security and World Food Summit Plans of action. *World Food Summit 13-17, November 1996, Rome, FAO*

Food and Agriculture Organization.(2012).World Food Programme, International Fund for Agricultural Development- The state of food insecurity in the world, *Rome, FAO.*

Food and Agriculture Organization.(2013).The State of Food and Agriculture: Food System for Better Nutrition. www.fao.org/publications.

Food and Agriculture Organization. (2013). Dietary Protein Quality Evaluation in Human Nutrition – *Report of an FAO Expert Consultation. FAO Food and Nutrition Paper;* 92, ISSN 0254-4725.

Food and Agriculture Organization, International Fund for Agricultural Development and World Food Programme. (2015). The State of Food Insecurity in the World in 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. FAO, Rome.

Huma, N., Anjum, M., Sehar, S., Khan, M. I., and Hussain, S. (2008). Effect of soaking and cooking on nutritional quality and safety of legumes.*Nutrition and Food Science*; 38(6): 570-577.

Jones, A. D., Ngure, F. M., Pelto, G. & Young, S. L., (2013). What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. *Advance Nutrition: 4:481-505*

Khattab, R. Y. and Arntfield, S. D. (2009). Nutritional quality of legume seeds as affected by some physical treatments and antinutritional factors. *LWT-Food Science and Technology*; *42*(6): 1113-1118

Lanipekun A.G., Obatolu V.A. and Oyekan P.O. (1993). Monitoring, survey and formative evaluation of soybean production, processing and utilization in Oyo and Lagos States. In: Soybean Utilization in Nigeria IDRC/IITA Soybean Utilization Project, Phase II, 3rd Year Technical Report. Pp 17-35

Liu, M. M., Huang, Y. and Wang, J. (2012). Developing phytoestrogens for breast cancer prevention. *Anticancer Agents Medicine and Chemistry*; 12 (10):1306–1313.

Obatolu V.A.,Lanipekun A.G and Adjebeng-Asem S. (1992). The status of soybean production, processing and utilization in Oyo and Lagos States. In: IDRC Second Year Technical Report, Soybean Utilization Project. Compiled and Edited by SelinaAdjebengAsem and Sidi M. Osho. Pp 23-54.

Obatolu V.A. (1995). An evaluation of the physical properties and palatability of soybean flour cake.*Agrosearch; Journal of Agricultural Food & Develo*pment:1(1): 41-46.

Obatolu V.A. (1999). Chemical and consumer evaluation of Soyvita.*European Food Research and Technol*ogy; 210(2): 90-92.

Obatolu V.A. (2002). Nutrient and sensory qualities of extruded malted or unmalted millet/soybean mixture. *Food Chemistry*;**76**: 129-133.

Obatolu V. A. (2003). Growth pattern of infants fed with a mixture of extruded malted maize and cowpea. *Nutrition:The International Journal Applied and Basic Nutrition Science;* 19: 174-178.

Obatolu V.A. (2008). Effect of different coagulants on yield and quality of tofu from soymilk.*European Food Research and Technology;* Vol 226 (3): 467-472.

Obatolu V. A. (2011). Product development Research: How relevant to Food Security*? A Lead paper presented at Institute of Agricultural Research and Training, Obafemi Awolowo University, 2011 In-House Review.*

Obatolu V.A., Ajani O.I. and Adeoti A.I. (2004). Sensitization and integration of marginalized and vulnerable groups into the national economy under the second National Fadama Development Project.*A Technical report on sensitization activities of Oyo State Fadama II Project*: 196pp. Nigeria.

Obatolu V. A and Cole A.H. (1999). Effect of soybean-fortified food on anthropometric variables of protein energy malnourished (PEM) children.*Journal of Food Technology in African;* 4(1): 18-21.

Obatolu V. A and Cole A.H. (2000). Functional properties of complementary blends of soybean and cowpea with malted or unmalted maize..*Food Chemistry;* 70: 147-153

Obatolu V.A., Cole A.H and Maziya-Dixon B. (2000). Nutritional quality of complementary food prepared from unmalted and malted maize fortified with cowpea using extrusion cooking. *Journal of the Science of Food and Agric*ulture; 80(6): 646-650. (UK).

Obatolu, V. A., Fasoyiro, S.B.and. Ogunsumi L(2001). An appraisal of chemical, physical and sensory characteristics of twelve cowpea (Vigna Unguiculata) varieties grown In Nigeria.*Moor Journal of Agricultural Research;* 2: 162-167.

Obatolu,V. A., Okoruwa, A. &Iken, J.E. (2007). Improvement of home-made maize tortilla with soybean. *International Journal of Food Science and Technology*; 42(4): 420-426.

Obatolu, V. A., Omueti, O. O., and Adebowale, E. A. (2006).Qualities of Extruded Puffed Snacks from Maize/Soybean Mixture. *Journal of Food Process Engineering*; 29(2): 149-161.

Obatolu V. A. and Osho S. M. (1990). Chemical and Organoeptic Evaluation of Soymilk from different Processors in Ibadan.In: Soybean Utilization in Nigeria IDRC/IITA Soybean Utilization Project, Phase I. 3rd Year Technical Report. Pp 172-177

Obatolu V. A. Skonberg, D. I., Camire, M. E. and Dougherty M. P. (2005). Effect of Moisture Content and Screw Speed on the Physical Chemical Properties of an Extruded Crab-based Snack.*Food Science and Technology International;* 11: 121-127

Ogundipe H. O. and Osho S. M. (1990). Introduction. In: Development and Introduction of improved soybean utilization technology for use in households and in small scale processing enterprises in rural Nigeria. *International Institute of Tropical Agriculture (IITA)*, IbadanPp 4-7

Ogunsumi L. O., Obatolu V.A., Afolami C.A. and Omoyajuowo A.O. (2005).Social Returns to soybean utilization technologies in Southwest of Nigeria.*Journal of Food, Agriculture and Environment;* 3(2): 84-87

Qiu, L.J. and. Chang, R.Z. (2010). The origin and history of soybean- In: G. Singh (Ed.), The soybean: botany, production and uses. CABI Publishing. Oxford, UK.

Olguin, M.C., Hisano N., D'Ottavio A.E., Zingale M.I, Revelant G.C. and Calderari, S.A. (2003). Nutritional and anti-nutrient aspects of an Argenitian soy as assessed on weaning rats. *Journal of Food Composition and Analysis*; 16: 441-449.

Osho S. M., Obatolu V. A., Uwaegbute A. C., Ndaeji C.F. and Olowoniyan F. (1997). Food uses of soybean in Nigeria: Opportunities and Constraints. In: Soybean feeds the World, Technology Utilization Section. Napompeth B. (ed.), *Kasetsart University Press*, Bangkok, Thailand. pp 422-430.

Obatolu, V. A., Omueti, O. O., and Adebowale, E. A. (2006).Qualities of Extruded Puffed Snacks from Maize/Soybean Mixture. *Journal of Food Process Engineering*; 29(2): 149-161.

Obatolu V. A. and Osho S. M. (1990). Chemical and Organoeptic Evaluation of Soymilk from different Processors in Ibadan.In: Soybean Utilization in Nigeria IDRC/IITA Soybean Utilization Project, Phase I. 3rd Year Technical Report. Pp 172-177

Obatolu V. A. Skonberg, D. I., Camire, M. E. and Dougherty M. P. (2005). Effect of Moisture Content and Screw Speed on the Physical Chemical Properties of an Extruded Crab-based Snack.*Food Science and Technology International;* 11: 121-127

Ogundipe H. O. and Osho S. M. (1990). Introduction. In: Development and Introduction of improved soybean utilization technology for use in households and in small scale processing enterprises in rural Nigeria. *International Institute of Tropical Agriculture (IITA)*, IbadanPp 4-7

Ogunsumi L. O., Obatolu V.A., Afolami C.A. and Omoyajuowo A.O. (2005).Social Returns to soybean utilization technologies in Southwest of Nigeria.*Journal of Food, Agriculture and Environment;* 3(2): 84-87

Qiu, L.J. and. Chang, R.Z. (2010). The origin and history of soybean- In: G. Singh (Ed.), The soybean: botany, production and uses. CABI Publishing. Oxford, UK.

Olguin, M.C., Hisano N., D'Ottavio A.E., Zingale M.I, Revelant G.C. and Calderari, S.A. (2003). Nutritional and anti-nutrient aspects of an Argenitian soy as assessed on weaning rats. *Journal of Food Composition and Analysis*; 16: 441-449.

Osho S. M., Obatolu V. A., Uwaegbute A. C., Ndaeji C.F. and Olowoniyan F. (1997). Food uses of soybean in Nigeria: Opportunities and Constraints. In: Soybean feeds the World, Technology Utilization Section. Napompeth B. (ed.), *Kasetsart University Press*, Bangkok, Thailand. pp 422-430.

Paetau, I., Chen, C. Z., and Jane, J. L., *(1994). Biodegradable plastic made from soybean products: Effect of preparation and processing on mechanical properties and water absorption. Industrial and Engineering Chemistry Research: 33:1821–1827.*

Padulosi, S. and Hoeschle-Zeledon, I. (2004). Underutilized plant species: what are they? *LEISA-LEUSDEN;20*: 5-6.

Shakir (2006). Repositioning Nutrition as Central to Development. Washington D.C. World Bank.

Shetty, P (2015). From food security to food and nutrition security: role of agriculture and farming systems for nutrition. *Current science*; 109 (3): 456-461.

Shaw, D. J. (2007) World Food Security: A History Since 1945, Palgrave Macmillan, Basingstoke, Hampshire, UK and New York, USA.

United Nations. (2015). The Millennium Development Goals Report (2015). http://www.undp.org/content/undp/en/home/librarypage/mdg/the-millennium-development-goals-report-2015.

United States Department of Agriculture. (2012). World Agricultural Production, Circular Series; World Agricultural Production:12-12.*usda.mannlib.cornell.edu/usda/.../worldag-production*

United States Department of Agriculture. (2013). National Nutrient Database for Standard Reference; Release 25: National Agricultural Library, USDA Agricultural Service,

World Health Organization. (2013). Obesity and overweight. Fact Sheet No. 311, http://www.who.int/mediacentre/factsheets/fs311/en/.