ISSN 2705-36-95

Alafas Prints
+234 803 361 2670

NUTRITIVE AND AFFORDABLE FOODS FOR HEALTHY LIVING: TOWARDS ATTAINING SUSTAINABLE DEVELOPMENT GOALS

INAUGURAL LECTURE SERIES 42

LADOKE AKINTOLA
UNIVERSITY OF TECHNOLOGY,
OGBOMOSO, NIGERIA

# NUTRITIVE AND AFFORDABLE FOODS FOR HEALTHY LIVING:
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BOLANLE AISHAT AKINWANDE
*Professor of Food Science*

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(FNIFST, MIFT, MISTRC, MANH Academy)
BSc (OAU), MSc (UI), PhD (LAUTECH)
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# INDIGENOUS LEGUMES

# RECIPES FOR FOOD AND NUTRITION SECURITY

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**By**

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**Professor of Food Science**

**Delivered at**

**Ladoke Akintola University of Technology**
**Ogbomoso, Nigeria**

**On**

**Thursday 22nd April 2021**

Ladoke Akintola University of Technology (LAUTECH)
Ogbomoso, Nigeria

**ISSN: 2705-3695**

Published by:
Ladoke Akintola University of Technology,
Ogbomoso, Nigeria





## BIOGRAPHY OF PROFESSOR BOLANLE AISHAT AKINWANDE

Bolanle Aishat Akinwande was born in Ibadan over five decades ago. She started her academic sojourn at Ibadan Municipal Government Primary School, Ibadan in 1974 and had her secondary education at Ibadan Grammar School, Ibadan between 1980 and 1985. She worked briefly as a Clerical Officer at West African Examination Council (WAEC), Ibadan between 1986 and 1987. She thereafter proceeded to Federal Polytechnic, Ilaro, where she obtained Ordinary National Diploma (OND) in Food Science and Technology in 1989. She obtained her Bachelor of Science (BSc) from Obafemi Awolowo University in 1994 and Master of Science (MSc) from University of Ibadan in 1996. She obtained her Degree of Philosophy (PhD) from Ladoke Akintola University of Technology (LAUTECH) in 2006. She has a Diploma in Agribusiness and Post-Harvest Management from Galilee International Management Institute, Nahalal, Israel in 2012. She also has a certificate in Internal Quality Assurance in Higher Education Institutions from Centre for Higher Education Development and Quality Enhancement (CHEDQE) of the University of Duisburg-Essen, Germany in 2016.

Professor Akinwande started her academic career at Ladoke Akintola University of Technology as an Assistant Lecturer at the then Department of Food Science and Engineering in 2001. She rose through the ranks and became a Professor of Food Science in 2014. She has supervised five (5) Ph.D. and eight (8) MSc students successfully, while three (3) Ph.D. and five (5) MSc students are being supervised, currently, in this University and University of Ibadan. She has sixty-nine (69) publications to her credit. She has mentored several younger researchers and academia. She served as resource persons for the Mentor-Mentee programme at the African Women in Agricultural Research and Development (AWARD) and Glooming Leaders in Agriculture (GLA) and informal levels. She served as External Examiner (undergraduate and post-graduate programmes) and Professorial

Assessor at several Universities including Obafemi Awolowo University, Ile-Ife, University of Ibadan, Ibadan, University of Ilorin, Ilorin, Federal University of Agriculture, Abeokuta, Federal University of Technology, Akure, and Bowen University, Iwo.

Professor Akinwande craves for knowledge always and does not miss any opportunity within her reach to improve herself. She has attended sixty-six (66) scientific meetings, conferences, workshops, and seminars. She was a recipient of Graduate Scholarship at International Institute of Tropical Agriculture (IITA) (2002 to 2005), Post-Doctoral Fellowship of African Women in Agricultural Research and Development (AWARD) (2011 to 2013), and Netherlands Fellowship Program (2017) for African Nutrition Leadership Program in 2017. Three other University lecturers became AWARD fellows through the university-wide awareness program that she organized in 2012. She facilitated the training of three (3) academic staff in the defunct Food Science and Engineering Department, LAUTECH as Graduate Scholars at IITA, Ibadan for Ph.D. She was also able to secure research placements for seven of her graduate students (6 MSc and 1 PhD) as Graduate Scholars at IITA for quality research and network.

Professor Akinwande served as LAUTECH representative in the team for GlobeE (Global Food Security) Biomass web grant to carry out a project titled "Improving Food security in Africa through Increased System Productivity of Biomass-Based Value Webs (BiomassWeb)" in 2013. The project was funded by the Federal Ministry of Education and Research, Germany under the umbrella of "GlobE –Global Food Security" within the "National Research Strategy BioEconomy 2030" framework programme. This opportunity facilitated the training of two MSc students.

Professor Akinwande won the competitive applications for Training on Internal Quality Assurance in Anglophone West Africa (TrainIQA) (part of the DIES programme – Dialogue on Innovative Higher Education





Strategies), which was meant for 30 institutions in Anglophone West Africa in 2013. Her pragmatic effort during the training led to the developed blueprint for the establishment and implementation of Internal Quality Assurance for LAUTECH. She was thereafter appointed as the pioneer Director of the Quality Assurance Unit, LAUTECH, from 2015-2019.

Professor Akinwande is an Expert and a Consultant on Quality Assurance in Higher Education Institutions. She is a member of the interim executive of the West African Anglophone Quality Assurance Network (WAAQAN). Her team won DAAD grant for Dialogue on Innovative Higher Education Strategies (DIES) National Multiplication Trainings (NMT) 2019-2020 Programme (Nigeria cohort). She is also a consultant at the workshop of the TrainIQA course in the Southern African Development Community (SADC) region. The SADC-QA 2020-2021 project is being facilitated by the Centre for Quality Development, University of Potsdam, Germany, and supported by DIES.

Professor Akinwande's passion is to address issues relating to access to healthy foods by people on the lower economic ladder. Her research focus is to solve the problems of nutritional deficiencies and the poverty trap of the smallholder farmers through the enhancement of utilisation of under-cultivated and neglected local crops that provide health benefits beyond basic nutrition. Most of her research activities center on the use of simple and low-cost technology that are affordable by smallholder farmers for food processing.

Professor Akinwande, as a team player, formed different research teams within and outside the university environment for impactful research. She was a principal investigator of a multi-disciplinary and multi-institutional project team that worked on "Promotion and Adoption of Orange-Fleshed Sweet Potato as Crop and Food in Oyo and Kwara States". The project was funded by World Bank and implemented

through West Africa Agricultural Productivity Program (WAAPP-Nigeria). Two of her other research teams won the first LAUTECH Senate research grant in 2013. She was a Principal investigator for one ("Value Addition to Underutilized Indigenous Legumes for Improved Nutrition and Income Generation for Smallholder Farmers") and a Co-investigator for the other ("Alkali Activation of Nigeria Clays for Vegetable Oils Refining, a Case Study of Nigeria Shea Butter").

In order to fulfill her passion in addressing issues relating to access to healthy foods by people on the lower economic ladder, Professor Akinwande endeavored to translate outputs of her several research efforts to outcomes through Community Outreach activities. Her research team created awareness on the different processing options for better utilisation of indigenous legumes at Onilaru village in Ogbomoso, with the aim to prevent the crops from going into extinction. The outreach equally targeted health and wealth initiatives. Her other research team also created awareness on the potentials of Orange–Fleshed Sweet Potato (OFSP) as a means of enhancing the livelihood and nutrition of the masses in Ogbomoso and Offa zones of Oyo and Kwara states, respectively.

Professor Akinwande serves as an ad-hoc staff of the National Universities Commission (NUC), and as a result, she has been involved in the accreditation of Food Science and Technology programs in different Universities in Nigeria. She was also involved in the evaluation of the Quality of Governance and Management Practices of Private Universities in Nigeria. She was a member of the 3-man committee that wrote a template on 'Education for the Development of Oyo State' for the incumbent government in 2019.

Professor Akinwande is a Fellow of Nigerian Institute of Food Science and Technology (NIFST), a member of the Institute of Food Technologists (IFT), a member of the International Society of Tropical Root Crops





(ISTRC), a member of Agriculture, Nutrition, and Health (ANH) Academy, a member of Nutrition Committee of Nigerian Heart Foundation (NHF), a member of the Scientific and Technical Committee of NIFST, and an Associate Editor of Nigerian Food Journal (NIFOJ). She currently serves on the advisory board of the African Food Research Network (AfREN).

Professor Bolanle Aishat Akinwande is happily married to Mr. Akinwunmi Abdl-Rasheed Akinwande, and the union is blessed with three children, Nurat, Salimat, and Maryam.

**PROTOCOLS**

Vice-Chancellor Professor M.O. Ologunde
Other Vice-Chancellors, present and past
Deputy Vice-Chancellor Professor M.A. Liasu
Registrar Dr. K.A. Ogunleye
Other Principal Officers of the University
Chairman, Committee of Provost and Deans
Provost, College of Health Sciences
Dean of Post Graduate School
Dean of Faculty of Food and Consumer Sciences
Deans of other Faculties
Ag. Dean of Student Affairs
Professors and other Members of Senate of LAUTECH
Heads of Departments and Directors of Units
Members of Staff of LAUTECH
Greatest Ladokites
Distinguished Invited Guests and Family Members
Gentlemen of the Press
Ladies and Gentlemen

## 1 INTRODUCTION

In the name of Almighty Allah, Al-Awwalu (The First), Al-Ahiru (The Last), Al-Zohiru (The Manifest/The Most High), Al-Batinu (The Hidden/The Most Near), I glorify ALLAH (SWT) for this day. With all my limitations and shortcomings, He makes me seem to be knowledgeable among reputable professionals. To Him alone be all praises and adoration for abundant grace, favour, mercy, and protection that I enjoy without limit.





### 1.1 Preamble

The first inaugural lecture in the Department of Food Science and Engineering titled "From Infancy to Adulthood: A Nexus for Healthy, Safe, Nutritious and Wholesome Food" was delivered by Professor M.O. Ologunde in 2016. The Food Science Programme of the Department metamorphosed, in 2018, into the Faculty of Food and Consumer Sciences, which started with two Departments, one of which is the Department of Food Science. The first inaugural lecture in the Department of Food Science was presented by Professor B.I.O. Ade-Omowaye in 2019. I have the privilege of presenting the second inaugural lecture from the Food Science Department, and the fourth in the Food Science Programme.

Today's lecture titled **Nutritional and Affordable Foods for Healthy Living: Towards Attaining Sustainable Development Goals (SDGs)** was conceived in the last one and a half years from three developments. The first was during the symposium of Rectors, Vice-Chancellors and Presidents at the 11$^{th}$ International Conference and Workshops on Quality Assurance in Higher Educationin Africa (ICQAHEA) which held from 7$^{th}$ to 10$^{th}$ October 2019 at the National Universities Commission (NUC), Abuja. The theme of the symposium was "Sharing Good Institutional Practices in Institutional Governance, Quality Assurance and Research towards Attainment of the SDGs and the Harmonisation of Higher Education Systems in Africa". The University leaders were expected to establish, in concrete terms, how they have contributed to the attainment of Sustainable Development Goals (SDGs) at institutional levels. I then realised the importance of documenting research activities concerning SDGs.

The second one was when top-notch NUC personnel noted on two different occasions in my presence that most academics are driven by publishing in high impact factor journals while it is not clear how impactful the publications are to the society. The third development occurred in April 2020 when Elsevier published the top 500 authours by scholarly output in Nigeria between 2014 and 2019. While some lecturers in the Faculty of Technology at the University of Ibadan were congratulating successful authors, one lecturer asked specifically, and I quote, "While I celebrate these people, what is the practical implication of the publications on solving local problems and changing our story. Where are the ones addressing our local challenges?". I then thought that it is very important to showcase the relevance of academic research activities for societal benefits.

Mr. Vice-Chancellor Sir, the crux of this lecture is two fold. The first is to inform the audience that access to 'good' food for 'good' health is not expensive but ignorance (inadequate knowledge) is what is expensive. The second is to demonstrate an example of how efforts from this reputable institution (LAUTECH) of ours have been making societal impacts and contributing towards achieving the global SDGs, especially Goals No. 1, 2, 3, and 4.

My research interest on the 'affordability of nutritive food for healthy living by the less privileged' was perceived years back as a young lecturer while teaching students and interacting with people on the lower economic ladder. My usual question to many people is: "Is it cheap or expensive to eat good/healthy food"? The general answer is that it is expensive, while I correct them that eating good food is cheap, but it is the ignorance of adequate information that is expensive. God, in His mercy, has provided food that is enough to





sustain us all. This assertion is supported by quotes from the two Holy Books, thus:

"He (Allah) it is Who sends down water (rain) from the sky, from it you drink and from it grows the vegetation on which you send your cattle to pasture. With it He causes to grow for you the crops, the olives, the date-palms, the grapes, and every kind of fruit. Verily, in this is indeed an evident proof and a manifest sign for a people who give thought" (Quran 16: 10-11).

"Therefore I say to you, do not worry about your life, what you will eat or what you will drink; Look at the birds in the air, for they neither sow nor reap nor gather into barns; yet your heavenly Father feeds them" (Mathew 6: 25-34 NKJV).

It is thus obvious from the above quotes that God has endowed us with crops to eat and are available cheaply in our environment. It is only left for us to look into possible ways of maximising their use as food. My interest as an academic is in value addition to the locally available crops for food purposes.

Mr. Vice-Chancellor Sir, my situation is an example of "when life throws a lemon at you, turn it into a lemonade". After the opportunity of having my PhD research work done at the International Institute of Tropical Agriculture (IITA), Ibadan, it became impossible for me to leave home for international environments where I can have access to sophisticated equipment for research activities. I then resolved to look inward and concentrate all efforts on value addition to local produce, especially indigenous and underutilised ones with the use of simple technology. This I did as a young lecturer in the lower cadre

without any clear-cut focus until the year 2011 when I won African Women in Agricultural Research Development (AWARD) Post–doctoral Fellowship. I, then, came up with a research focus, which is solving the problems of nutritional deficiencies and the poverty trap of smallholder farmers through the enhancement of utilisation of under-cultivated and neglected local crops that provide health benefits beyond basic nutrition.

### 1.2 Sustainable Development Goals (SDGs)

SDGs, also known as the Global Goals, were adopted by 193 United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. SDGs are a good collection of 17 goals (Fig. 1), which include 169 targets and 230 Key Performance Indicators (KPI). Each goal has specific targets to be accomplished by 2030, and intends to transform the world. Simply put, SDGs are universal call to end poverty, safeguard the planet and ensure that all people enjoy peace and prosperity by the year 2030.

#### 1.2.1 Sustainable Development Goals No. 1, 2, 3, and 4

SDGs 1, 2, and 3 are linked with food security with the ultimate of having a food secured and healthy global world, while good health and nutrition are linked with SDG 4. SDG 1 (no poverty – eradicate extreme poverty for all people everywhere, currently measured as people living on less than US$1.25/Day) calls for an end to poverty in all its manifestations by 2030 (UNDP, 2015). It also aims to ensure social protection for the poor and vulnerable, increase access to basic services and support people harmed by climate–related extreme events and other economic, social, and environmental shocks and disasters.






Fig. 1: Illustration of sustainable development goals

Source: https://blog.aiesec.org/sustainable-development-what/

SDG 2 (end hunger –achieve food security and improved nutrition, and promote sustainable agriculture) is meant to provide sustainable solutions to end hunger in all ramifications by 2030 and achieve food security. The intention of this is to ensure that everyone everywhere has enough good-quality food for a healthy life. There is a need for better access to food with the attendant extensive promotion of sustainable agriculture to achieve this goal (UNDP, 2015). This requires improvement in the productivity and incomes of small-scale farmers by promoting equal access to land, technology and markets, sustainable food production systems, and resilient agricultural practices. It also entails an increase in investments through international cooperation to strengthen the

productive capacity of agriculture in developing countries.

SDG 2 in Sub-Saharan Africa is yet to be attained due to a very high rate of under-nourishment and the prevalence of stunting in under 5 years of age (although there is fair progress, acceleration is still needed) (SDG Progress Chart, 2019). The targets in SDG 2 will be achieved by 2030 with concerted and accelerated efforts from all stakeholders, especially with heavy investment in agriculture by the government.

SDG 3 (good health and well-being for people –ensure healthy lives and promote well-being for all at all ages) has targets of ensuring healthy lives and promoting well-being for all at all ages. Good nutrition is essential to reducing maternal and child mortality around the world and reaching the U.S. Agency for International Development (USAID) goals for preventing child and maternal deaths (USAID, 2019). Undernutrition has a direct effect on child mortality as it compromises immune function, increases susceptibility to infectious diseases, and hastens the progression, severity, and duration of disease (Bhutta *et al.,* 2013). Since undernutrition is an underlying cause of mortality, there is need to intensify nutrition interventions to reduce the menace of child and maternal mortality. According to the WHO, "a healthy diet helps to protect against malnutrition in all its forms, as well as against non–communicable diseases (NCDs) such as diabetes, heart disease, stroke and cancer" (WHO, 2020).

SDG 4 (quality education –ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) is meant to reaffirm the fact that education is a powerful and proven





means for sustainable development. Education is a basic right and elementary to human dignity and it will help the youth prepare for employment in the high-skill jobs of the fourth industrial revolution. It provides the opportunities to transmit knowledge, values, and skills across generations and thereby enable societies to set the foundation for thriving in the future (HLPF, 2019). Education is essential for sustainable development, but investments in education needs to be accompanied by concurrent progress in other aspects of human wellbeing to enable all people to realise their full potentials in life. Good child health and nutrition are important to secure learning outcomes in terms of increased class attendance and improved educational achievements (HLPF, 2019). Also, ending poverty will reduce pressures to put children to work, and eventually increase universal school enrolment. Such considerations are very relevant for vulnerable groups that suffer from multiple deprivations and are therefore critical to realizing the overall objective of 'leaving no one behind'.

The SDG Index of 149 countries, comparing their current progress with a baseline measurement taken in 2015, indicated that Nigeria is ranked 141 with 36.1% success, while Benin and Sierra Leone ranked 130 and 138 with 40.0% and 36.9% success, respectively (WEF, 2017). Sweden tops the ranking list with 84.5% success.

Nigeria faces serious development gaps with healthy life expectancy of 49 years and with placement among the bottom six countries in the world (IMF, 2019). In recognition of these challenges, Nigeria embraced the SDGs Agenda. Although modest progress has been achieved across the goals and indicators, the outbreak of the COVID-19 pandemic and its health and

socioeconomic impacts will slow down progress on the achievement of the SDGs in Nigeria (Buhari, 2020). The effect of lockdown measures enacted by the government on daily earners could make more households to fall below the poverty line. Disruptions in the market, supply chain and trade have tendencies to further aggravate people's access to food and nutrition. Good health and well-being are the major casualties of the impact of the COVID-19 pandemic.

Mr. Vice-Chancellor Sir, in this lecture, I will provide information on nutritional and health benefits of some local and cheap food crops and demonstrate the interventions that I have made with these crops towards contributing to the achievement of SDGs No. 1, 2, and 3 in the area of food security. It will be obvious in this lecture that access to healthy food for healthy living is cheap, but that it is only lack of, or inadequate, knowledge that is expensive. I wish to also provide evidence on how I have been able to contribute to the achievement of quality education, as entrenched in SDG 4.

## 2 FOOD

Food is regarded as any substance that is normally eaten or drunk by living things. It is anything eaten to satisfy the appetite and meet physiological needs for growth, maintain all body processes, and supply energy to maintain body temperature and activities. Foods vary to a large extent in their nutrient composition and are thus classified based on their composition and the source from which they are derived. Healthy eating means eating a variety of foods that give the nutrients (protein, carbohydrate, fat, water, vitamin, and minerals) that are needed to maintain good health, with a good sense of feeling and energy.





### 2.1 Food Security

Food security, as defined by the United Nations' Committee on World Food Security, means that all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Meijl *et al.*, 2020). The four pillars of food security are food availability, access to food, utilisation and stability (could be purchased all year round at a controlled price). The pillars are broken down as:

(i) Enough food must be available to meet people's needs;

(ii) People must have access to the food that is available under normal circumstances;

(iii) Volatility in production or prices must not threaten this availability; and

(iv) The quality of food that people consume must be adequate for their needs.

Food insecurity leads to malnutrition, which refers broadly to deficiencies (undernutrition), excesses (overnutrition), or imbalances in a person's intake of nutrients (IFPRI, 2016). Inadequate food intake is harmful to children's growth, intellectual development, and immune system (Pinstrup-Andersen and Schiler, 2001). Undernourished children could also succumb to what would normally be a trivial illness in a well-fed child. However, in adults, malnourishment results in insufficient energy to carry out regular work obligations which make them more vulnerable to common illness. Hunger and malnutrition are a long–

term burden on societies, impeding economic and social development and sustainable management of resources. Food security and nutrition for present and future generations are, thus, both integral part of sustainable development goals.

There is no gainsaying that access to safe and nutritious food is very important for sustaining life and the promotion of good health. Poverty reduction is very important in a policy for food security. This is because poor people spend a large part of their incomes on food, which makes them more vulnerable to high food prices. Food processing at the grassroot level goes a long way in value addition to food commodities which enables smallholder farmers to charge higher, which thereby leads to higher revenue.

The coronavirus (COVID-19) pandemic, which is a humanitarian crisis ravaging almost every nation, upending lives, livelihoods, business and economic stability, also risks stunting decades of progress in the fight against poverty and aggravates the already high levels of inequality. There are risks to food security in many countries, including Nigeria. These risks include disruptions in domestic food supply chains, losses that affect food production, preservation, distribution, and loss of income and remittances due to measures taken to combat the spread of COVID-19.

There is widespread impact of COVID-19 on household incomes and food security (HPLE, 2020). The United Nations World Food Programme warned that an additional 130 million people could face acute food insecurity by the end of 2020 to the 135 million people who are already acutely food insecure before the crisis, due to income and remittance losses (World Bank Brief, 2020). Higher retail prices, combined with reduced incomes, mean more and





more households are having to cut down on the quantity and quality of their food consumption, with potentially lasting impacts on nutrition and health. Many countries and organisations are mounting special efforts to keep agriculture running safely as an essential business, markets well supplied with affordable and nutritious food, and consumers able to access and purchase food despite movement restrictions and income losses as a result of the potential rise in food insecurity.

## 2.2 Indigenous and Traditional Foods of Nigeria

Indigenous plants are plants that grow spontaneously in natural ecosystems while traditional foods are foods and dishes that have either passed or consumed through generations. They are produced locally and they form part of the food culture inherent in the locality. They are nutrient-rich with a history of being supportive of health and wellness due to their medicinal values. The local climate enables the cultivation of indigenous crops either for subsistence, income, or both. Since the 1960s, when research and extension agents in South Africa have been labeling traditional leafy vegetables as weeds, there has been stigmatisation of the crops, especially among young people (Ineke *et al*., 2007).

Indigenous and traditional foods have the advantage of being accessible, affordable, healthy and are nutrient-dense. They also have economic benefits because they are usually easily cultivated and require fewer inputs than their exotic counterparts, and some can be grown under marginal conditions due to their tolerance to poor soils, fires, insects, and pests. This is an advantage to the resource-poor smallholder farmers (that account for most of the food produced in Africa) who may not be able to afford most

agricultural inputs. These crops are always well adapted to the regions where they originate and are grown specifically for human foods. Furthermore, these crops have the ability to adapt to adverse growth conditions and could be relied upon when other crops fail to survive or are out of season (Aworh, 2018). In addition, these indigenous and traditional plant foods tend to offer varieties to human diets and thus enhance the living environment. Many of the crops constitute inexpensive and rich sources of protein, carotenoids, Vitamin C, and dietary fibre.

Most traditional foods are prepared from indigenous food crops/plants due to ease of availability and low cost. They, most times, constitute the bulk of the local diet and tend to be more popular and nutritious than some introduced plants. Traditional foods are classified as roots and tubers, cereals and legumes, fruits and vegetables, herbs and spices, livestock and game, and soup condiments (Onimawo, 2010).

According to a Bioversity International report, about 75% of the global food supply comes from just 12 crops and five animal species, yet there are more than 20,000 known edible plant species worldwide (FAO, 2020). Food and Agricultural Organisation (FAO) claims that neglected and underutilised species have a central role to play in the fight against hunger and malnutrition, but they are currently being overlooked. Over the years, indigenous and traditional plant foods are more prevalent in Nigeria than animal foods and have served as food security.

Mainstreaming indigenous crops into the food system of the communities that produce them offers opportunities to develop a





sustainable and healthy food system. This will enable good livelihood with nutritional, environmental, economic, and socio–cultural benefits, in line with key themes of the sustainable food system framework (Akinola *et al.*, 2020).

The number one healthiest food, based on the nutritional composition, is spinach, a family of Amaranthaceae (dark green leaves that are eaten cooked or raw in salads) that is native to central and western Asia. It has high nutrients, but low in calories, and provides Vitamins A, $B_2$, C, and K, and essential folate as well as a good source of manganese, magnesium, and iron (Table 1). Spinach-derived phytochemicals and bioactive compounds could contribute to the anti-cancer, anti-obesity, hypoglycemic, and hypolipidemic properties (Roberts and Moreau, 2016). The spinach found in Nigeria is called African Spinach (amaranth green and called 'tete' in Yoruba). It is available cheaply with lots of nutrients and numerous health benefits.

## 2.3 Functional foods

Foods are no longer evaluated only in terms of macro and micronutrient contents. There is global shift to positive eating habit. Daily diets have an impact on health and wellness beyond basic nutrition. This fact has necessitated an increase in the characterisation and development of foods and their products that have additional effects than just protein, energy, vitamin or mineral supply, and as a result, they are referred to as functional foods. Simply put, foods can be indicated as 'functional' if they can serve as dietary supplements, and that in addition to their nutritional values, they can beneficially modulate body functions (Fig. 2) towards enhancing physiological response towards

improving the state of health and wellbeing, or reducing a risk of certain diseases (Martiroyan and Singh, 2015), and to the extent that they can be nutraceuticals (Nicoletti, 2012). Nutraceuticals, on the other hand, are substances that are obtained from food items that are taken as a medicine in the form of pills, capsules or syrup for demonstrated physiological benefits.

| Nutrient | Value | Nutrient | Value |
|---|---|---|---|
| Water (g) | 91.58 | Carbohydrate, by difference (g) | 3.50 |
| Energy (kJ) | 92 | Fiber, total dietary (g) | 2.7 |
| Protein (g) | 2.86 | Ash (g) | 1.72 |
| Total lipid (fat) (g) | 0.35 | | |
| Vitamins | | Minerals | |
| Vitamin C (mg) | 28.1 | Calcium, Ca (mg) | 99 |
| Thiamine (mg) | 0.078 | Iron, Fe (mg) | 2.71 |
| Riboflavin (mg) | 0.189 | Magnesium, Mg (mg) | 79 |
| Niacin (mg) | 0.724 | Phosphorus, P (mg) | 49 |
| Pantothenic acid (mg) | 0.065 | Potassium, K (mg) | 558 |
| Vitamin $B_6$ (mg) | 0.195 | Sodium, Na (mg) | 79 |
| Folate, total (µg) | 194 | Zinc, Zn (mg) | 0.53 |
| Vitamin $B_{12}$ (µg) | 0.00 | Copper, Cu (mg) | 0.130 |
| Vitamin A (µg RE) | 672 | Manganese, Mn (mg) | 0.897 |
| Vitamin E (mg ATE) | 1.890 | Selenium, Se (mg) | 1.0 |

Table 1: Nutritional value of spinach per 100 g raw fresh
RE, retinol equivalents; ATE, alpha-tocopherol equivalents
Source: USDA (2001)





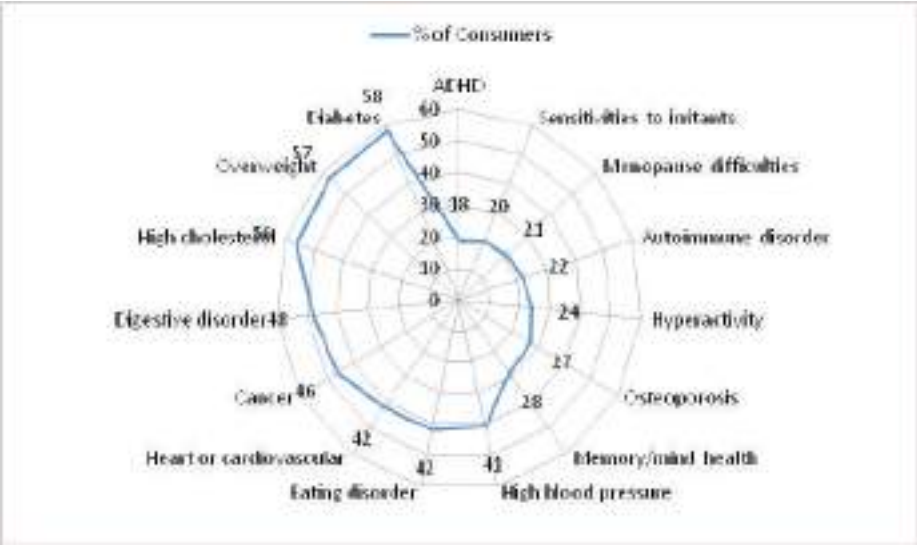


Fig. 2: Use of food to prevent specific health conditions
Source: Hartman group (2010) in IFT magazine (04/2012)

There is a close association between traditional diet and traditional medicine in Africa (Aworh, 2018). Vitamins (A, $B_6$, $B_{12}$, folate, C, D, and E) and trace elements (zinc, copper, selenium, iron) in foods support the human body immune system by protecting the host from pathogenic organisms (bacteria, viruses, fungi, parasites) and thereby reduce the risk of infections (Calder, 2020). According to Garba and Mungadi (2019), neem leaves contain compounds like zinc, quercetin, vitamin A, vitamin $B_1$, vitamin $B_2$, vitamin $B_6$, vitamin C, vitamin E which may boost immunity. The availability of health-promoting functional foods in the diet has the potential to help ensure a healthier population. Insight into how the role of physiologically active food components, from both phytochemicals

and zoochemicals, have changed the role of diet in health has been provided (Akinwande, 2008).

The 'functionality' idea is the relationship between diet and health. Nutritionists have concentrated, traditionally, on identifying a 'balanced' diet, which ensures adequate intake of nutrients while avoiding certain dietary imbalances like excessive consumption of fat and salt, which can contribute to disease. In recent times, the focus is on achieving 'optimised' nutrition and maximising life expectancy and quality by identifying food ingredients, which when added to a 'balanced' diet, improve the capacity to resist diseases and enhance health. Nutraceuticals and functional foods have broad potential for preventing the mechanisms of viral infection and modulating immune responses (Haslbeger *et al.*, 2020). Phenolic components in tea exhibit an inhibitory effect on some gut microbiota species (Farag *et al*., 2020), like *Bacteroides* spp., *Clostridium* spp. (*C. perfringens* and *C. difficile*), *E. coli* and *Salmonella yphimurium*, caffeic acid has shown the highest inhibitory activity (Lee *et al*., 2006). Indigenous/traditional foods contain functional components (Table 2) as discovered in my research activities and they are discussed further in the next sections.

## 3 MY RESEARCH ACTIVITIES ON INDIGENOUS FOOD CROPS

Mr. Vice-Chancellor Sir, permit me to highlight some of my contributions on the use of functional indigenous and traditional food crops to improve the livelihoods and wellbeing of the populace. The global concern about food security and sustainable agricultural production among smallholder farmers spurred my





interest in research activities that will proffer solution to increase the utilisation options for indigenous crops. As a follow-up to the goal of the FAO, which is to investigate alternative food sources to improve food security and widen the world food basket, it became pertinent to investigate the potentials of underutilised/neglected functional indigenous crops. Several of my research activities are based on the economic, environmental, and social impacts, which are the three main pillars of sustainability. They were carried out to address the possibility of developing desirable food products from locally available and cheap, but nutrient-dense, raw materials. These activities were done with the use of simple technology, which guarantee minimal loss to food nutrients in order to address the prevalent food insecurity problems in developing countries such as Nigeria. My research concerns were centred on value addition to food commodities.

Table 2: Examples of food sources* with functional components and potential benefits

| Food source(s)* | Class/Component | Potential benefit(s) |
|---|---|---|
| **Carotenoids** | | |
| Carrots, various fruits | Beta-carotene | Antioxidants; can be converted to vitamin A in the body |
| Spinach, corn, eggs, citrus, carrots | Lutein, Zeaxanthin | Supports maintenance of eye health |
| Tomato and its processed products, water melon, red/pink grapefruit | Lycopene | Supports maintenance of prostate health |
| **Dietary (functional and total) Fiber** | | |
| Wheat bran, corn bran, fruit skins | Insoluble fiber | Supports maintenance of digestive health; may reduce the risk of some cancer |
| Oatmeal, oat flour, barley, rye | Beta-glucan** | May reduce the risk of Coronary Heart Disease (CHD) |
| Peas, beans, apples, citrus fruits | Soluble fiber** | May reduce the risk of CHD and some types of cancer |
| Cereal grains, whole wheat bread, oatmeal, brown rice | Whole grains** | May reduce risk of CHD and some cancer; maintains healthy blood glucose |
| **Fatty Acids** | | |
| Tree nuts, olive oil, canola oil | Monounsaturated fatty acids (MUFAs)** | May reduce the risk of CHD |
| Walnuts, flaxseeds, flaxseed oil | Polyunsaturated fatty acids (PUFAs) & Omega-3 fatty acids – ALA | Supports the maintenance of heart and eye health; supports the maintenance of mental function |
| Salmon, tuna, marine and other fish oils | PUFAs –Omega-3 fatty acids –DHA/EPA** | May reduce the risk of CHD; supports the maintenance of eye health and mental function |
| Beef and lamb, some cheese | Conjugated linoleic acid (CLA) | Supports the maintenance of desirable body composition and immune health |
| **Soy Protein** | | |
| Soybeans and products | Soy Protein** | May reduce the risk of CHD |
| **Sulfides/Thiols** | | |
| Garlic, onions, leeks, scallions | Diallyl sulfide, Allyl methyl trisulfide | May enhance immunity, detoxification, and healthy heart |
| **Flavonoids** | | |
| Berries, cherries, red grapes | Anthocyanins | Antioxidant; supports healthy brain function |
| Tea, cocoa, chocolate, apples, grapes | Flavanols | Supports maintenance of heart health |
| Cocoa, apples, grapes, tea, peanuts, chocolate | Proanthocyanidins | Supports maintenance of urinary tract and healthy heart |
| Citrus foods | Flavanones | Antioxidants |
| Onions, apples, tea, broccoli | Flavonols | Antioxidants |





| | | |
|---|---|---|
| **Isothiocyanates** | | |
| Cabbage, Cauliflower, broccoli, kale | Sulphoraphane | Antioxidants; may enhance detoxification. |
| **Phenols** | | |
| Apples, pears, citrus fruits, some vegetables | Caffeic acid, Ferulic acid | Antioxidants; may contribute to the maintenance of heart and healthy vision |
| **Plant Stanols/Sterols** | | |
| Corn, soy, wheat, fortified foods and beverages | Free Stanols/Sterols** | May reduce the risk of CHD |
| Fortified table spreads | Stanol/Sterol esters** | May reduce the risk of CHD |
| **Polyols** | | |
| Some chewing gums and other food applications | Sugar alcohols –xylitol, sorbitol mannitol, lactitol | May reduce the risk of dental caries |
| **Prebiotics/Probiotics** | | |
| Whole grains, onions, some fruits, garlic, honey, leeks, fortified foods and beverages | Inulin, Fructo–oligosaccharides (FOS), Polydextrose | May improve gastrointestinal health; may improve calcium absorption |
| Yoghourt, other dairy and non-dairy applications | Lactobacilli, Bifidobacteria | May improve gastrointestinal health and systemic immunity |
| **Phytoestrogens** | | |
| Soybeans and soy-based foods | Isoflavones – Daidzein, Genistein | May contribute to the maintenance of bone health, healthy brain and immune function; menopausal health |
| Flax, rye, some vegetables | Lignans | May contribute to the maintenance of heart health and immune function |

* Examples are not an all-inclusive list;
** FDA-approved health claim established for component
Source: Adapted from IFIC (2011)

Special emphasis was placed on under-processed and underutilised/neglected functional food crops towards enhancing nutrition while considering the vulnerable groups. The impacts of these food crops in ensuring poverty reduction, food security, and

good health within the Nigerian context are highlighted and discussed in the following sections. The potential impacts of nutrient-enhanced indigenous food materials in combatting the COVID–19 pandemic are inferred based on the phytochemical/nutraceutical components of these food products.

### 3.1 Ogi: Supplementation and Process Improvement

Ogi is a fermented food product made from cereals (maize, sorghum, and millet) and it is obtained, traditionally, in wet form. It has a characteristic mild sour taste. The fluid or semi-solid cooked ogi (pap) is called by different names such as ogi/'eko' (Yoruba) and 'akamu'(Igbo) in different localities, while the stiff gel (corn jello) is called 'eko jije'/'tutu' (Yoruba), 'agidi' (Igbo) and 'kafa' (Hausa) in Nigeria. Pap from ogi serves as a complementary meal for growing children. It is consumed as a breakfast meal and also serves as the food of choice for convalescents.

While whole cereals are rich sources of vitamins, minerals, carbohydrates, fats, oils, and protein (Adeyemi, 2018a), the traditional process of making ogi involves the removal of bran. This results in loss of its protein, fat, fibre, minerals, and vitamins contents, but higher starch content (Aminigo and Akingbala, 2004). The protein-rich part of the grain is mainly located in the testa and germ, which are usually sifted off during processing. The consequence of this is the prevalence of malnutrition in infants that are fed mainly with pap.

Traditional processing of ogi without sieving of the bran is a means of retaining all nutrients of the whole cereal. Wet milling of grains, after soaking, to very fine particle size is encouraged for ogi





production. This will remove the associated drudgery of sieving in traditional processing and also enhance the nutrient density and health benefits of the final meal. Unsieved ogi from yellow maize has higher mineral, protein, fibre, and oil content than sieved one (Farinde, 2015). Pap from finely ground unsieved ogi has the desired reduced viscosity and smoothness (Personal observation). Consumption of products (pap and jello) from unsieved ogi (whole grains) by adults could contribute to the prevention of obesity, cancer, cardiovascular diseases, and diabetes (Kushi *et al.*, 1999; Anderson *et al*., 2000). The effects were associated with the presence of carbohydrate components like resistant starch and dietary fibre.

Cooked ogi (pap or jello) is nutritionally deficient due to the high swelling capacity of starch content of ogi. This makes the product to swell and absorb more water during cooking. The cooked products have a lot of water than other nutrients. The addition of any other substance to ogi produced from cereal interferes with the starch structure and reduces its swelling capacity. The inclusion of indigenous and cheap plant protein crops like melon, okra, cowpea, and soybean to ogi improves nutrient contents of the cooked products. This makes use of more slurry possible to obtain the required pap viscosity and thereby enhances increase in nutrient content of the cooked product ('nutrient-dense'). Ogi supplemented with ground okra planting seed has higher protein, ash, oil and fiber contents, with desired reduced viscosity but with objectionable aroma (Ashaye, 1992).

We addressed this limitation of unpleasant colour and aroma with the addition of colouring agent and vanilla flavour to mask the

unpleasant colour and flavour of untoasted okra seed fortified ogi (Akingbala *et al.*, 2003). The outcome of the preference sensory test carried out on the reconstituted products showed that the addition of yellow colour did not improve the colour rating but the vanilla flavour improved the flavour of ogi supplemented with untoasted okra meal. However, there was the problem of incomplete separation of the kernel from the hull. We pre-treated fresh matured okra seeds with blanching and fermentation before incorporating them into ogi, in order to solve this limitation. Steam blanching for 10 min or fermentation for 2 days improves the nutritional quality of okra supplemented maize ogi without any objectionable sensory quality (Ajala, 2015). This solves the problem of dark specks, objectionable flavour and colour that limits the use of okra seed meal in maize-okra 'ogi' with enhanced consumer acceptability. This could also serve as a means of reducing post-harvest losses of okra and value addition.

We (Abioye *et al*., 2019) substituted yellow maize with African Yam Bean (AYB) (*Sphenostylis stenocarpa*) seed, an underutilised legume in Nigeria in order to further produce nutrient-dense ogi from a cheap and locally available crop. AYB has protein content of about 24-28% and with most of its essential amino acids, especially lysine and methionine levels being higher than those in other legumes including soybean (Adewale *et al.*, 2013). Our findings indicated that ogi with AYB substitution has about 50.62% reduced viscosity and higher nutrients when compared with the one produced from 100% maize. This has an advantage of more nutrient density per volume when compared with that made from 100% maize and is a better option for feeding children as pap. Subjective sensory ratings showed that ogi product from maize





and AYB at a ratio of 80:20 compares with that of 100% maize in terms of taste, aroma and general acceptability.

My research efforts were able to address the usual deficiencies of sensory qualities of improved ogi with supplemented okra meal and underutilised AYB. Also, sieving of ogi before cooking could be avoided by fine-milling of soaked grains to prevent associated processing drudgery and for maximum nutritional benefits. Consumption of products from improved ogi from locally available crops makes it possible to produce nutrient-dense food product that is cheap and readily available. This is an opportunity to make the populace to have access to food product from cereals like maize, which is the third most produced crop in Nigeria (FAO, 2016), and thus prevent them from hunger and equally be healthy towards the achievement of SDGs 2 and 3.

### 3.2 Okra (*Abelmoschus esculentus L.*)

Okra, also known as okro, is an important economic vegetable crop that is grown in tropical and sub-tropical parts of the world. It is popular as a vegetable for its nutritional values and health benefits. The fresh leaves, buds, flowers, pods, stem and seeds all have value (Mihretu *et al.*, 2014). It is an example of a locally domesticated crop that is rich in nutrients and adapted to low–input agriculture. It is easily cultivated as garden crop and on large commercial farms. It is widely consumed as a fresh vegetable in salads, soups and stews. Okra contains valuable nutrients, which play a vital role in the human diet and health as indicated in Table 3. It has low anti-nutrient contents, high mineral bioavailability (Gemede *et al.*, 2015), and antioxidant activity. It is one of the vegetables with the highest contents of beta-carotene, lutein, and

xanthin, and it is also rich in linoleic acid, a polyunsaturated fatty acid essential for human nutrition (Sami *et al.*, 2013).

Several pharmacological properties of okra have been reported. It has a gastro-protective effect (Ribeiro *et al*., 2016), and anti-fatigue and antioxidant effects (Xia *et al*., 2015). It reduces neurological disorders (Alzheimer's) and other neurodegenerative diseases related to oxidative stress (Mairuae *et al.*, 2015). It can reduce blood glucose, corticosterone, cholesterol, and triglyceride levels elevated by acute stress (Doreddula *et al.*, 2014). Okra is used in folk medicine as antiulcerogenic, with potency more than the reference misoprostol at 0.4 mg/kg (Gurbuz *et al*., 2003). Water-soluble polysaccharide from okra exerts antitumor activity by probably stimulating macrophage activities through the nuclear NF-κB pathway (Zheng *et al.*, 2014).

Okra has been used traditionally as an alternative treatment for diabetes and its regular consumption has been shown to protect against diabetes and other coronary heart diseases (Khatun *et al*., 2011; Moise *et al*., 2012; Fan *et al*., 2014). Its inclusion in the daily diet up to about three times in one week has the potential to protect against the incidence of diabetes and diabetic-induced hyperglycemia (Prabhune *et al.*, 2017). The root extract of okra reduced steatosis, necrosis and inflammation of the liver (Saravanan *et al.*, 2013). Folate and vitamin C contents of okra are responsible for optimum pregnancy (Zaharuddin *et al.*, 2014), while its beta-carotene is important nourishment for sustaining an exceptional eye-sight with healthy skin (Messing *et al.*, 2014).





Table 3: Nutrition profile of fresh okra raw pods per 100 g

| Nutrient | Value | %RDA | Nutrient | Value | %RDA |
|---|---|---|---|---|---|
| Energy | 33 Kcal | 1.5% | Electrolytes | | |
| Carbohydrates | 7.03 g | 5.4% | Sodium | 8 mg | 0.5% |
| Protein | 2.0 g | 4% | Potassium | 303 mg | 6% |
| Total Fat | 0.1 g | 0.5% | Phytonutrients | | |
| Cholesterol | 0 mg | 0% | Carotene-ß | 225 µg | — |
| Dietary Fiber | 9% | 3.2 g | Crypto-xanthin-ß | 0 µg | — |
| | | | Lutein-zeaxanthin | 516 µg | — |
| Vitamins | | | Minerals | | |
| Folates | 60 µg | 22% | Calcium | 82 mg | 8% |
| Niacin | 1.000 mg | 6% | Copper | 0.109 mg | 10% |
| Pantothenic acid | 0.245 mg | 5% | Iron | 0.62 mg | 10% |
| Pyridoxine | 0.215 mg | 16.5% | Magnesium | 57 mg | 14% |
| Riboflavin | 0.060 mg | 4.5% | Manganese | 0.788 mg | 43% |
| Thiamine | 0.200 mg | 17% | Phosphorus | 61 mg | 9% |
| Vitamin C | 23.0 mg | 36% | Potassium | 299 mg | – |
| Vitamin A | 36 µg | 12.5% | Sodium | 7 mg | – |
| Vitamin E | 0.27 mg | 2.5% | Selenium | 0.7 µg | 1% |
| Vitamin K | 53 µg | 44% | Zinc | 0.58 mg | 5.5% |

Source: USDA (2020)

### 3.2.1 Preservation of fresh okra pods

Okra is highly perishable due to its high moisture content and post harvest respiratory activities (Boonyaritthongchai, 2013) with high susceptibility to water loss, colour fading and decay with subsequent reduced commercial value. Freshly harvested pods are usually packed into containers or baskets, which are ventilated

because of their high respiration rate at a warm temperature, which may cause deterioration. Fading of colour by oxidation and enzymatic activities also occur which affect the commercial value of okra when stored at room temperature (Idowu, 2005). It is, thus, very important to explore simple techniques that could be adaptable to developing technology in extending the shelf life of okra pods.

We, Akinwande *et al.* (2009), evaluated the use of three local storage structures, i.e., pot-in-pot (evaporative coolant structure as described by Nigerian Stored Products Research Institute), raffia basket and calabash in storing three varieties of fresh immature okra pods (LD-88, 'jokoso' and 47-4) (Plate 1). The pot–in-pot had two burnt clay pots, one placed inside the other, and the space between them was filled with riverbed sand that was constantly kept wet. Storage was done for two weeks at ambient condition and evaluated for weight loss, freshness quality (in terms of marketability, fibrousness, and moldiness), and sensory attributes (colour, aroma, texture, and general acceptability).

Lower temperature (26 ± 1 °C) and higher relative humidity (92%) were obtained in pot-in-pot than the temperature (27 ± 1 °C) and relative humidity (87%) obtained in both raffia basket and calabash. Pods in pot-in-pot had the highest value for marketability and least values for fibrousness and mouldiness when compared to those stored in calabash and basket. Pods stored in pot-in-pot also had the best ratings for sensory qualities at the end of the storage period, while those in calabash had the least ratings.





Pot-in-pot, or a similar storage structure, would find useful application in extending the shelf life of fresh okra pods in developing countries like Nigeria. Farmers and marketers of okra are encouraged to use pot-in-pot for storage as a means of reducing the heat stress to the pods and extend their storage life for more economic benefits.

(a) (b) (c)

Plate 1: Storage structures for okra: (a) pot-in-pot; (b) calabash; and (c) raffia basket

Adequate storage of okra will help in retaining essential nutrients that are needed for healthy living. Okra, with its diverse array of nutritional quality and potential health beneficial effects on some of the human diseases like cardiovascular disease, type 2 diabetes, digestive diseases, and some cancers, is an important food crop. Its regular consumption can be a factor in mitigating food insecurity and possibly alleviate malnutrition in developing countries like Nigeria. Since okra is very cheap with enormous nutritional and health benefits, it is advised to be included in the individual menu towards the achievement of SDGs 2 and 3.

### 3.3 Mushroom

Mushrooms are macro-fungi with distinctive and visible, edible fruiting bodies that may grow above or below the ground (Plate 3) and are widely consumed as food around the world. They are among the man's earliest natural foods, and yet the most neglected and underutilised foods in the Nigerian food system. They grow wild and are sometimes cultivated.

The underground tuber (edible sclerotium) of *Pleurotus tuberregium* has a history of economic importance as food in Africa. It is known in the local languages as 'olu ile' or 'egusi olu' in Oyo State, 'ogu' in Ondo State, 'katsala' in Hausa, 'owu' or 'umoho' in Igede (Benue State), 'usu', 'ike usu' or 'ero usu' in Ibo and 'awu' in Igala. The above–and below-ground mushrooms are high in protein but low in fat and calories, and could serve as a protein supplementary diet (Teklit, 2015). They also contain significant amounts of fibres, vitamins (thiamine, riboflavin, ascorbic acid, vitamin A, $B_1$, $B_{12}$, C, D, E, and vitamin $D_2$) and minerals (Kalač, 2009; Heleno *et al*., 2010). They have more antioxidants than fruits and vegetables.

In addition to the nutritional values, some mushrooms have antitumor, antiviral, and hypolipidemic effects which make them attractive functional foods (Poucheret *et al*., 2006; Ferreira *et al*., 2007). Some mushrooms can suppress cell proliferation and induce apoptosis and cytotoxicity in human breast cancer cells (Martin and Brophy, 2010). Many people consume mushrooms due to their flavour, meaty taste and medicinal value (Grangeia *et al.*, 2011). They can be used as food to solve the problem of malnutrition (Guillamon *et al*., 2010).





In a developing country like Nigeria, where the protein intake of the population is low due to the expensive nature of protein foods, wild-growing species of mushroom are used as a meat substitute in the time past by people in the lower economic ladder.

a b

Plate 3: Examples of mushroom: (a) above-ground (*Pleurotus pulmonarius)*; and (b) below-ground mushroom (*Pleurotus tuberregium* with sclerotium)

#### 3.3.1 Mushroom safety evaluation

While some wild mushrooms (*Chlorophyllum molybdites*, *Panaeolus subalteatus*, *Macrolepiota procera*, *Leucopaxillus albissmus*, *Hygrophoropsis aurantiacus*, and *Pholiota aurea*) from Zaria in Nigeria have been found to be toxic (Ambali *et al*., 2008), ethnomedicinal uses of some (e.g., *Pleurotus tuberregium*, *Agaricus bisporus*, *Lentinus squarullosus*, *Gandoderma lucidum*, *Volvariella vovaceae* have been documented (Oyetayo, 2011) which shows that they are edible. Research has indicated the use of various substrates for the cultivation of mushrooms to take care of apprehension in consumers about the poisonous nature of some wild edible mushrooms (Akinwande and Adetola, 2014). Easily cultivated mushrooms and common wild mushrooms are often available in the market. To rekindle interest in mushroom

consumption, some research efforts were made to encourage their consumption for nutritional and health benefits.

I studied the safety (in terms of toxic mineral components) of five species of wild-growing mushroom ('oluoowu', 'olugodongbo', 'oluokitinla', 'oluokitiwewe', and 'oluonirugboroo') collected from the bush in the Ogbomoso metropolis, Nigeria (Akinwande, 2011). Essential minerals [Mg (22.90–33.52 ppm), Co (0.32–3.04 ppm), Mn (5.15–17.36 ppm), Cu (13.71–34.08 ppm), Fe 62.70–141.20 ppm), Ni 0.76–21.25 ppm) and Zn (27.81–44.59 ppm)] were obtained in the samples. Two heavy metals, i.e. cadmium and lead, which were detected had the highest values of 0.69 and 3.77 ppm, respectively, which are lower than those reported for other mushroom samples (An *et al*., 2020). The findings from the research indicate that consumption of the five species does not pose any danger in terms of heavy metals and that they could serve as good sources of essential micro-nutrients like Mg, Mn, Cu, Fe and Zn.

### 3.3.2 Mushroom preservation and utilisation

Due to the structure and chemical composition of these edible fungi, mushrooms are generally very perishable. Hence, they are marketed fresh or must be delivered to the consumer as soon as possible after they have been picked (FAO/WHO, 2005). We looked into the possibility of using three local spices (ginger, garlic and nutmeg) as flavour enhancers in the production of shelf-stable and ready-to-cook mushroom soup-mix. The product is meant to be reconstituted with water and boiled before being served as a soup.





Different combinations of ginger, garlic, and nutmeg were mixed with other spices and seasoning and added to coarsely ground dry mushroom (*Pleurotus pulmonarius*) to produce the mushroom soup-mix. The aroma of the served reconstituted product from the sample with the combination of three spices had the highest rating Akinwande *et al.* (2007a). The microbiological load of samples stored on the shelf at ambient conditions decreased as the storage period progressed. The inclusion of garlic in the soup–mix led to more reduction of microbial load. This confirms the antimicrobial activities of the local spices (Liu *et al.*, 2017).

Akinwande and Abegunde (2013) explored the possibility of replacing turkey meat and beef with mushroom in Nigerian pepper soup for enhanced nutrition. The crude protein content of chicken pepper soup was highest with a value of 5.20% and was followed by 3.43% in mushroom pepper soup. Mushroom soup recorded the least amount of 1.18% for crude fat. Crude fibre content was highest (5.64%) in mushroom soup and lowest in beef soup. While sensory attributes of chicken pepper soup were most preferred, there was no significant difference between the chicken pepper soup and mushroom soup in all the attributes, except aroma. The use of mushroom could thus be encouraged to replace meats in preparing pepper soup.

In contrast to the high perishability nature of above-ground mushrooms, the below-ground, i.e., sclerotium, is shelf-stable due to its very low moisture content. It has higher nutrient contents in terms of protein, fat, crude fiber, minerals and carbohydrates (Ude *et al.*, 2001). The hard sclerotium is peeled, ground, used as soup thickener or for preparation of 'egusi' in the southern and western

part of Nigeria. It has been used as a disintegrant in the formulation of paracetamol at the industrial level (Iwuagwu and Onyekweli, 2002).

As a follow-up on the use of its powdery form, we made effort to diversify the diet from this nutrient-dense indigenous crop as a food-based strategy for food and nutrition security and sustainable diets in resource-poor communities. We developed locally adaptable nutritious and health-friendly snacks from composite flour of orange-fleshed sweet potato and *P. tuberregium* sclerotium.

Cookies and chin-chin (Plate 4) with high contents of protein (with all essential amino acids except tryptophan), ash, crude fiber, phytochemicals, minerals, vitamins, antioxidant activities, and acceptable sensory quality were produced from OFSP and sclerotium flours at a ratio of 80:20 (Kolawole *et al.*, 2018; 2020). These snacks could, thus, be categorised as healthy based on their nutritional contents (Garba and Mungadi, 2019). Inclusion of these products in the dietary pattern of the consuming populace could boost their nutritional status and reduction of incidence of diseases.

(a) (b)

Plate 4: (a) Cookies and (b) Chinchin made from composite flour of OFSP and sclerotium tuber





Mr. Vice-Chancellor Sir, mushrooms that are encouraged to be consumed are those that are already commercialised, grown by farmers and sold in the markets. They have potentials in future food supplies and new dimensions of sustainable agriculture and could be used to develop different healthcare biotechnology products. The above–and below-ground mushrooms can serve as a cheap source of protein, especially to those who cannot afford animal protein. Their incorporation in foods will make it possible to have a new range of functional foods. While mushroom cultivation can provide gainful employment to youths and rural women for sustainable income to the families, both cultivation and processing can be explored by small and medium scale industries. Mushroom cultivation, production, and processing into food products are very promising for health and wealth initiatives, thus they are encouraged. These activities will contribute to the achievement of SDGs 1, 2, and 3.

### 3.4 Legumes

'Legumes' is a general term for the seeds of plants from the legume family which includes beans, peas, lentils and peanuts. They are cheap sources of dietary vegetable proteins and minerals when compared with animal products like fish, meat, and egg. They contain carbohydrates, minerals, dietary fiber, resistant starch, and water-soluble vitamins in good quantity, which are important in human health. They have essential amino acids (Iqbal *et al.*, 2006), including lysine that is deficient in cereals. Legumes can be supplemented with cereals to give a balance of amino acids called protein complementation. However, they also contain anti–nutritional factors such as lectins, saponin, haemagglutinin, protease inhibitor, oxalate, goitrogen, phytates, trypsin inhibitor,

and tannin (Amarowicz and Pegg, 2008), which can be eliminated or reduced by processing.

Indigenous legumes like pigeon pea, African yam bean, and Bambara groundnut grow wild and require no formal cultivation. They are drought-tolerant, which makes them ideal crops in the era of climate change. These legumes are good protein foods in this era of economic stress, high-value food expectations and environmental responsibility. They are an important source of affordable alternative protein and other nutrients for people in the lower economic ladder where they are predominantly consumed.

### 3.4.1 Awareness studies and group discussion on indigenous legumes

In recent times, indigenous legumes are not commonly consumed as in the time past due to their hard-to-cook phenomenon and inadequate knowledge of how to diversify utilisation options. In order to establish the current perception and opinions of rural dwellers concerning the cultivation and consumption of indigenous legumes, we carried out a focus group discussion as a participatory assessment tool at Onilaru village, in Orire local government area in Ogbomoso. The community was purposively selected due to the established relationships and ease of access, using both transcript and audio. The participants were farm families (both male and female to ensure gender balance) and the state Agricultural Development Programme (ADP) officials who assisted in the identification of group participants.

All the participants were observed to be familiar with indigenous legumes. However, it was realised that both cultivation and





consumption of the legumes had reduced for a very long time. The lack of interest in consumption was expressed to be due to the associated processing drudgery. This finding triggered our interest to look into the possibility of reducing the associated drudgery of some hard-to-cook legumes in food processing (Akinwande *et al*., 2017). Our interest was on possible diversification of their usage using locally adaptable simple procedures for value-added products to prevent further neglect and enhance their cultivation and consumption by smallholder farmers.

### 3.4.2 Product development from indigenous legumes

I and my research team worked on product development from indigenous legumes in three stages. The first stage was the preliminary investigation to confirm the acceptability of products from pigeon pea (*Cajanus cajan*), Bambara groundnut (*Vigna subterranea*), and African yam bean (*Stenostylis stenocarpa*). The second stage was a follow-up to the first by the production of 'moinmoin' (bean pudding) and 'akara' (bean cake) from an intermediate flour recipe. Production of flour from both underutilised legumes and cowpea was done with wet decortication of seed coat before drying and milling of the seeds. This process was discovered to be laborious and might not be sustainable, especially in the area of energy demand. The third, and the last, stage was on process optimisation to develop a shelf–stable intermediate flour recipe which will only require the addition of water to produce a paste for 'moinmoin' and 'akara' processing at the domestic level. This was done to completely eliminate the associated drudgery of hard-to-cook nature of the indigenous legumes and make their utilisation easy. Procedures for product developments were collated and published in form of a

recipe booklet for free distribution to the public.

3.4.2.1 Product development and evaluation of acceptability
Ready-to-eat breakfast cereal was produced from a composite of whole maize and decorticated African yam bean flour in ratio 100:0, 90:10, 80:20 and 70:30. A slurry was produced with the addition of 33% (g/mL) portable water to form a paste that was cooked for 10 min with low heat. Drying with simultaneous toasting of the cooked slurry was done to have a flake-type cereal product to mimic a popular and acceptable commercial corn flake product. We observed that the substitution of maize flour with up to 30% African yam bean produced ready-to-eat breakfast cereal with higher mineral contents, except phosphorous, than commercial corn flakes (Akinwande *et al*., 2014b). The reconstituted product in sweetened milk after soaking for 10 min was liked by sensory panellists.

Improved ogi was made by wet milling mixture of steeped maize (56 h) and African yam bean (12 h) at ratio 100:0, 90:10, 80:20 and 70:30, respectively (Abioye *et al*., 2019). The sieved slurry was allowed to settle and ferment for 24 h before drying the sediment at 50 ± 5 °C for 20 h. Reconstituted slurry (25 g flour in 50 ml water) was added to boiling water (150 ml) to obtain ogi porridge. Sensory properties of improved ogi made from separately wet-milled yellow maize and African yam bean at 80:20 ratio compares with that from only maize. This indicates the fact that the beany flavour in the legumes is no longer a factor to prevent their use in supplementing other grains. The use of maize and African yam bean at a ratio of 80:20 is advised for the production of improved 'ogi'.





'Kokoro' was made from a composite of whole maize and dehulled pigeon pea flour at ratios of 100:0, 90:10, 80:20 and 70:30, respectively (Adejuyitan *et al.*, 2019). The mixture with added ingredients, salt and sugar, was processed further using a traditional method to obtain kokoro. Substitution of maize flour with pigeon pea flour up to 20% produced 'kokoro' that compares with that made from 100% maize flour.

Bambara nut and cowpea were also used to produce 'moinmoin' using the traditional wet decortication and milling process, and with added pepper, onion and seasonings (Akinwande *et al.*, 2017). Bambara groundnut required more water for processing than cowpea due to its higher swelling capacity. 'Moinmoin' from 100% Bambara grain was preferred to that made from 100% cowpea. Since Bambara groundnut requires more volume of water for the same weight of the two legumes used, and with higher sensory ratings for its 'moinmoin', it is more profitable to use Bambara groundnut for the processing.

3.4.2.2 Development of shelf-stable pre-mixes
Development of shelf-stable intermediate flour pre-mix was done with the addition of dry spices and seasonings. The pre-mix is meant to require the addition of only water to produce a paste for 'moinmoin' and 'akara' preparation at the domestic level (Akinwande *et al.*, 2017). Production of flour from underutilised legumes (African yam bean, pigeon pea and Bambara groundnut) and cowpea was done with wet decortication of seed coat before drying with a locally fabricated tunnel drier (50 °C for 48 h) and milling of the dry seeds. Composite flour of cowpea and each of the legumes singly at the ratios of 100:0, 75:25, 50:50, 25:75, and 0:

100, respectively, was prepared. To each of the different sets of the composite flour was added habanero pepper (1.32%), bell pepper (2.64%), onion (5.83%), and salt (1.59%). Reconstituted paste (with minimum water requirement in 100% cowpea flour than other flour mixes) was produced from each pre-mix and used to prepare 'moinmoin' and 'akara'.

The results obtained from the sensory evaluation of the two samples from different legumes indicated those made from Bambara nut to have the highest preference ratings of the three legumes while those made from pigeon pea had the least ratings. 'Moinmoin' and 'akara' made from the flour recipe compared with those produced using traditional methods that involve the laborious process of wet decortication and milling. However, this process was also realised to be laborious and might not be sustainable, especially in the area of energy demand. This necessitated further research on the development of shelf-stable flour mix.

3.4.2.3 Process optimisation of shelf-stable pre-mix

Process optimisation to develop shelf-stable flour mix from Bambara nut and cowpea was done. This was to eliminate any form of associated processing drudgery of the hard-to-cook nature of the indigenous legumes and make their utilisation easy. The dry decortication process was used to remove testa before final dry milling, which saved the use of a lot of energy and time of wet decortication and drying process. Optimisation of the intermediate flour recipe from Bambara and cowpea flour was done by maximising for water absorption capacity, swelling capacity, flavonoid content, and minimising for terpenoid and





phytate contents (Akinwande *et al*., 2017). The flour obtained produced end products that compared with 'moinmoin' and 'akara' that were produced from the more laborious wet milling process. This shows that the dry milling process could be used for the decortication of legumes to speed up the process of flour production at reduced cost and time.

3.4.2.4 Potentials of indigenous legumes as traditional foods

The underutilised legumes have been realised to have the potentials to be of impact in a more diversified and sustainable food production system. Efforts to reawaken interest in the underutilised legumes can contribute to sustainable agricultural productivity. This is because they have benefits as food and nutritional security climate-smart crops that are capable of growing on marginal lands. Cultivation, production, and utilisation of the crops will contribute to financial empowerment while their access as food will be a solution to good nutrition and wellness. This will contribute in no small way to the socio-economic development of the rural areas where the legumes are abundantly available and also help in the attainment of SDGs 1, 2, and 3.

## 3.5 Roots, Tubers, and Bananas

Roots and tubers are the set of plants that produce starchy roots, tubers, corms, stems, and rhizomes. They are mostly used as human food (either raw or in a processed form), animal feed, and industrial applications. The prominent difference between the stem tuber (tuber) and root tuber (root) is that the stem tuber is a swollen stem while the root tuber is a swollen root.

### 3.5.1 Yam

Yam belongs to the genus *Dioscorea*. Only six species are of importance as a staple food, which are white yam (*D. rotundata*), water yam (*D. alata*), yellow yam (*D. cayenensis*), trifoliate yam (*D. dumetorum*), aerial yam (*D. bulbifera*), and Chinese yam (*D. esculenta*). It ranks eleventh among global food crops in both total production (50 MT) and food consumption in developing countries with production concentration in tropical Africa (96%), mostly by smallholders (CGIAR, 2020). Nigeria is the largest producer of yam in the world with over 65% of the world's production in 2019 (FAOSTAT, 2020).

#### 3.5.1.1 Yam maturity

Maturity indices for harvesting yam tubers most times are subjective and non-quantitative. These include farmers' judgment or observations of the plant and/or the tuber, as well as a calculation based on the date of planting, senescence of the aerial apparatus, percentage of the tuber length that was whitish at harvest, sogginess, and/or bitter taste after cooking (Degras, 1993). Any of the indices is used to maximise the number of times that the tuber may be extracted for nutritional and/or financial reasons. It became important to determine the relationship between food quality and tuber maturity in varieties of white yam to establish a rapid maturity index to determine the ideal tuber harvest time. This was to enable farmers and breeders to determine the earliest possible time for harvest so that the same plot of land could be used for planting another crop before the end of the rainy season. It is also meant to enable processors to determine the ideal stage of yam maturity that will be appropriate for processing, based on the desired product quality.





Mr. Vice-Chancellor Sir, with the view of attending to the global concern of establishing the time that yam tuber matures, I studied the properties of yam tuber and quality of the food products at different stages of growth in 2002. This was done on six local varieties and 10 IITA genetic accessions of white yam. A study of some properties was also done on stored tuber (for four months) in an open-air barn. The highest tuber yield was realised to be obtainable at six months after vine emergence (MAVE), which is before complete foliage senescence at seven MAVE (Akinwande *et al.*, 2007b). Good sensory attributes of boiled and pounded yam are also obtained at six MAVE, which coincide with the highest tuber yield. Yam tubers are, thus, ready for harvesting at six MAVE for both economic and food quality reasons.

The results of the rate at which fresh and stored tuber parenchyma turns brownish upon exposure to air showed that colour change from white to brown color is not dependent on age and storage period of the tuber, but could be an inherent attribute of polyphenoloxidase of the variety. However, tuber section (i.e. proximal, middle, and tail) is a factor that influences the rate at which browning occurred in the parenchyma (Akinwande *et al.*, 2011).

Findings about the suitability of yam tuber for processing at different maturity stages showed that changes in starch paste characteristics during the developmental stage up to 5 MAVE were more pronounced than those observed during storage (Akinwande *et al.*, 2007c). Differences in the starch viscosity profiles exhibited by six varieties indicated the possibility of multidimensional use (which the yam starch could be subjected to at different stages of

maturity) that could be of benefit for industrial application. Starch obtained from the tubers at 3 MAVE was indicated to be better suited for certain products (e.g. noodles) than those obtained when yam is normally harvested due to high values for holding strength and cold paste viscosity.

Assessment of the properties of leaves of 10 accessions of *D. rotundata* during growth done to determine an indicator for maturity for rapid assessment that could indicate the best time to harvest tuber showed that the tuber is matured at the point when the dry matter of the leaves is highest, and before a very sharp increase as foliage senesces (Akinwande *et al.*, 2008a). Also, the starch content of leaves is a possible indicator for determining tuber maturity since the tuber was discovered to be matured when minimum starch content is obtained in the leaves, which coincides with the time that yellowing of lower leaves of the plant is observed.

I was able to establish the relationship between food quality and tuber maturity in white yam. Farmers can conveniently harvest yam tuber before complete foliage senescence occurs. A crude index to confirm this is an observation of yellow colour in the lower leaf of foliage. The starch content of leaves could also serve as an indicator for determining tuber maturity since the tuber is matured when minimum starch content is obtained in the leaves, which coincides with the time that yellowing of lower leaves of the plant is observed. Also, for processors of starch-based products, starch properties of tuber at three months before complete foliage senescence is most ideal for a certain product and tuber for such could be harvested at an early stage. This information is very





important to both farmers and breeders who, had over the years, had to wait for final foliage senescence before yam tubers could be harvested.

3.5.1.2 Value addition to underutilised yam species

Bitter yam, also commonly called wild yellow yam, trifoliate yam, and cluster yam, is a lesser-known yam among the yam species and is underutilised. It is known as 'esuru' in south-western Nigeria and 'ji una' or 'ji ona' in south-eastern Nigeria. The tubers are eaten during the time of famine or scarcity and are usually boiled with peel and eaten as boiled yam. The tubers grow on various soils and the yield is 3–7 times that of other widely grown yams. Bitter yam has crude protein content of 11.37% and contains essential amino acids (tryptophan, phenylalanine, threonine and valine) with levels that compare favourably with the FAO/WHO provisional pattern (Alozie *et al.*, 2009). It has easily digestible starch compared to other yam varieties (Adebowale *et al.*, 2011). It has desirable medicinal values and could be considered as possible health supplements (Salau *et al*., 2017). The tubers contain an alkaloid dihydrodioscorine, which causes paralysis of the nervous system. Dihydrodioscorine is reported to be water-soluble and can be dissipated by soaking and boiling. It has a limitation of tuber hardening, which begins a few hours after harvest, thus becoming hard to chew even after long hours of cooking, making their consumption almost impossible.

Mr. Vice-Chancellor Sir, we (Akinwande *et al.*, 2008c; 2013a; 2014a) studied the potentials of bitter yam and another underutilised yam specie, water yam (*Dioscorea alata*), for industrial use. The two species were compared with commonly

consumed species, i.e. white yam (*D. rotundata*) and yellow yam (*D. cayenensis*), for production of raw and pre-gelatinised flour using different steaming methods and time in an autoclave (5 min) and Barlet steamer (10, 20, and 30 min). Values obtained for most pasting properties in the samples that were steamed for 5 min in autoclave were close to those obtained in samples steamed for 20 min in Barlet steamer. The use of autoclave for steaming at higher pressure could be an opportunity to reduce the cost of energy in processing pre-gelatinised yam flour. Steaming for pre–gelatinisation under atmospheric pressure for 20 min is ideal for optimum values of variables measured. Raw and pre-gelatised bitter yam flour samples have the least amount of oxalate content when compared with the three other species and low bulk density (Akinwande *et al.*, 2008b).

Pre-gelatinised bitter yam flour compares with white and yellow yam in terms of consistency but has the least value of swelling index in comparison to the other three species (Akinwande *et al.*, 2013a). Steaming improves and enhances the swelling ability of flour, with higher values in pre-gelatinised flour, which increases with steaming time. The four species have lower breakdown values in pre-gelatinised samples than raw samples, which makes them more relevant as ingredients in food products that have to be subjected to high heat and shear force during processing (Akinwande *et al.*, 2014a). Sensory attributes of pre-gelatinised samples of white yam and yellow yam that were steamed in autoclaved for 5 min and in Barlet steamer for up to 20 min were desirable for instant pounded yam flour. Pasting properties of pre–gelatinised bitter yam flour shows that it could be useful in ingredient formulation as a thickener and gelling agent in pudding





and in heat sensitive products like cold desserts, instant soups and salad dressing. It can also find application in instant foods like infant food formulation based on its protein content, amino acid profile, low bulk density, and ease of starch digestibility.

It is important to encourage cultivation and utilisation of bitter yam, most especially because of its high yield, nutritional composition, and industrial potential, to enhance the nutritional and financial well-being of the populace and the economy of the nation. Information on the combination of processing method and time of the different yam species could also serve as a guide in flour processing. Industrial application of bitter yam tuber for the diverse product is encouraged due to its nutrient profile and starch properties after pre-treatments. Cultivation and utilization of bitter yam, that can withstand harsh weather conditions, can contribute towards achievement of SDGs 1 and 2.

### 3.5.2 Cassava

Cassava is one of the major sources of carbohydrates and the fourth most important crop in developing countries. In Nigeria, cassava is grown in all agroecological zones of Nigeria, but it is produced more in the rainforest and derived savannah areas. It is the most important crop by production as at 2019 in Nigeria (FAOSTAT, 2020). As of 2019, Nigeria stood as the leading global cassava producing country with a production of 59 million tons (21.6%) out of world production of about 278 million tons (FAOSTAT, 2020). Most of the cassava that is produced in Nigeria is for domestic utilisation, with limitations in the area of industrial exploitation. There is a cyclic glut in cassava marketing in Nigeria as a result of limited industrial applications which results in

recurrent wastages and losses.

Cassava is a good food security crop, it grows on soil with poor fertility and provides food and income for many households. It is one of the indispensable crops in Nigeria with a great positive effect on the livelihoods of the populace which projects it as having high economic importance in the country. Cassava roots are highly perishable and contain cyanogenic glucosides, which are potentially toxic but can be reduced to a minimal level during processing. Processing into more storable form makes it possible to overcome the perishability problem. The root is processed into food products like 'gari', 'fufu', fermented flour ('lafun'), high–quality flour, tapioca, starch, and chips.

3.5.2.1 Development and assessment of cassava chips in 'gari' manufacture

'Gari' is a creamy-white granular flour produced from grated, fermented, and gelatinized fresh cassava root with a slightly fermented flavour and sour taste. Of all the food products from cassava root, 'gari' is widely consumed and traded as a staple food in Nigeria and other West African countries. The processing of 'gari' is labour intensive. In consideration of the high rate of the perishability of cassava root and the associated processing drudgery of 'gari', we carried out research to add value to it to reduce postharvest loss and possible use of a shelf-stable product as starting material for ease of processing.

Chips of 7% moisture content were made from cassava root and stored for 6 months in a high-density polyethylene bag. Rehydrated coarse-milled chips to 62.51% were seeded with fresh





cassava mash (FCM) at levels of 5%, 10%, and 20% and used to produce 'gari'. Sensory evaluation was carried out on water–soaked 'gari' and 'gari' paste after reconstitution with hot water ('eba'). 'Gari' produced from cassava chips seeded at 10% level is good for making 'eba' while that seeded at 5% level is good for consumption as soaked 'gari' (Akinwande *et al.*, 2013b). The use of stored cassava chips with 10% FCM for 'gari' production could thus be encouraged to reduce the postharvest problem of cassava roots and also reduce the labour-intensiveness of 'gari' processing by rural women. This will also enable more time for the processor to do other income-generating activities for improved livelihood. Processing of cassava chips from fresh roots by farmers during glut would address the problem of post-harvest losses and the possibility of selling the crop at a give-away price. Value addition will enable the farmers to sell at higher prices and, thus, enhance their livelihoods. It is, however, important that consumers should get used to the difference in the taste of 'gari' that is produced from chips for the sake of its benefits.

3.5.2.2 Production of modified starches from cassava root

Starch from plants, due to the adhesive, thickening, gelling, swelling and film-forming properties, has many industrial applications in food, chemical, pharmaceutical, textile, and adhesive industries, among others. Native starches have limitations like weakness of hydration, swelling, and structural organization. However, most pharmaceutical industries in Nigeria rely on the importation of millions of tons of corn starch as their major raw material. This background information led to our study on the potential of the use of pre-gelatinised cassava starch as a material in tablet compression in pharmaceutical industries. This

was with the view to reducing the cost of pharmaceutical products.

Native starch from three varieties of cassava (TME 419, TMS 98/0505 and TMS 98/0581) was pre-gelatinized at concentrations of 25, 30 and 35% (w/v). Effect of pre-gelatinization on the physical characteristics (bulk and true densities, porosity, particle sizes), flow rate, and tableting characteristics (maximum volume reduction, consolidation index and rate of consolidation) of the pre-gelatinized starch was evaluated. The results obtained showed that the pre-gelatinised cassava starch at 25% (w/v) possesses good properties of pharmaceutical excipients and compares with imported corn starch (Otutu *et al.*, 2015; 2017a). The use of pre-gelatinised cassava starch by pharmaceutical industries has the potential of reducing production cost, which will directly reduce the cost of drugs. Reduction in the importation of corn starch for pharmaceutical use will also reduce the drain on foreign earnings and thus improve the economic situation of Nigeria.

We also considered modification of cassava starch by acetylation for possible use in the food industry to replace imported stabilisers (such as guar gum, carboxymethyl cellulose, locust bean gum, carrageenan, and xanthan gum) in ice cream production. Native starch from three varieties of cassava (TME 419, TMS 98/0505 and TMS 98/0581) was acetylated at substitution levels of 10, 15, 20, 25 and 30%. Ice cream was produced from the native and acetylated starches and analysed for percentage overrun, foam stability, meltdown rate and consumer preference in terms of colour, taste, creaminess, mouth feel and appearance. The





preference sensory test result showed that acetylated cassava starch at 10% substitution compares with commercial ice cream (Otutu *et al.*, 2017b). Food industries are, therefore, enjoined to consider the possible use of acetylated cassava starch to replace imported and costly commercial stabilisers in food processing to reduce overhead cost.

3.5.2.3 Production of resistant starch from cassava root

Resistant starch (RS) is the total amount of starch and the products of starch that is not digested in the small intestine of healthy people and passes into the colon where it can be fermented by natural microflora to short-chain fatty acids. It is a non-caloric food component that does not contribute to the increase in blood glucose. It has physiological effects in the human body that are similar to that of dietary fiber and with properties such as small particle size, white appearance, bland flavour, and good gel formation, among others. These properties make it useful in various food formulations such as baked goods, extruded cereals, and snacks (Sajilata *et al*., 2006).

Still on value addition to cassava root for industrial application, we investigated the possible use of native cassava starch for the production of resistant starch (RS) as an alternative to a more expensive high amylose corn starch. Effects of debranching, steam cooking methods, and storage conditions on the yield of RS type 3 (retrograded starch) from cassava roots (TMS 30572 and 98/0581) were studied. The native starch samples were debranched with isoamylase enzyme (90 mU/g starch), steam cooked at atmospheric and high pressure (15 psi), and stored under refrigeration (5–7°C) and freezing condition (−18°C) for 48 h.

The findings indicated that cassava starch is suitable for producing resistant starch with isoamylase debranching. The debranching process increases RS formation by 73–78% (Abioye *et al*., 2017). High autoclave temperature (121 °C) and an increase in storage time up to 48 h under refrigeration and steaming increases the RS content (Abioye *et al*., 2018). Cheaper RS can, thus, be produced from cassava root, which can be used as an ingredient in low and intermediate-moisture foods such as jams, jellies, bakery products, and snacks, and possibly serve as a functional ingredient.

The glut in cassava marketing can be avoided if cassava utilisation is diversified. Rural economy could thus be strengthened by boosting cassava farmers' income by converting relatively cheap and highly perishable cassava root into value-added products that have higher value and export potential. This would make Nigeria to be prominent in the world's export market. In countries with high labour availability and unused land, like Nigeria, an increase in cassava production and processing can lead to better income for farmers as a result of a possible increase in industrial utilization.

3.5.2.4 Food intake among smallholder cassava value chain households

Value chain is used to describe the full range of activities that are involved to create a product or service. Cassava value chain actors comprise of input suppliers, farmers, farmers' cooperatives, processors, marketers, transporters, and consumers within and outside the production zone. Smallholder farmers and processors that are the key players in the cassava value chain in Nigeria generally have low-capacity. Smallholder farming families are at





risk of food insecurity and malnutrition (Lawal and Samuel, 2010).

As a result of the recent increase in cassava industrialisation in Nigeria, there is an expanding cassava value chain that is rapidly transforming into cassava value web for all its actors. The interlink involving a series of value chains through which food and forage, fuels and other raw materials are produced, processed, and marketed is called value web. Cassava value web has good opportunities for improved livelihoods of value chain actors. To be able to establish whether this translates into improved food consumption and nutrient intake or nutritional (particularly micronutrients) status of smallholder cassava value chain actors, we (Samuel *et al*., 2019) compared the food consumption and dietary diversity of Cassava Value Chain Households (CVCHs) and non-CVCHs in selected communities of Oyo and Kwara States in the Guinea Savannah zone of Nigeria. This was to determine the nutritional status of CVCHs, especially as cassava moves from value chain to value web.

Food frequency questionnaire was administered to collect data on the frequency of consumption of different food items in the household over the past month. Dietary intake data were obtained using the multi-pass 24 h recall method, which was used to calculate the dietary diversity scores. Household Dietary Diversity Score (HDDS) (a proxy indicator of household economic access to food) and the Minimum Dietary Diversity for Women of Reproductive Age (MDD-W) (an indicator of risk of micronutrient deficiency) were measured.

CVCHs constituted about 80 percent of the 572 households that

participated in the study. Most of the households consumed monotonous staple based diets mainly from roots and tubers, cereals, and legumes. The result of the household dietary diversity indicated that most households primarily consumed their food from the roots and tubers, oil and fats, spices and condiments, cereals, and vegetables group. Other food groups consumed by a large proportion of the households were legumes, nuts, and seeds, followed by meat and fish, while eggs, milk, and fruits were consumed the least. Fruits were hardly consumed. There was no significant difference in HDDS (6.70 ± 1.37 and 6.77 1.12p = 0.12) and MDD-W (4.78 ± 1.12 and 4.95 ± 1.16; p = 0.09) for CVCH and non-CVCH, respectively. About one-third of all women did not achieve the MDD-W score required for micronutrient adequacy, with the main dietary gap being vitamin A-rich fruits and vegetables. The findings suggest that there was no influence of households' involvement in cassava value chain activities on their pattern of food consumption and dietary diversity.

Conversion of relatively cheap and highly perishable cassava root into value-added products that have higher value and export potential will directly improve its economic value and, thus, contribute to the achievement of SDG 1.

### 3.5.3 Sweet potato

Sweet potato (*Ipomoea batatas*) is the eighth most important food crop in developing countries, which can provide nutrition, besides energy. It has advantages of high yield, hardiness, low demands on soil nutrients and cultivation input, storability, and versatility for use in processing. It is among the world's most important, versatile, and under-exploited food crops. Orange-Fleshed Sweet





Potato (OFSP) (Plate 5) is an improved sweet potato cultivar with enhanced micronutrient status through plant breeding. It is rich in β-carotene (pro-vitamin A carotenoid) ranging from 30 to 100 ppm in contrast to 2 ppm in local varieties (Meenakshi *et al*., 2010) It has considerable potential to contribute significantly to the intake of vitamin A (retinol) which is normally obtained from food of animal origin (Aworh, 2015). Thus, it can serve a food–based approach to tackle the problem of vitamin A deficiency (VAD) and hidden hunger, a major public health concern of the poor populace, especially in developing countries such as Nigeria (Low *et al*., 2001; Maziya-Dixon *et al*., 2006).

#### 3.5.3.1 Promotion of orange-fleshed sweet potato

A multi-disciplinary and multi-institutional research team with members from LAUTECH, Federal Polytechnic, Offa and Institute of Agricultural Research and Training (IAR&T), Ibadan executed a project to promote OFSP. The project was on 'Promotion and Adoption of Orange-Fleshed Sweet Potato as Crop and Food in Oyo and Kwara States: Ogbomoso and Offa zones' to use OFSP as a test-crop to improve the level of vitamin A intake through its adoption, acceptability and consumption.

OFSP tuber is easily subjected to several forms of post harvest spoilage. The high rate of perishability is also one of the challenges that limit its use and consumption. It becomes imperative to look for strategies of value addition to the tubers immediately after harvest to prevent post-harvest losses. Maziya-Dixon *et al*. (2004) identified value-added products that are considered widely accepted among the populace in all settings of developing countries such as Nigeria to include bread, biscuit, and pasta.

In order to address the problem of post-harvest spoilage, and also contribute to reducing the prevalence of vitamin A deficiency and malnutrition in sub-Saharan Africa, I and my research team tried to diversify utilization options of OFSP tuber as food. Fresh tuber was processed to fried chips and flour (shelf-stable). Composite blends of 70:30; 77.50:22.50; 85:15; and 100:0 from wheat and OFSP, respectively, were obtained with Design Expert software using Simplex Lattice Design. Range of products (chin chin, bread, and biscuit) were developed from the flour blends from two varieties (Mother's Delight and King J). Simplex Lattice Design was also used to optimize OFSP and cassava starch in the production of the flour mix to produce dough ('amala') with enhanced beta-carotene content.

Plate 5: Pictorial view of OFSP

(a) (b) (c) (d)

Plate 6: (a) Fried chips, (b) Chinchin, and (c) Bread made from composite flour of OFSP and wheat flour; (d) Amala made from admixture of OFSP flour and cassava starch





Acceptable chips, chin chin (87.5% of wheat flour and 12.5% of OFSP flour), bread, and biscuit (79.75:20.25) of good sensory qualities were produced from composite of wheat and OFSP flour (Plate 6). Out of the two OFSP cultivars that were used for product development, bread and biscuit that were produced from King Jay cultivar had higher protein, beta-carotene, and energy contents than those produced from Mother's delight (Akinwande *et al.*, 2020). Reconstituted dough ('amala') with good sensory ratings for appearance, mouldability, and overall acceptability was also produced from admixture of unfermented OFSP flour and cassava starch (Adedeji and Akinwande, 2019). Beta-carotene was observed to be retained in the products, with the potential to curb the incidence of vitamin A deficiency among vulnerable groups.

Consumption of these products needs to be encouraged to enhance nutrition for young children and other vulnerable groups, thereby reducing the prevalent VAD and malnutrition at a relatively low cost. The products will also be good sources of dietary fibre, which has gained much importance as a means to reduce the incidences of certain degenerative diseases. Consumption of the products will create opportunities for supply and demand for the new food products in the household and market sales. It will also make it possible for farmers to process the perishable product to a shelf-stable flour that would reduce post–harvest losses and make regular consumption of the functional food possible, towards contributing to achievement of SDGs 1, 2, and 3.

### 3.5.4 Bananas

Bananas (*Musa spp*), including dessert banana, plantain, and

cooking banana, are extremely important in developing countries due to their ease of cultivation and lower cost of production compared to other food crops. They provide food security and income for small-scale farmers who are the major producers. Nigeria is one of the largest plantain producing countries in the world and occupies the fifth position in 2019 (FAOSTAT 2021), with most production from the South and Central regions of the country. They are widely consumed by the entire population across the multi-ethnic groups, irrespective of locations and socio–economic status due to their ease of preparation and consumption. They are considered for special diets where ease of digestibility, low fat, minerals, and vitamins are essential (Fahrasmane *et al.*, 2014). Their several health benefits have also been reported. Their importance as food crops indicate that they have enormous potentials to aid food security.

Dessert bananas are usually soft, sweet and eaten raw. Plantains are usually cooked or processed before being eaten because they contain more starch and less sugar than dessert bananas. Cooking bananas may be eaten raw, but are not as sweet and flavourful as dessert bananas, so are usually processed like plantain. Improved cultivars of cooking banana were bred and introduced to enhance food security, income and well-being of farmers. Cooking bananas have been established to have rare qualities including being a climate-smart crop that survives where banana and plantain cannot. However, farmers were initially reluctant to accept it due to lack of information on utilization options and poor market value. Their products (fried chips, dry chips/flour) are not valued much and do not have the same economic power as those made from plantain.





3.5.4.1 Properties and utilization of improved cultivars of plantain and cooking banana

With the interest of enhancing the utilisation of improved cultivars of plantain ('Dominico Rojo' and 75.195) and cooking banana ('bluggoe', 'maduranga' and 'ngerm'), we produced fried chips and flour from the cultivars and compared them with those made from popular 'agbagba' variety. Flour from cooking banana varieties ('maduranga' and 'ngerm') have higher peak viscosity, holding strength, and pasting temperature than those from plantain cultivars (Babalola *et al.*, 2009). This indicates that they could withstand the processing conditions to which plantain cultivars are subjected to. Low peak and final viscosity values were obtained in 'bluggoe' which suggests that it could be used as a carbohydrate base in weaning food formulations. The cooking banana cultivars also compared with plantains in all the sensory attributes that were evaluated in fried chips, except the colour. Cooking banana cultivars could, thus, be as suitable as plantain for fried chip production if the colour is modified. Value addition to the improved plantain and cooking banana cultivars could create an avenue for wealth creation among rural dwellers. The exploitation of their industrial potentials is also advised to enable their acceptance into the farming system.

3.5.4.2 Assessment of quality of plantain chips dried with solar tent dryer

Mature unripe plantain is processed into chips by local processors using open sun-drying to extend shelf life, but the critical control points that affect product quality and safety are not controlled. Drying of food materials by open sun-drying is cheap but it is prone

to contaminations with grits, dirt, dust, flies, insect parts, urine, faecal material, rodent infestation, and microbial contamination. Improper farming, processing, preservation, and storage can cause food poisoning as a result of food contamination. It becomes very important to ensure food safety through the reduction of hazards in the value chain for improved nutrition and food security, and as well promote economic growth by meeting standards in domestic, regional, and international trade.

Solar tent dryer is an advanced technology of open sun-drying. Solar tent is simple to build and consists of a frame of wooden pole covered by a plastic sheet (Plate 7). It is an evaporative drying process with a greenhouse principle. After being set up in the sun, solar energy passes through polythene and gets trapped inside it which leads to an increase in internal temperature and faster drying rate. This covered structure gives protection against the limitations of open sun drying, which is important in addressing food safety issues.

Mr. Vice-Chancellor Sir, in order to attend to this important national challenge, we thought it right to establish the safety of solar tent and open sun-dried plantain chips through measurement of parameters that are of safety concerns. Four plantain varieties ('agbagba', 'bobby tennap', 'mbiegome', and 'pita 23') were dried with solar tent and open sun (Plate 8). Dried chips, and the commercial ones, were analysed for heavy metals, microbial and mycotoxin properties.

The result indicated lower microbial loads and heavy metal contents in the samples that were dried with solar tent than those





dried with open sun (Adenitan *et al*., 2020a). Faster drying of chips and with reduced final moisture content was observed in solar tent-dried chips. All regulated mycotoxins produced by *Aspergillus, Penicillium* and *Fusarium* in the samples, as stipulated by the Commission of the European Union, were at concentrations that are toxicologically acceptable in many other crops (Adenitan *et al.*, 2020b). The mycotoxin metabolites are lower in the solar tent-dried plantain chips compared to those from the open sun-dried chips and the chips produced by local processors.

Since solar tent dryer can produce chips with lower microbial, heavy metals and mycotoxin content than open sun-drying method, the use of solar tent in drying plantain chips and other agricultural produce is encouraged for the safety of human consumption. There is a need for enlightenment and awareness program on the use of solar tent dryer, that is affordable, for safety measures.

Plate 7: Constructed solar tent dryer

Plate 8: Drying platform of (a) open sun and (b) solar tent

3.5.4.3 Preservation of fresh banana fruit

Post-harvest spoilage of banana as a problem for smallholder farmers cannot be underestimated. To be able to still attend to this problem, we looked into the possibility of extending the shelf life of two banana cultivars (*Musa acuminata* and *Musa sapientus*) using preservation techniques that smallholder farmers can afford. This becomes very important due to lack of standard storage media such as controlled atmospheric storage and modified atmosphere packaging. The three techniques employed were: (i) wrapping of banana fingers with dry banana leaves with





further covering; (ii) wrapping of banana fingers with dry fabric; and (iii) keeping of banana fingers in clay pots that were layered with banana leaves and covered thereafter (Babarinde *et al.*, 2018). The preserved samples were kept on the farmland for 10 days. Control samples were kept on the shelf without wrapping at ambient conditions (28±2°C; 79±3%). It was observed that the samples that were kept under ambient conditions spoilt faster (kept for only 7 days) than others that maintained their qualities till the end of the 10 days that they were preserved. Starch content was retained most in samples wrapped with only leaves, which also had the least moisture content. Starch retention and low moisture content are the indicators of good plantain preservation. Wrapping of banana fingers with a lot of dry leaves is thus advised for preservation at farmstead to prevent post-harvest loss.

3.5.4.4 Product development from over-ripe plantain

Plantain is prone to high rate of perishability, which is a strong factor for quality loss and subsequent post-harvest losses. In order to further reduce the post-harvest losses of plantain, conversion of supposed to be a waste over-ripe plantain, which has very low market and economic value, to a value-added product of industrial potential was considered. We, therefore, made effort to produce jam from over-ripe plantain as a contributory effort to reduce its wastage. Jam was produced from over-ripe plantain pulp and sugar at ratios 50:50, 45:55 and 40:60, respectively, using standard method and stored for two months at ambient conditions to evaluate its shelf stability.

Jam produced from pulp to sugar ratio of 50:50 was most preferred in terms of spread-ability and overall acceptability

(Babarinde *et al.*, 2019). All the products retained vitamins A and C, which were relatively stable during the two-month storage period. Bacterial count in the products at the end of the storage period was within the acceptable limit indicated by the International Commission on Microbiological Specification of Foods. This research was able to establish that over-ripe plantain has a prospect in the production of quality jam to reduce post–harvest losses and ensure food and nutrition security.

Since the high spoilage level of some bananas and their perishability are great challenges for farmers and marketers, the above-indicated strategies for value addition to the crops would go a long way in the prevention of their wastages and post-harvest losses. Small and medium scale industries could look into this potential of over-ripe plantain for a business venture and job creation, and thereby contribute to achievement of SDGs 1 and 2.

## 3.6 Leafy Vegetables

Vegetable crops are grown in many parts of the world and contribute to the nutritive diet of several households and income security. In Nigeria, vegetable production has been going on for ages and provides employment and income for the population, most importantly during the dry season. Traditional leafy vegetables are important components of human diets that provide a variety of nutrients, ascorbic acid, β-carotene, minerals, and dietary fibre (Amin and Cheah, 2003; Ejoh *et al.*, 2019). They have also been reported to be rich sources of health-promoting non–nutrient bioactive phytochemicals (phenols, flavonoids, and antioxidants compounds) (Oboh, 2005), which protect the human body from free radicals that cause degenerative diseases because





of their antioxidant activity.

Traditional vegetables are rich in folic acid, which is present in smaller quantities in cereals and other dietary staple foods in Africa, and are mostly the best and cheapest sources of many essential vitamins and minerals in the diet of the people, especially the rural populace (Aworh, 2015; 2018). Inclusion of the leafy vegetables in African traditional diets reduce the risk of several diet-related non-communicable diseases such as obesity, diabetes, hypertension and cardiovascular diseases. They are, thus, vital for food security and wellness in Africa due to their availability and affordability, great nutritional value, chemotherapeutic and health promoting properties, and other unique qualities (Aworh, 2018).

### 3.6.1 Determination of ideal harvesting time, mineral profile, and effect of processing methods

Leafy vegetables with their substantial contribution of several nutrients are usually in short supply in daily diets. With the view to enhance the consumption of indigenous vegetables, especially those with medicinal values, we investigated the appropriate time to harvest *Sesamum radiatum*, (locally called "ekuku gogoro" in Yoruba language). The vegetable is an indigenous and neglected vegetable that is a good source of total phenolic and mineral contents with multiple uses. Harvesting was randomly done weekly from the 4$^{th}$ week after planting till when the plant became very thin at the 10$^{th}$ week. Total phenol, mineral contents, and antioxidant activities of the leaves increased with the age of the plant during the initial period. The highest values were obtained in the leaves at 7 weeks after planting (Oduntan *et al*., 2011). The

obtained information could guide the farmers on the appropriate time to harvest the plant for good nutrition and also use the same plot of land for the planting of other crops.

To further promote the consumption of indigenous and underutilised vegetables, we ventured to determine the mineral profile of eight wild-grown vegetables from Southwest Nigeria. This was done to establish their nutritional potentials in ensuring adequate nutrition and food security, and thereby promote them for consumption. The samples were subjected to simultaneous multi-mineral contents by inductively coupled plasma-atomic emission spectroscopy. Potassium that is desirable, especially in old age, is the most abundant mineral present in *Senecio biafrae* ('worowo') (an underutilised vegetable) (Babalola and Akinwande, 2013). The result of the mineral profile of the vegetables provides useful information that could sensitise the people on the need for their consumption. This can be a good opportunity to enhance the micronutrient supply of the diet of low-income earners which form the majority of the society. Findings from this study indicated that the indigenous vegetables that are not formally cultivated could be important in improving the micronutrient deficiency of low-income earners.

We also studied the effects of different processing methods on the chemical constituents of the leaves of chaya (*Cnidoscolus chayamansa*), an edible tropical shrub that is neglected. Freshly harvested leaves were subjected to different traditional processing methods (blanching with hot water and steam, and squeeze–washing with and without salt) before being subjected to further chemical and sensory analyses. Blanching of the vegetable in hot





water completely removed the cyanide in the vegetable. The soup prepared from it was best rated for sensory qualities (Akinwande *et al.*, 2014c). This suggests the suitability of blanching as a pre–treatment in the preparation of this vegetable.

Some indigenous vegetables are advised to be harvested at about seven weeks after planting for optimum nutrient and bioactive contents. Indigenous vegetables that are not formally cultivated need to be considered as being important in improving the micronutrient deficiency of low-income earners. The information obtained indicates the potentials of the local vegetable as a good promissory commodity in the human diet in Nigeria. The inclusion of more vegetables as part of a daily diet would likely increase their production capacity, access as food, and reduce the risk of some chronic diseases since they provide nutrients that are vital for health and body maintenance towards attainment of SDGs 1, 2, and 3.

### 3.7 Spices

Spices are aromatic plants or parts of plants, e.g. roots, seeds, fruit, or other plant substances, in various forms (native, dried, ground, whole). They are very important as food and as medicine and are used primarily for their flavour, colour, or preservative effects, rather than for any nutritional benefit. Survey and available literature indicate that spices and herbs play a significant role against viral infections (Namita *et al.*, 2021). They have been used for centuries by many cultures to enhance the flavour and aroma of foods. Examples of spices from which flavouring is made include black pepper, chilli pepper, cinnamon, garlic, ginger, onion, nutmeg, clove, etc. Certain spices and essential oils prolong the

storage life of foods by their antimicrobial activity. Based on the quantity that is used for culinary purposes, it can be indicated that spices are extremely cheap, especially concerning their medicinal and health benefits.

Spices play an important economic role in agriculture. In Nigeria , some spices (onions, garlic, and *Piper guineensis*) are most important economically, some (garlic, *Cymbopogon citratus*, *Piper guineensis*) are most important medicinally, while others (onion, *Parkia biglobosa*, garlic and ginger) are most important nutritionally (Adebayo *et al.*, 2011).

### 3.7.1 Onion and garlic: Mineral profile and other components

Onion (*Allium cepa* L.) bulb and garlic (*Allium sativum* L.) clove have been cultivated since antiquity as vegetable and flavouring agents due to their characteristic pungent flavour. They are used by diverse cultural groups for the treatment of parasitic, fungal, bacterial, and viral infections, with investigations suggesting sulphur compounds as the main active antimicrobial agents (Rose *et al*., 2005). Garlic and onions promote the bio-accessibility of iron and zinc from food grains (Gautam *et al.*, 2010). Garlic is among the most used vegetables for the treatment of Type II diabetes mellitus in diabetic women groups from the United States (Johnson *et al.*, 2006).

To guide consumers in the choice between the two to be used more often for culinary purposes, Akinwande and Olatunde (2014) compared the mineral profile and selected properties of three cultivars of onion and garlic. This was done through the





determination of their multi-elements (i.e., the content of minerals) with inductively coupled plasma-optical emission spectroscopy (ICP-AES) to establish their potentials in ensuring adequate nutrition and food security.

All the *Allium* spp have potassium in abundance with a very low content of sodium. Garlic was discovered to have the highest amount of phosphorus and zinc. It also had higher contents of pyruvic acid (which is an indicator of pungency), ash, and total soluble solids than onion cultivars. However, the onion cultivar (red creole) with the least content of pyruvic acid and the highest content of TSS would be preferred for culinary purposes. A smaller quantity of garlic could conveniently be used to flavour foods to obtain the similar nutritional benefit of some components that are obtained when a higher quantity of onion is used. This is important since the current consumers' tendency is towards foods with beneficial attributes for health and good organoleptic characteristics. Regular inclusion of *Allium* spp in meals, especially in powdery form can also be a good opportunity to enhance the micronutrient supply of the diet of low-income earners, which form the majority of the society.

Information from this research suggests that both onion and garlic could be consumed generously in the diet, especially when in season as a result of their nutritional and health benefits. Scientific research studies support the fact that onions and garlic are worthy of being eaten every day to provide optimum health benefits.

### 3.7.2 Ginger: Industrial potential

Ginger (*Zingiber officinale* Roscoe), 'atale' in Yoruba, is one of the

oldest and widely spices used worldwide. It is used for its peppery taste, preservative power, and typical aroma, and has lots of medical benefits. It contains antioxidants including phenolic compounds, terpenes, polysaccharides, lipids, organic acids, and raw fibres. Its health benefits are attributed to its phenolic compounds, such as gingerols and shogaols with multiple biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, cardiovascular protective, respiratory protective, antiobesity, antidiabetic, antinausea, and antiemetic activities (Mao *et al*., 2019).

Ginger is mentioned in the Quran as a drink for pious ones in Paradise as indicated in Qur'an, 76:17, "And they will be given to drink there of a cup mixed with 'Zanjabil' (ginger)". Whole ginger extract is effective against prostate cancer and did not exert any detectable toxicity in normal, rapidly dividing tissues such as gut and bone marrow (Karna *et al.*, 2011). In pregnancy, ginger improves symptoms of nausea with a daily dosage of <1.5 g, which neither poses a significant risk for spontaneous abortion nor side-effects of drowsiness or heartburn (Viljoen *et al.*, 2014). It is safe and well-tolerated, and decreases the severity of postoperative nausea and vomiting, and may serve as an alternative to antiemetic medications (Tóth *et al.*, 2018). However, high doses increase bleeding risk and stomach acid production specifically if taken with other herbs or medicine that have the same effect (Cassileth and Deng, 2004). Ginger supplementation can, thus, have additive or competitive interactions with some medicines.

Mr. Vice-Chancellor Sir, we thought it wise to study the potential of





the industrial application of ginger as a flavouring agent in food processing. Previous efforts to produce nutrient-dense foods by supplementation of cereals and root and tuber flour with soybean indicated products with residual beany flavour. Acceptance and purchase of soy-containing biscuits will be greatly influenced by whether or not the biscuit is similar to non-soy products. The research team looked into the potential of ginger flour to flavour cassava flour supplemented with full-fat soybean flour to produce high protein biscuit. It was observed that ginger powder as a flavouring agent effectively masked the beany flavour that is normally associated with soybean products when compared with the control (Akinwande *et al.*, 2008c). The aroma of biscuit made from 40% substituted cassava flour with full fat soy-flour was preferred to the one that was made from 100% wheat flour while the taste of the biscuit from the same flour was similar to that of 100% cassava flour. This indicates the endless possibilities of protein enrichment of cassava flour with legumes for the production of biscuits as a potentially effective strategy for enhancing protein-energy balance in children.

Our research effort in an earlier study also established the use of ginger as a preservative in food product. Ginger, in combination with garlic and nutmeg, was confirmed to be effective as a preservative when added to mushroom spice-mix powder as a ready-to-cook soup (Akinwande *et al*., 2007a). Stored powdered soup that was packed in both plastic and glass bottles recorded a decrease in microbial contamination, especially those with a combination of garlic.

We also explored the possible use of ginger for the production of

beverages to enable its consumption at the household level. Ginger juice was produced and packed in commonly available polyethylene terephthalate (PET) bottles, preserved with three preservatives separately, and stored for 12 weeks at ambient conditions. Potentials of three different preservatives, i.e., picolinic acid, potassium sorbate, and sodium benzoate at concentrations of 0.07, 0.067, and 0.073%, respectively, were evaluated. Picolinic acid is a naturally occurring degradation product of L-tryptophan detected in the human body (Dazzi *et al.*, 2001). Total phenolic content and total flavonoids were best retained in ginger juice with picolinic acid when compared to the others but the proliferation of mould growth was best controlled by sodium benzoate (Akinwande *et al*., 2012). Depending on the period of storage, picolinic acid could be used in preference to the other two preservatives due to its ability to preserve bioactive substances as well as its health and medicinal advantages over others.

The addition of spices to the diet can be of benefit for healthy living. Their use as flavouring and preservative agents could be further explored as additives in food product developments, which could lead to increase in their cultivation and utilisation towards achievement of SDGs 1 and 3.

## 4 COMMUNITY OUTREACH PROGRAMMES: RESEARCH AS INSTRUMENT OF 'TOWN AND GOWN'

Mr. Vice-Chancellor sir, I would like to give examples of the community outreach programmes that this university has been involved in. The mission statement of Universities, in general, is teaching (formal and informal), research (significant aspect for promotion) and services (administrative responsibilities within and





outside the university system) (Adeyemi, 2020). Informal education is accomplished through the creation of awareness through workshops, seminars teachings in public places, market research, etc., in various disciplines and can be linked with community outreach.

Community outreach is the activity of offering education, social planning, and support of activities and services to any population that might not have had access to them. It involves meeting people in need of an outreach service at the location where they are. It is an opportunity to connect the academic institution with the public through the dissemination of research findings. This synergetic relationship is vital in the spirit of 'Town and Gown', which enables the university to be a functional part of the community, where they are located through such participatory activities (Adeyemi, 2018b). However, it is important to note that community outreach activities are very financially demanding and can only be executed with a funded project.

With the view to contributing to the attainment of SDGs 1, 2, and 3 (directly and indirectly), I made several efforts towards reducing poverty through empowerment programmes, reduction of hunger through enlightenment programmes on processing options of locally available and cheap food crops, and improved health through consumption of sustainable nutrient-dense and functional foods from locally available crops. All these were done in collaboration with extension agents of Oyo and Kwara State Agricultural and Development Programme for extension services. Findings from different research projects were disseminated to different communities. Hands-on-training programmes on food

processing were also executed to create health and wealth initiatives among selected groups in communities.

### 4.1 Training on Value Addition to Indigenous Hard-to-Cook Legumes

I and my several research team members (Drs. G.O. Babarinde, V.F. Abioye, J.A. Adejuyitan, M.A. Ojo and Professor M.O. Oke) of the defunct Food Science and Engineering Department employed a two-level training programmes. The first training was done at 'Onilaaru' village and environs in Orire local government to provide information on alternatives to the usual cooking method of hard–to-cook indigenous legumes. This was to rekindle the interest in cultivation and consumption of the crops as was done in the time past. Practical training on the processing of products like ready-to–eat breakfast cereal, 'akara' and 'moinmoin' from wet-milled Bambara groundnut was demonstrated (Plate 9). The project was funded with the first University Senate grant in 2013.

The second training was done to demonstrate the procedure for the formulation of intermediate flour recipe from hard-to-cook legumes and its use after reconstitution with water for 'akara' and 'moinmoin' preparation (Plate 10). The project was funded by Tertiary Education Trust Fund, Nigeria in 2015. A recipe book was developed which covers a range of all developed products from indigenous legumes. This was to make it possible for users to process for diversified products. Copies of the recipe book were distributed freely to all participants at the training venue. Enlightenment programme on values, benefits, and procedures for reducing the associated drudgery of hard-to-cook legumes was done on a radio station in Ogbomoso (Parrot FM) on the





programme "Ise opolo" in 'Yoruba' language. Distribution of the recipe book also continued at the department where the members of the public came to collect.

Plate 9: Hands-on training on the processing of breakfast cereal, 'akara', and 'moinmoin'

Plate 10: Training on the processing of 'akara' and 'moinmoin' from shelf-stable intermediate flour from indigenous legumes

### 4.2 Promotion and Adoption of Orange-Fleshed Sweet Potato as Crop and Food

Our multi-discipline and multi-institutional research team on "Promotion and adoption of orange-fleshed sweet potato as crop and food in Oyo and Kwara States" created awareness on the potentials of OFSP as a means of enhancing the livelihood and nutrition of the masses. The project was supported by the West Africa Agricultural Productivity Program (WAAPP-Nigeria) Competitive Agricultural Research Grant Scheme under the Agricultural Research Council of Nigeria with funding by the World Bank in 2013. This community service was offered by a research team in the Departments of Food Science (Professors B.A. Akinwande and B.I.O. Ade-Omowaye), Crop and Environmental Protection (Professor T.I. Olabiyi), and Rural Extension and Rural Development (Professor R.G. Adeola).

As a means of introducing the crop, OFSP vines were distributed among farmers for planting, while vines and tubers were distributed among people in local markets to encourage planting and consumption in six local government areas in Ogbomoso and Offa zones (Ogbomoso North, Ogbomoso South, Ogo Oluwa, Orire, Surulere, and Offa). Training on value addition, especially conversion of the highly perishable crop to a shelf-stable flour, as a postharvest loss prevention strategy of OFSP, and production of acceptable products (fried chips and chin chin) was carried out (Plate 11).

The importance of eating OFSP tuber was discussed and procedures for the production of chinchin and chips were demonstrated to encourage its utilisation. Creation of awareness





through jingle and drama in three radio stations in Oyo State [Amuludun FM (Radio Nigeria) and Parrot FM] and Kwara State (Harmony FM) on possible health benefits of eating OFSP was done for several weeks.

Plate 11: Training on utilisation options for OFSP at the different local governments





### 4.3 Lessons Learned on the Importance of Community Outreach Engagements

Mr. Vice-Chancellor Sir, I will like to share some of my experience in community outreach engagements. It is very important to start any research that seeks to address societal problems with the communities that the intervention is meant for. Community outreach enables a better understanding of communities' needs and aspirations. Farmers and other rural people use innovation groups to express their interests and guide activities that are intended to benefit them. Since donors regard innovation platforms as a way to improve the targeting and effectiveness of development interventions, the inclusion of community outreach activities in the WAAPP proposal that my team submitted was a strong factor for the success. Non-inclusion of the rural people at the inception of some projects might have been a factor why most failed.

The outreach programmes developed and enhanced academic skills, leadership qualities, self-confidence, communication skills, managerial skills, and responsibilities of the team members towards the rural community. Information obtained in the process of interaction opened up other research concepts that can be channeled to the need of the people in the local settings. It provided an opportunity to introduce new and simple technologies for easy uptake, especially when explanations are made directly by those that developed them. However, follow-up on monitoring and evaluation is very important but this can only be achieved with continuous funding of research activities.

It is very important for all researchers, most importantly those that

have the intention of solving societal problems, to collaborate with agricultural extension professionals to gain access to the communities and for effective communication with the people. The extension agents can explain the process in a clear local language and are knowledgeable in developing appropriate strategies. They are in the best position to extend the research findings of the scientists in other disciplines.

All the various activities we executed as community outreach programmes demonstrated the relevance of this university in the community, thus fulfilling the essence of 'Town and Gown'. Our research findings have been confirmed to be relevant to the society and with direct impact on the livelihood of the populace towards the achievement of SDGs 1, 2, and 3.

## 5 QUALITY ASSURANCE IN HIGHER EDUCATION INSTITUTIONS: CONTRIBUTION TO QUALITY EDUCATION

In the recent times, higher education systems in Africa are characterised by dynamic changes that relate in particular to an increasing demand for education services and increasing student enrolment rates. These developments constitute major challenges for maintaining quality standards in higher education. Among the new and rapidly changing challenges are globalisation, technological development, social and political transformation, the concepts of lifelong learning and of a knowledge-based society (Bernhard, 2014). There are many reasons why institutions should do more than what policy makers expect them to do with regard to quality assurance. It, thus becomes very important to build up national capacities in the field of quality





assurance to facilitate the comparability of student performance and degrees and promote the mobility of students and academics between different countries. Teachers, school leaders, educators and trainers play a vital role in the collective responsibility of preparing future generations. Consequently, greater support and resources are needed for relevant initial and continuous professional development.

### 5.1 Training on Internal Quality Assurance

Mr. Vice-Chancellor Sir, I will like to use this opportunity to establish the importance of any sitting Vice-Chancellor supporting applications of members of staff for training and personal development. I came across the 'Call for application' on Training on Internal Quality Assurance (TrainIQA) in Anglophone West Africa while defending WAAPP grant in 2013 in Abuja. The training was part of the DIES programme (Dialogue on Innovative Higher Education Strategies) that was meant for 30 institutions between 2014 to 2016. One core condition for the application was institutional support. I discussed this with the immediate past Vice-Chancellor (Professor A.S. Gbadegesin) who pledged the required support. While some institutions were invited, I made it on behalf of LAUTECH through rigorous competition.

The training on Internal Quality Assurance (IQA) was sponsored by DAAD (German Academic Exchange Service) and was facilitated by experts on Internal Quality Assurance in Higher Education Institutions. All of us that participated were certified as Quality Assurance Experts and were the pioneer members of West African Anglophone Quality Assurance Network (WAAQAN) (www.waqan.net). Immediate benefit for the University was the

development of the blueprint for the establishment and implementation of Internal Quality Assurance, the outcome of which were development of policy on LAUTECH IQA (Plate 12) and the establishment of LAUTECH Quality Assurance Unit. I subsequently became the pioneer Director of the University Quality Assurance Unit from 2015–2019.

As an Expert on Quality Assurance in Higher Education Institutions, I was part of the team that won DAAD grant for DIES National Multiplication Trainings (NMT) 2019–2020 Programme (Nigeria cohort). The training was tagged 'National Multiplication Training on Internal Quality Assurance and Curriculum Development for Anglophone West Africa Higher Education Institutions'. Twenty participants (both academic and non-teaching university staff) were trained and LAUTECH was the host of the second workshop in 2020. As a follow-up to this, I was co-opted as a 'Project Consultant' to participate in the workshop of TrainIQA course in the Southern African Development Community (SADC) region. TrainIQA SADC-QA 2020–2021 project is facilitated by the Centre for Quality Development, University of Potsdam, Germany and supported by DIES.

### 5.2 Contribution to Professional Developments of Staff and Students

I have made several efforts to contribute to the professional development of different categories of people. The first was facilitation of graduate placements at IITA, Ibadan for quality research. Three (3) academic staff (Professor M.O. Oke, Drs. S.A. Olaniyan and V.F. Abioye) in the defunct Food Science and Engineering Department were trained as Graduate Scholars for





PhD between 2005 and 2014. Seven graduate students (6 MSc and 1 PhD) have also enjoyed training as Graduate Scholars from 2014 till date. Still on quality training, four post graduate students enjoyed funding of their research activities between 2014 and 2016 while 13 undergraduate students also enjoyed funding of their research activities between 2013 and 2014 from different research grants that I and my team members were able to secure. This effort made it possible for all the concerned people to have quality research towards quality education, which is SDG 4.

My contributions in this area were done to increase the pool of quality assurance experts on Internal Quality Assurance and also enhance quality research of post graduate students in Higher Education Institutions towards the achievement of 'Quality Education' (SDG 4).

## 6 COMBATING VIRAL INFECTIONS LIKE COVID-19: POTENTIALS/PROSPECTS OF INDIGENOUS CROPS

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first discovered in Wuhan city, China in December, 2019, and within three months spread throughout the globe (Leone and Ahmad, 2020). The deadly virus attained the status of a global pandemic on 11th of March, 2020 as declared by the World Health Organization. It is no longer news that the COVID-19 pandemic has spread and affected several continents including Africa in a variety of ways. It was envisaged that the African continent, being the poorest of all the continents in the world with the most vulnerable populations to infectious diseases, would be substantially affected by the COVID-19 outbreak Leone

and Ahmad, 2020). Apparently, this prediction would appear to be wrong as the African continent has been the least affected in terms of mortality rates (Dongarwar and Salihu, 2020). Europe recorded the highest mortality rates, followed by North America, while Africa remain the least affected continent (Fig. 3). Although there seems to be an upsurge in recent time, Lone and Ahmad (2020) indicated that the magnitude of the impact will depend on the management and control of COVID-19 within the respective African countries.


Plate 12: Cover page of LAUTECH IQA policy

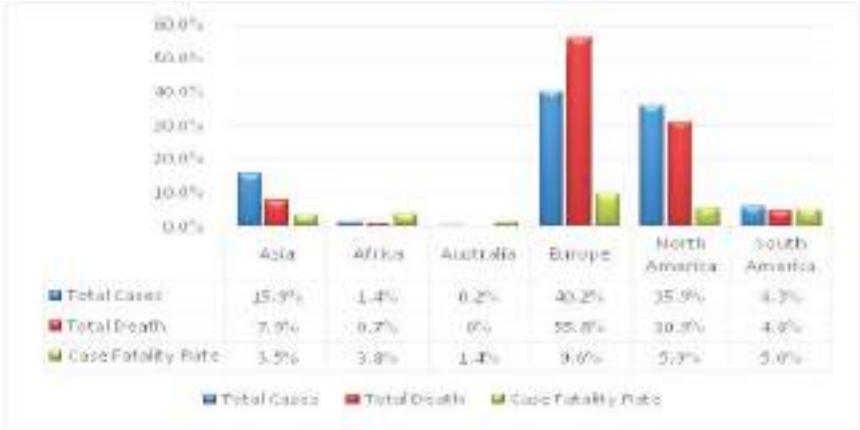


Fig. 3: Covid-19 cases, deaths, and case fatality rate by continents
Source: Dongarwar and Salihu (2020)





The immediate global intervention to curb the spread of the virus seem a great deal of effort and the lockdown strategies also played significant role in reducing the spread of this terrible disease. Complementing this approach is the use of herbal medicines, with immunomodulatory effects, which are known to contain some certain active compounds that have antimicrobial, antiviral, or anti-inflammatory activities and which have been shown to possess healing properties for patients with COVID-19 infection (Sharma *et al*., 2009; Zhang and Liu, 2020). Indigenous medicinal plants and spices like *Allium sativum* (garlic), *Tinospora cordifolia* (giloy) ('epa ikun'), *Ocimum basilicum* (tulsi) ('efirin'), clove ('kanafuru'), cinnamon, ginger, black pepper, turmeric, among others, have been established as immune boosters with antiviral properties (Sharma *et al*., 2017; Shrivastava, 2020; Srivastava *et al.*, 2020).

Mr. Vice Chancellor Sir, while these moves are timely and have been largely successful, it is important to emphasize the role of good nutrition in boosting the immune system. Also important is the consumption of certain foods that contain natural sources of phytochemicals and some active compounds that possess antiviral agents like those plants referred to above, which could reduce the susceptibility of the individuals to the virus. The fortunate experience of the African continent, as shown by low mortality rate (Fig. 3), may not be unconnected with the relatively better immunity to the virus due to the consumption of traditional and indigenous foods, which are relatively higher in some of the antiviral active compounds, especially in raw or in minimally processed forms.

Developed nations of the world, especially Europe and America, eat a lot of processed foods compared to African countries like Nigeria. It has been suggested that optimal nutrition, in addition to consumption of relatively higher antiviral active compounds, is vital to ensuring the physical and psychological health during the current pandemic (Malek *et at.*, 2021). This is because an optimal immune response depends largely on the intake of a balanced diet that is nutrient-dense, and which can keep infection away. The consumption of foods high in protein and micronutrients such as vitamin A and zinc, and some phytochemicals are important for optimal antibody production and to decrease infection risk (Iddir *et at.,* 2020).

The role of several traditional crops, such as okra, mushroom, OFSP, and the spices (onion, garlic and ginger), which are some of the crops that I have used in my research activities in the last 2 decades, cannot be overemphasized. For example, okra contains certain bioactive polysaccharides (Wang *et al.,* 2020) with strong radical-scavenging ability and high antioxidant activities (Petropoulos *et al.,* 2018). It is equally an excellent source of minerals such as magnesium, manganese and potassium (Table 3) and also contains appreciable amounts of bioactive components, such as flavonoids, especially quercetin and phytosterols (Bawa and Badrie 2016). The content of vitamin K, vitamin C, folate, $B_1$, $B_6$, and zinc in okra may hold some promise for the treatment of COVID-19 (Zabetakis *et al*., 2020). The high protein content of mushroom and their antiviral, antimicrobial, antioxidative, and immunomodulatory agents has been linked with the presence of bioactive compounds such as polysaccharides, phenolic compounds, terpenes and terpenoids, phenols, peptides and





proteins (Sanchez, 2017; Xu *et al*., 2011). These bioactive components, many of which possess anti-inflammatory, antithrombotic, and antioxidant properties may prevent or attenuate the inflammatory and vascular manifestations associated with COVID-19 (Zabetakis *et al.*, 2020).

Garlic is well-known to contain one of the most efficient natural antibiotics against the wide spectrum of viruses and bacteria (Khubber *et al*., 2020). It is rich in sulphur-containing phytochemicals with the most important ones being garlic thiosulfinates (allicin), S-allyl cysteine sulfoxide (alliin), ajoenes (E–and Z-ajoene), vinyldithiins (2-vinyl-(4H) -1,3-dithiin, 3-vinyl–(4H)-1,2-dithiin), and diallyl (di and tri) sulfide (Khubber *et al.*, 2020).

Another notable crop of interest that my research group worked on and that I am advocating for as a diet to boost our immunity during this pandemic and thereafter is orange-fleshed sweet potato. This crop is particularly rich in a number of nutrients including bioactive components such as carotenoids, phenolic acids, and antioxidants that do not only play a role in vitamin A deficiency (VAD) management (Kuyu *et al*., 2018; Neela and Fanta, 2019), but is also known to boost the immune system (Neela and Fanta, 2019; Olagunju *et al.*, 2020). While all these crops listed above have shown promising potentials to boost the human immune system and may partly explain the very low mortality rate as mentioned earlier, it would be necessary to carry out future studies using empirical data to further establish the undeniable role of these traditional and indigenous crops in combating COVID-19. Therefore, one of the imports of my

research findings and this lecture is a wake-up call to all relevant stakeholders to initiate and fund multidisciplinary research into the potentials of Nigeria's food systems in combating COVID-19 pandemic and similar viral infections using traditional, conventional and lesser-known food crops.

This lecture serves as a wake-up call to all including academics, researchers, students, government, and other stakeholders for the need to do more research using these traditional crops.

## 7 CONCLUSION

Mr. Vice-Chancellor Sir, distinguished guests, ladies and gentlemen, malnutrition, hunger, poor health, and starvation still rank high as some of the world's greatest challenges. Due to the fact that the majority of the world's hungry people live in developing countries, it is very important that we reorient our palates and embrace all available sources of nutritious food and maximise their use. Underutilised traditional foods can contribute to the mix of affordable and nutrient-dense food options. In order to meet the global food demands, the focus should be on promoting the cultivation and utilisation of other crops that have been neglected and underexploited but have the potential to enhance food and nutrition security, and also boost immunity, especially in developing countries like Nigeria. Due to their resilience to drought, poor soil, and weather conditions, underutilised crops may also help to stem the decline in food crop production, caused by climate change. Some of these crops can withstand the harsh environmental changes currently taking place. They can also perform well in traditional production systems with little or no external inputs.





There is a need to draw attention to traditional foods that are almost forgotten in preference to westernised diets. One of the main areas that need attention, if our traditional food system will assure food security, is encouragement in the consumption of diversified diets. Cheap foods that are overlooked are actually what are needed to be consumed for good nutrition and healthy wellbeing. Consumption of cheap, available, and affordable health–promoting functional foods like *D. dumetorum*, unsieved ogi from cereals, okra pod, sweet potato, especially OFSP, vegetables, all varieties of legumes, mushroom, and spices has great potentials in ensuring a healthier population. Consistency in the consumption of cheap and healthy foods is a panacea to the ravaging food insecurity. Availability of health-promoting locally available and cheap functional foods in the diet has the potential to help ensure a healthier population. However, as a note of caution, excess of everything is bad, if certain foods like spices, could be taken for health benefits to remedy illness, such should be taken with moderation.

Since high post-harvest food losses is a major factor of poverty among farmers and food insecurity, value addition to food crops by the rural populace using simple techniques will reduce food loss and wastages. It will also improve access to sustainable livelihoods, entrepreneurial opportunities and productive resources, promote food security, and contribute to economic growth. The use of simple techniques that could be adaptable to developing technology is equally important in extending the shelf life of fresh produce in developing countries, where access to sophisticated equipment is not possible by low-income earners. Development of innovative and locally adaptable health-friendly food products for

the purpose of diet diversification from indigenous staple foods with the use of simple technology, with the tendency to lessen the burdensome methods of food preparation, could be adopted at all levels to enable implementation by local stakeholders. Processing of the crops into convenient products will encourage their acceptance by the urban population. It will subsequently lead to wider utilisation of the crops which will directly encourage their cultivation. This will guarantee the availability of, and access to, food through the production of more nutrient-dense foods for both immediate and market-oriented food products.

It has been clearly indicated that indigenous and traditional plant foods have benefits to sustainable foods system, especially in Nigeria. Consumption of such foods and their products could serve as a food-based approach to tackle the problem of vitamin A deficiency (VAD) and hidden hunger, a major public health concern of the poor populace and also possibly reduce the risk of several diet-related non-communicable diseases such as obesity, diabetes, hypertension and cardiovascular diseases.

They have an important role to play in the achievement of the global objectives of the Sustainable Development Goals. They have considerable commercial value that can make a significant contribution to household income and livelihood which relates to SDG 1, which is no poverty. They are also rich in terms of the provision of healthy, nutrient-dense foods, that meet nutritional requirements and promote healthy diets which relates to SDG 2, which is ensuring zero hunger. They have chemotherapeutic and health promoting properties for healthy living which relates to SDG





3, which is good health and wellbeing.
I have been privileged to provide sufficient information that good food for good nutrition and health could cheaply be obtained from sources that abound in our immediate environment. Under–nutrition can be reduced significantly when the traditional Nigerian food system is improved using a combination of strategies including nutrition education on the consumption of diversified diets and product development.

I provided information on our multi-disciplinary and multi–institutional research and collaboration with Oyo and Kwara State Agricultural and Development Programme. I also gave examples of interventions that I and my research teams have made to fulfil the second and the third components (research and services) of the mission statements of universities and for 'Town and Gown'. Our roles as academics in fulfilling the purpose of 'town' and 'gown' as a university community have been demonstrated, especially through informal education of some communities on processing options for hard to cook legumes and orange-fleshed sweet potato. These are means of verifying some examples of the roles that our institution, LAUTECH, plays in contributing towards the achievement of SDG Nos. 1, 2, and 3, especially in Nigeria.

I have been able to chronicle some of my activities to increase the pool of quality assurance experts on Internal Quality Assurance and also enhance quality research of post graduate students in Higher Education Institutions towards the achievement of SDG 4. Quality Assurance in Higher Education Institutions has come to stay in Nigeria towards maintaining quality standards in higher education. All relevant stakeholders are enjoined to rise up to the

responsibilities of providing necessary facilities and perfecting the procedures for its sustainability. Evidence based activities on Internal Quality Assurance in Universities have now been included as one of the tools for programme accreditation by National Universities Commission.

This lecture would have instigated research ideas on nutritional and affordable traditional foods, among others, in eminent researchers and academic scholars that have listened to it for about one hour. The clock is ticking and there is less than 10 years left to achieve the 17 global SDG goals and transform the planet. I will like to enjoin my fellow academics and researchers in different disciplines to strive more in carrying out research activities that will contribute towards the attainment of SDGs. Each department/faculty can make a contribution to achieving any of the 17 SDGs. We have the potentials to make great strides until 2030.

## 8 ACKNOWLEDGEMENTS

Mr. Vice-Chancellor Sir, distinguished guests, getting this far has not been on a platter of gold but with the support of God and those He used for me. First and foremost, I express my profound gratitude to Almighty Allah for His unlimited mercy and favour, Who makes this lecture possible at His own ordained time. I am eternally grateful to my parents, late Alhaji Moshood and Alhaja Bilikis Oyeleye, for the parental love and care and for the educational legacy. I appreciate my father's unique love, among my other siblings, for a reason best known to him. The roles and sacrifices that my mother made at crucial time in my life meant so much to my success. She taught me the virtues of a responsible





wife. I also extend my gratitude to my late parents-in-law, Mr. Jimoh and Mrs. Eunice Akinwande, for accepting me in the first instance and their love.

My immense gratitude to my teachers from basic to tertiary institutions including Aunty Tokunbo Adesoye, Mr. Ajayi, Dr. Ayeleye, and Professor Michael Idowu. Those of prime importance are my mentors and role models, my sources of inspirations, on whose back I ride to get 'doors' opened. They include Professor Charles T. Akanbi, Professor John Olusola Akingbala (my MSc supervisor), Professor Isaac A. Adeyemi (my PhD supervisor, my God-sent 'father' who accepted to supervise my PhD work when I almost lost a golden opportunity of research placement at IITA, Ibadan). Others are my IITA based PhD supervisors, Dr. Robert Asiedu (who initiated my involvement with international scientific world by accepting me as a student) and Dr. Busie Maziya-Dixon (who enabled my timely completion). The two have been my strong supports that facilitate training opportunities for LAUTECH postgraduate students at IITA, Ibadan.

I am mostly indebted to Professor Ogugua C. Aworh, my official African Women in Agricultural Research and Development (AWARD) mentor of inestimable value, who taught me skills of grant winning proposal writing in 2011. My one-hour interaction with him translates to one-year academic training session. I thank Mama Adeyemi, for valuable and timely advice, Mama Akingbala, for treating me like her child, and Mama Aworh, an outstanding role model that I treasure. I am most grateful to Professor Ruth K. Oniang'o for the global profile publicity she did for me in 2015 through African Journal of Food, Agriculture, Nutrition and

Development (AJFAND).
I would like to express my profound appreciation to our former Vice-Chancellor, Professor Adeniyi Sulaiman Gbadegesin. He came in at the most appropriate time of my career journey. His regime provided enabling platform for me to exhibit my academic potentials which started with the university-wide AWARD fellowship sensitization seminar that I organized in 2012. His belief in Internal Quality Assurance made it possible for me to become a Quality Assurance Expert. He appointed me as the Ag. Head of Department and also pronounced my Professorial Chair. I am very thankful to him for believing in me by appointing me as the Pioneer Director of Quality Assurance Unit.

I am immensely grateful to the facilitator of my appointment at LAUTECH, Professor Abdl-Wahab Tijani and Professor A.M. Salau (of blessed memory), our former Vice-Chancellor. I wish to use this opportunity to thank the entire LAUTECH Muslim Community for the support and large turnout at the Quranic recitation as thanksgiving service for my Professorial Chair. I thank all the foundation members of Ithad Jamuhiyat Sheikh Nazeer Ibraheem Niass, from where my spiritual journey began.

I am grateful to the former Deans of Faculty of Engineering and Technology (Profs. J.O. Ojediran, A.A. Adegbola, J.O. Olajide, and K.A. Adebiyi) for their diverse roles in my career life and successful accomplishments. I equally recognise the incumbent Dean (Professor S.O. Jekayinfa) and all Faculty staff. My sincere appreciation to all staff members (serving and retired) of the defunct Food Science and Engineering department. The academic (Profs. I.A. Adeyemi, M.O. Ologunde, J.O. Olajide, E.T. Otunola,





B.I.O. Ade-Omowaye, T.Y. Tunde-Akintunde, O.J. Oyelade, O.O. Fapojuwo, E.O. Akande, M.O. Oke, Drs. H.A. Agboola, E.O. Adelakun, V.F. Abioye, J.A. Adejuyitan, A.O. Abioye, A.S. Ajala, G.O. Ogunlakin, J.A. Adeyanju, S.A. Olaniyan, G.O. Babarinde, I.F. Bolarinwa, S.J. Olatunde and Miss T. Oyadare), technical and administrative staff members have all made a peaceful working environment possible for me. I am grateful to all for rising to support me for the success of this lecture. I also recognise and appreciate NAWACs executives and all the members for finding me worthy to make presentations to the chapter association on some topical issues and their support.

I acknowledge, and with gratitude, all staff members that support the course of Faculty of Food and Consumer Sciences from inception. Worthy of mentioning are Profs. M.O. Ologunde, Dapo Akande, Ezekiel Otunola, Omololu Fapojuwo, and Beatrice Ade–Omowaye, of Food Science programme, and several others from the University community.

I thank our immediate past Vice-Chancellor, Professor M.O. Ologunde, for always believing in me. He made me the LOC Secretary of the 32nd NIFST Conference in 2008 and also facilitated my part-time work at the old WUTSO (Now Wesley University, Ondo) in 2011. I also appreciate his innumerable supports on several occasions when I was the Ag. Head of the defunct Food Science and Engineering Department. I am equally most grateful to him for giving me the privilege to present the 42nd LAUTECH Inaugural Lecture series. I am thankful to Professor T.A. Adebayo, our former Deputy Vice-Chancellor, with whom I worked directly as the pioneer and former Director of Quality Assurance Unit. I

cannot forget all his supports in that capacity.
I recognise, with gratitude, the wonderful, inestimable, intelligent and hard-working seven pioneer faculty members (Profs. A.O. Adeniji, O. Ojurongbe, R.G. Adeola, O.S. Bello, J.A. Ojo, and Drs. M.O. Jelili and H.A. Adele) of LAUTECH Internal Quality Assurance team that served with me as the Pioneer Director of Quality Assurance. The team spirit, with selfless commitments and efforts is unparalleled. I dedicate all my successes and achievements in that capacity to them all. I equally appreciate the administrative staff that worked with me (Mrs. M.S. Falokun-Peters, Mrs. R.T. Ishola and Mrs. G.T. Yekeen) for their diligence and hard work. I am very grateful to the University Registrar (Dr. K.A. Ogunleye) and Bursar (Mr. O. Okediji) for their support while in the office. I equally recognise the University Librarian (Dr. M. A. Aboyade) for her hard work.

I appreciate our University Senate, Tertiary Education Trust Fund and World Bank (through West Africa Agricultural Productivity Program (WAAPP-Nigeria) for the grants that were used for the projects, especially for community outreach engagements. I render special appreciation to my research teams. Drs. G.O. Babarinde, V.F. Abioye, J.A. Adejuyitan, Ayo Ojo, T.O. Salawudeen, and Professor M.O. Oke are valued for Senate grant and Tetfund projects. Profs. B.I.O. Ade-Omowaye, T.I. Olabiyi, and R.G. Adeola, together with Dr. O.A. Idowu and Mr. Tesleem Adebayo (Federal Polytechnic, Offa), are mostly appreciated for the team spirit in executing WAAPP grant project. I appreciate the publicity roles of the staff in Public Relations Unit, especially Mr. G.O. Fadeyi. I thank Dr. Sadiat Oyenike Babalola (NIHORT), Dr. Wasiu Awoyale (KWASU) and Professor Bolanle Otegbayo (Bowen





University, Iwo) for diverse collaborative research. I recognise Mrs. Ogunwobi and Mr. Ajao of OYSADEP for numerous assistance on extension activities in the five Local Government Areas in Ogbomoso. I appreciate all academic staff of Food Science and Technology Department, FUNAAB (especially Profs. Lateef Sanni, Taofik Shittu, Razak Adebowale, Adewale Obadina, Olajide Sobukola, and Dr. Ganiyat Olatunde) for the academic relationship.

My unreserved gratitude to all the academic staff of Food Technology Department, University of Ibadan for approving by sabbatical placement twice. I appreciate Dr. and Dr. (Mrs.) Uzo-Peters for their immense assistance to my family at all times. We all appreciate the true love. Dr. Folake Samuel (UI) is mostly treasured for encouraging and supporting my application for AWARD fellowship in 2010, and for research collaboration. All AWARD staff are appreciated mostly for the workshops on mentoring and scientific training programmes. I also cherish the relationship that I have with the AWARD Fellows.

I am immensely grateful to the Deputy Executive Secretary (Academics) of NUC, Dr. Suleiman B. Rahmon-Yusuf, for the TRAINIQA mentoring and other assistance when it mattered most. I appreciate all pioneer members of West African Anglophone Quality Assurance Network (WAAQAN) for the mandate of being a Steering Committee Member. Very important to me is the friendship experience of 'The great 5', including Profs. Solomon Okunuga (Unilag, Lagos), Aderemi Ogunfowokan (OAU, Ife), Oluwatoyin Odeku and Titilayo Fakeye (UI, Ibadan), during the two years of TRAINIQA at different locations. I equally appreciate my DIES National Multiplication Training team, Professor Kayode

Adekeye (Redeemer's University, Ede), Dr. Baboucarr Njie (Maritime University, Accra) and Mr. Segun Adeosun (Federal University of Agriculture, Abeokuta), for the team spirit. I thank Ms. Petra Pistor (FH Münster) for facilitating my international collaboration with the University of Potsdam, Germany, and Frank Niedermeier (University of Potsdam) for the consultancy opportunity in the SADC-QA 2020-2021.

Highly priced to me are the post graduate students that I was privileged to supervise (Drs. Adunni Abiodun, Funmi Abioye, Olufumilola Ajala, Olatunde Otutu, Fausat Kolawole, Kamal Oladele, Kemi Oduntan, Olatunde Sogo, Mrs. Toyin Adetola, and Miss Ayodele Adenitan). Of equal importance are my current students (Mrs. Folasade Jayeoba, Mr. Olutayo Mayaki, and Mr. Diran Alamu, among others). My numerous undergraduate students are equally appreciated. I also cherish my mentees at formal and informal levels (Dr. Grace Babarinde, Mrs. Abiodun Olalude, Dr. Samson Oyeyinka, Dr. Islamiyat Bolarinwa, and Dr. Monsurat Jimoh, among others). All of them made replication of myself possible and have made me an achiever with their productivity and achievements. I am immensely grateful to every other people that came together as a group, that are worthy of note but are too numerous to list, for the commitment to support and celebrate me at this my most important lifetime event. I thank all the members of staff of the new Faculty of Food and Consumer Sciences (especially the Dean and the Heads of the two Departments) and Department of Food Engineering for the sincere love and support to make sure that this event is most successful.

I extend my gratitude to my friends of inestimable value, Mrs.





Aminat Bolatito Abdl-Kareem and Mrs. Ibukun Monsurat Oshoala, for their pure love like family members. My relationship with Professors Muibat Bello, Ramota Karim (Unilorin), Fatai Akande, Drs. Olubukola Oyerinde (FUTA), and Dola Adeboye (former PRO of NIFST) is mostly cherished. Worthy to be appreciated also are my 'egbons', Mr. Gbenga Adeoye, Mr. Wale Adeyemo, and Dr. Sunday O.S. Akinyemi. My world rated Ibadan Grammar School (85 set), Federal Polytechnic, Ilaro (87 set), Obafemi Awolowo University (94 set), and University of Ibadan (96 set) classmates are most appreciated for diverse roles during my academic journey and for the sustainable friendship till the present moment. 'Ogun omode ti n se ere fun ogun odun' ('twenty children now play for twenty years') nowadays as against the old sayings, courtesy of social media.

I recognise all the professional members of Nigerian Institute of Food Science and Technology (NIFST), especially the past Presidents, Professor Lateef Sanni, Mr. Wole Toye (who decorated me as a Fellow), the incumbent President (Professor Madu Iwe) who nominated me as the Welfare Officer of the Body of Fellows, Dr. Larry Umunna, all other members of the Body of Fellows. I thank all my elderly 'associates' who did not see me to be too young to relate with. The likes of Dr. Olabisi Akinlua (who loves me like her child), Professor Margaret K. Akinloye (a role model on leadership), Professor Esther O. Okunade, Professor Florence O. Adeyemo, Professor Omololu Fapojuwo (DVC of KWASU), and Professor R.G. Adeola (for the free weekly ride of several years to and from Ibadan).

I wish to specially thank Profs. Ogugua Charles Aworh (University

of Ibadan), Charles Taiwo Akanbi, Kehinde Taiwo (both of Obafemi Awolowo University), Toyin Odeku (Dean of Faculty of Pharmacy, UI), Drs. Grace Babarinde, and Abass Alade for the painstaking efforts in reading through and for valuable inputs. Of special note are Professor Isaac Adebayo Adeyemi and Dr. Samson Oyeyinka, who did not just read to correct but also supplied several reference materials. The quality of this lecture note is made possible due to all their efforts.

My unquantifiable gratitude to all my loved ones, that are too numerous to mention their names, that supported me in diverse forms that I least imagined. Most important are physical, moral, financial, and prayer support for the success of today. I thank everyone that graciously attend this lecture amidst several other contending engagements, and all those that love me dearly (openly and remotely).

To God be the glory for my wonderful siblings. Sincere gratitude to my senior sister (our 'small mummy'), Mrs. Saudatu Adesola Ogunbadejo, and brother (our 'small daddy'), Mr. Ibraheem Adekunle Oyeleye, for spiritual, moral and financial supports over the years. They have both been my 'EJIKA TI KO JE KI ASO YE' (my pillar of supports). My other sisters (Mrs. Rukayat Adebimpe Akintunde, Mrs. Azeezat Adebola Adeniji and Mrs. Ameenat Aderonke Adegbola) and brother (Mr. Akeem Olalekan Oyeleye), together with all their spouses, are sincerely cherished for always rendering helpful hands. Of special recognition are Mrs. Modinat Oyeleye and Mrs. Abibat Oyeleye who have been outstandingly supportive in diverse forms.





I say 'thank you' to all my paternal and maternal uncles, aunties, and cousins who have been of great value to me. I recognise all my nieces and nephews, especially Mrs. Zeinab Afolabi and Mr. Sulaiman Ogunbadejo who are of inestimable values for holding forth when my children were young. I equally recognise Mr. Afis Afolabi and Mrs. Wakilat Ogunbadejo. I recognise and appreciate all my in-laws and their spouses (Ayodejis, Ajibades, Sololas, Adegbites, Adebisis, Gusanus, Onafuyes, and all Akinwandes globally) for their love in different ways.

My success has been possible with the support of my husband, Abdl-Rasheed Akinwunmi Akinwande. I could get this far because he gave me peace of mind and a stable home. He is my jewel, my pillar of support for sustainability, survival, achievements and successes. His patience is unequalled and he is a man that any woman meant to be successful would desire to have. He made several selfless sacrifices for the sake of our children by holding forth in my absence. He desired a peaceful home at the expense of a very rewarding job at the beginning of his career and God gave him exactly that. I love him truly and I am immensely grateful which I am sure that he knows.

I thank my wonderful children, my 'Angels', Nurat, Salimat, Maryam, and, by extension, Faizat. I wonder where I can start from to appreciate their understanding for just the weekend motherly roles. I did not miss each time they cried but only could react with bold face whenever I needed to travel for work. The 'supper sacrifice' in the course of preparing for this inaugural

lecture is most appreciated.

Mr. Vice-Chancellor Sir, I finally return all glory and adoration to Almighty Allah, The Most Beneficent and The Most Merciful, for my lifelong journey.





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Fig. 1: Illustration of sustainable development goals

Source: https://blog.aiesec.org/sustainable-development-what/

SDG 2 (end hunger –achieve food security and improved nutrition, and promote sustainable agriculture) is meant to provide sustainable solutions to end hunger in all ramifications by 2030 and achieve food security. The intention of this is to ensure that everyone everywhere has enough good-quality food for a healthy life. There is a need for better access to food with the attendant extensive promotion of sustainable agriculture to achieve this goal (UNDP, 2015). This requires improvement in the productivity and incomes of small-scale farmers by promoting equal access to land, technology and markets, sustainable food production systems, and resilient agricultural practices. It also entails an increase in investments through international cooperation to strengthen the





Fig. 2: Use of food to prevent specific health conditions
Source: Hartman group (2010) in IFT magazine (04/2012)

There is a close association between traditional diet and traditional medicine in Africa (Aworh, 2018). Vitamins (A, $B_6$, $B_{12}$, folate, C, D, and E) and trace elements (zinc, copper, selenium, iron) in foods support the human body immune system by protecting the host from pathogenic organisms (bacteria, viruses, fungi, parasites) and thereby reduce the risk of infections (Calder, 2020). According to Garba and Mungadi (2019), neem leaves contain compounds like zinc, quercetin, vitamin A, vitamin $B_1$, vitamin $B_2$, vitamin $B_6$, vitamin C, vitamin E which may boost immunity. The availability of health-promoting functional foods in the diet has the potential to help ensure a healthier population. Insight into how the role of physiologically active food components, from both phytochemicals

Plate 7: Constructed solar tent dryer

Plate 8: Drying platform of (a) open sun and (b) solar tent

3.5.4.3 Preservation of fresh banana fruit

Post-harvest spoilage of banana as a problem for smallholder farmers cannot be underestimated. To be able to still attend to this problem, we looked into the possibility of extending the shelf life of two banana cultivars (*Musa acuminata* and *Musa sapientus*) using preservation techniques that smallholder farmers can afford. This becomes very important due to lack of standard storage media such as controlled atmospheric storage and modified atmosphere packaging. The three techniques employed were: (i) wrapping of banana fingers with dry banana leaves with





programme "Ise opolo" in 'Yoruba' language. Distribution of the recipe book also continued at the department where the members of the public came to collect.

Plate 9: Hands-on training on the processing of breakfast cereal, 'akara', and 'moinmoin'

Plate 10: Training on the processing of 'akara' and 'moinmoin' from shelf-stable intermediate flour from indigenous legumes

In a developing country like Nigeria, where the protein intake of the population is low due to the expensive nature of protein foods, wild-growing species of mushroom are used as a meat substitute in the time past by people in the lower economic ladder.

a b

Plate 3: Examples of mushroom: (a) above-ground (*Pleurotus pulmonarius)*; and (b) below-ground mushroom (*Pleurotus tuberregium* with sclerotium)

### 3.3.1 Mushroom safety evaluation

While some wild mushrooms (*Chlorophyllum molybdites, Panaeolus subalteatus, Macrolepiota procera, Leucopaxillus albissmus, Hygrophoropsis aurantiacus,* and *Pholiota aurea*) from Zaria in Nigeria have been found to be toxic (Ambali *et al*., 2008), ethnomedicinal uses of some (e.g., *Pleurotus tuberregium, Agaricus bisporus, Lentinus squarullosus, Gandoderma lucidum, Volvariella vovaceae* have been documented (Oyetayo, 2011) which shows that they are edible. Research has indicated the use of various substrates for the cultivation of mushrooms to take care of apprehension in consumers about the poisonous nature of some wild edible mushrooms (Akinwande and Adetola, 2014). Easily cultivated mushrooms and common wild mushrooms are often available in the market. To rekindle interest in mushroom





part of Nigeria. It has been used as a disintegrant in the formulation of paracetamol at the industrial level (Iwuagwu and Onyekweli, 2002).

As a follow-up on the use of its powdery form, we made effort to diversify the diet from this nutrient-dense indigenous crop as a food-based strategy for food and nutrition security and sustainable diets in resource-poor communities. We developed locally adaptable nutritious and health-friendly snacks from composite flour of orange-fleshed sweet potato and *P. tuberregium* sclerotium.

Cookies and chin-chin (Plate 4) with high contents of protein (with all essential amino acids except tryptophan), ash, crude fiber, phytochemicals, minerals, vitamins, antioxidant activities, and acceptable sensory quality were produced from OFSP and sclerotium flours at a ratio of 80:20 (Kolawole *et al.*, 2018; 2020). These snacks could, thus, be categorised as healthy based on their nutritional contents (Garba and Mungadi, 2019). Inclusion of these products in the dietary pattern of the consuming populace could boost their nutritional status and reduction of incidence of diseases.

(a) (b)

Plate 4: (a) Cookies and (b) Chinchin made from composite flour of OFSP and sclerotium tuber

In order to address the problem of post-harvest spoilage, and also contribute to reducing the prevalence of vitamin A deficiency and malnutrition in sub-Saharan Africa, I and my research team tried to diversify utilization options of OFSP tuber as food. Fresh tuber was processed to fried chips and flour (shelf-stable). Composite blends of 70:30; 77.50:22.50; 85:15; and 100:0 from wheat and OFSP, respectively, were obtained with Design Expert software using Simplex Lattice Design. Range of products (chin chin, bread, and biscuit) were developed from the flour blends from two varieties (Mother's Delight and King J). Simplex Lattice Design was also used to optimize OFSP and cassava starch in the production of the flour mix to produce dough ('amala') with enhanced beta-carotene content.

Plate 5: Pictorial view of OFSP

(a) (b) (c) (d)

Plate 6: (a) Fried chips, (b) Chinchin, and (c) Bread made from composite flour of OFSP and wheat flour; (d) Amala made from admixture of OFSP flour and cassava starch





Pot-in-pot, or a similar storage structure, would find useful application in extending the shelf life of fresh okra pods in developing countries like Nigeria. Farmers and marketers of okra are encouraged to use pot-in-pot for storage as a means of reducing the heat stress to the pods and extend their storage life for more economic benefits.

(a) (b) (c)

Plate 1: Storage structures for okra: (a) pot-in-pot; (b) calabash; and (c) raffia basket

Adequate storage of okra will help in retaining essential nutrients that are needed for healthy living. Okra, with its diverse array of nutritional quality and potential health beneficial effects on some of the human diseases like cardiovascular disease, type 2 diabetes, digestive diseases, and some cancers, is an important food crop. Its regular consumption can be a factor in mitigating food insecurity and possibly alleviate malnutrition in developing countries like Nigeria. Since okra is very cheap with enormous nutritional and health benefits, it is advised to be included in the individual menu towards the achievement of SDGs 2 and 3.

Plate 11: Training on utilisation options for OFSP at the different local governments





and Ahmad, 2020). Apparently, this prediction would appear to be wrong as the African continent has been the least affected in terms of mortality rates (Dongarwar and Salihu, 2020). Europe recorded the highest mortality rates, followed by North America, while Africa remain the least affected continent (Fig. 3). Although there seems to be an upsurge in recent time, Lone and Ahmad (2020) indicated that the magnitude of the impact will depend on the management and control of COVID-19 within the respective African countries.

Plate 12: Cover page of LAUTECH IQA policy

Fig. 3: Covid-19 cases, deaths, and case fatality rate by continents
Source: Dongarwar and Salihu (2020)