



BELLS UNIVERSITY OF TECHNOLOGY
OTA, OGUN STATE, NIGERIA

MY NIGERIA FOOD STORY: SCARCITY IN THE MIDST OF PLENTY

An Inaugural Lecture

By

NGOZI UGO ARISA

MNIFST, FICA
Professor of Food Technology



Bellstech Inaugural Lecture Series No. 7

Wednesday, 24th September, 2025



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The Seventh (7th) Inaugural Lecture Delivered at
Bells University of Technology, Ota, Nigeria
On Wednesday, 24th September, 2025

By

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CITATION OF PROFESSOR NGOZI UGO ARISA

Education and Work Experience

Professor Ngozi Ugo Arisa is a distinguished Professor of Food Technology in the Department of Food Science and Technology, Bells University of Technology, Ota.

She began her educational journey at Etche Road Primary School, Aba, Abia State, and proceeded to Muslim Girls' High School, Ijebu-Ode, Ogun State, for her secondary education. She later gained admission into the Federal University of Technology, Owerri, where she obtained a Bachelor of Technology (B.Tech.) degree in Food Science and Technology.

Upon graduation, she worked briefly as Quality Control Manager at Trimco Limited, a vegetable oil expression company. Drawing from her undergraduate research project on oil refining, she was able to single-handedly set up the company's Quality Control Laboratory from scratch and successfully managed its daily operations, an uncommon achievement for a fresh graduate.

She further pursued postgraduate studies at the University of Ibadan, where she earned both her Master of Science (M.Sc.) and Doctor of Philosophy (Ph.D.) degrees in Food Technology.

Her academic career commenced at Abia State University, where she served as an Assistant Lecturer and later as Lecturer II, before joining Bells University of Technology as a Lecturer II in December 2005. She has since risen through the ranks to the position of Professor.

Positions Held

Throughout her academic and professional journey, Professor Arisa has held numerous leadership and administrative roles, reflecting her commitment to service and discipline. These include:

- Sanitary Prefect, Muslim Girls' High School, Ijebu-Ode.
- Treasurer, Igbere Students Union, Federal University of Technology, Owerri.
- Hall Warden, Female Hall of Residence, Abia State University, Uturu (Umudike Campus).
- Coordinator, Department of Food Science and Technology.
- Secretary, Departmental Board Meeting, Bells University of Technology.

At Bells University of Technology, Ota, she has held many positions and is a member of numerous committees some of which are listed below:

Coordinator Department of Food Technology (August, 2006-February, 2007)
 College examination officer (2005/2006 and first semester 2006/2007)
 Member University Library Committee (2006)
 Member Orientation Committee 2006/2007 Session
 Member Protocol Sub-committee 1st Bells University of Technology,
 Technology Fair
 College examination officer (2007/2008)
 Examination officer Department of Food Science and Technology (2006-2015)
 Member space allocation Committee
 Chairman, Bells University of Technology Co operative and credit Society
 Creche Committee (2009/2010)
 Coordinator Department of Food Technology (August 27, 2012-September 24,
 2012)
 Coordinator Department of Food Technology (January 30-February 14, 2013)
 Member Convocation Sub Committee on Technology fair(2011,2012,2013,
 2014, 2015)
 Member University Budget Committee (2015)
 Acting Head, Department of Food Science and Technology (July, 20-July, 31
 2015)
 Acting Dean, College of Food Sciences (July, 20-July, 31 2015)
 Acting Head, Department of Food Technology and Nutrition (August 1, 2015
 to August 12, 2016))
 Member, Postgraduate School Board (2015 to October 2016)
 Member, University Senate (August, 1 2015 to August 12, 2016))
 Member, University Ceremonials Committee (2016 to Date)
 Member, Committee on Fire Outbreak in COLMANS Resource Centre (2016)
 Member, Mock Resource Accreditation Team to Biotechnology Programme
 for PhD Biotechnology (2016)
 Chairman, Convocation Sponsorship and Income Generation Sub-committee
 (2016-)
 Acting Director, University Central Teaching and Research Laboratory (2016)
 Director, Academic Planning (2017- 2025)
 Member, Committee of Deans and Directors (2017- Date)
 Member, Campus Development Committee (2017- 2025)
 Member, University Budget Committee (2017-2025)
 Member, Central Admissions Committee (2017- Date)
 Member, Postgraduate Board (2017-2025)

Member, Non-Teaching Staff Appointments and Promotions Committee (2017- Date)

Member, Committee on Proposed College of Theatre Technology (2017)

Member, University Senate (2017- Date)

Member, Editorial Board, Bells University Journal of Applied Science and Environment (2017- 2023)

Member, Governing Council Bells University of Technology, Ota, Ogun State (September 1, 2019-2023)

Member, Academic Staff Appointments and Promotions Committee (2019-Date)

Member, Committee of Directors of Academic Planning of Nigerian Universities (CODAPNU) (2017- 2025)

Chairman and Member, School Resumption Committee (2020-2025)

Member, Open and Distance Learning Committee (2019-2023)

Member, Quality Assurance Committee (2019-2023)

Member, Sub Committee on Retirement from the University

Sunday School Superintendent, Lagos Presbyterian Church, Yaba, Lagos (2020-2022)

Chairman, Senate Committee for writing of 30% addition to core curriculum and minimum academic standard (CCMAS) for Bells University of Technology, Ota, Nigeria.

Member, Ad-Hoc Committee on Review of Academic Staff Promotion Guidelines (2022 and 2023)

Member, Postgraduate Admissions and Research Committee (2020-2025)

Member, Research and Learned conferences committee (2022-date)

Member, Ad-Hoc Committee on Modalities for the Award of Dr. Alhaji Ibrahim Dankwambo Prize for the Staff with the Highest Number of Publications in Scopus Indexed Journals in the Year of Convocation (2022).

Member, University Health Board (2023).

Member, Ad-Hoc Committee for Review of the University's Financial Regulations (2023).

Member, Adhoc committee on review of academic staff appointment and promotion document (2024)

Member, Adhoc committee on the proposal for restructuring of MBA part time programme (2024).

Chairman, Academic and Research committee of the Postgraduate Board (2025)

Chairman, Adhoc committee on curriculum harmonization of postgraduate programmes (2025).

Member, Olusegun Obasanjo leadership institute special management advisory board (2025)

Assistant editor, Olusegun Obasanjo leadership institute quarterly news letter.

She is a Sunday School teacher too in her church; Lagos Presbyterian Church, Yaba, where has served as Welfare officer for both the Sunday School Department and Dorcas House of Womens' Guild of the parish. She had also served as the Sunday school Superintendent and Coordinator, Lagos Presbyterian Church, Yaba, Lagos.

She is also the Convener, Scholarship award committee of the Church's Board. Professor Ngozi Arisa is the treasurer to Adebola North Community Development Association, Surulere, Lagos. A position she contested for and was voted in, in 2023.

Research Focus

- Processing and preservation of foods from lesser-known fruits and legumes
- Development of appropriate cassava peeling process (chemical peeling)
- Processing of under utilized foods (trifoliate yam, native pear, African yam beans etcetera) into shelf stable products
- Preservation of Local Nigerian Vegetables
- Research to find out the effects of processing on and actual nutritional value of "*pomo*" edible hide
- Food consumption pattern and access to nutritious and safe foods and general nutritional practices of humans.

Mentorship and Supervision

Professor Ngozi Ugo Arisa has mentored over 300 students and supervised over 100 undergraduate and postgraduate projects and dissertations.

Publications

She has published over sixty articles in reputable journals and refereed conference proceedings.

She is married to Mr Joseph Arisa and they are blessed with children.

1.0 Introduction

Food Science and Technology as a programme is often misunderstood by majority of the population. I remember when as an under-graduate at Federal University of Technology, Owerri, a classmate of mine was laughed at or so to speak was talked down at by another student who felt he was wasting his time studying Food Science and Technology. He said “Look at you is it that your mummy could not teach you how to cook that you had to come to the university to learn how to cook? Shame on you”

1.1 So, what is Food Science and Technology and who are the professionals?

Food Science and Technology is that discipline that applies the basic knowledge of science, engineering and technology in solving food related problems: production, processing, preservation, food engineering principles, distribution, food safety and nutrition. The programme ensures that professionals (Food Chemists, Food Engineers, Food Processing and Preservation experts, Food Micro-biologists, Food Biotechnologists, Food Physicists, Food Psycho-logists) are trained and are well equipped to handle, add value to primary raw materials, and produce secondary products from the raw materials in a manner that is safe and that will result in nutritious foods, that are as fresh and additive free as possible.

They are involved in the pre-harvest and postharvest processes of handling, processing, preservation, ware housing, distribution and final consumer access of the finished products.

2.0 Foods

Foods are mostly sourced and derived from living things and may be from either plant or any animal origin. They consist of complex chemical substances in form of solutes dissolved in suitable solvents which can be polar or non-polar in nature and often referred to as nutrients. The nutrients are situated in the cells of the food material.

2.1 Food nutrients

Nutrients fall into different categories: water, carbohydrates, proteins, fibre, vitamins, minerals, fats and oils. A particular food usually contains more than one nutrient but one will dominate the others making the food to be categorized as such.

In addition to the nutrient composition in the cells of the food, the cells also contain chemical substances that catalyze biochemical reactions such as respiration, photosynthesis, ripening etc. When the cells of the food are

broken down, they are spilled from the cells and begin to catalyze reactions. These substances are known as enzymes.

Also, every food harbours groups of microorganisms on its surface which are peculiar to it. These microorganisms known as micro flora when present do not cause harm to the food because they do not have access into the cells. When the cells are broken, the microorganisms gain entrance into the hitherto sterile cells.

The reactions that take place in foods may be said to be of two natures; microbiological and biochemical. The actions of the biochemical and microbiological substances if not controlled, can lead to deterioration of foods.

Factor that may lead to changes, commencement of microbiological and biochemical reactions or increase/decrease in these reactions are physical factors (cuts, bruises and breakage as a result of handling, increase or decrease in temperature, light, air, water activity, humidity etc).

Food materials when intact in their natural state are in good condition and the rate at which normal biochemical reactions take place in them are usually slower resulting in their being able to last/store for some time depending on type/species, stage of maturity, handling, temperature at harvest etc.

As earlier pointed out there are components in the cells of food which when the integrity of food has been compromised as a result of processing operations or handling will initiate chemical reactions and hasten the reactions in the food product. These substances are referred to as enzymes. Enzymes are proteins that act as biological catalyst in biological materials facilitating and increasing the rate of reactions in them. Enzymes in living cells aid metabolic reactions such as respiration, photosynthesis, digestion, ripening etc. Enzymes are usually substrate specific. Examples of enzymes are amylases, proteases, lactases etc.

It should be noted that in healthy living organisms; plants and animals, the enzymes in them only aid metabolic processes, but in diseased or harvested or slaughtered foods the enzymes that before then aided normal biochemical reactions in the cells contribute in the degeneration of the cells. When chemical or physical processes (processing by: removal of heat; addition of heat; and/or reduction of water activity etc.) that can be used in the reduction

of their activities are not employed, the food product deteriorates very fast. This is because in living plants and animals there is a natural balance in the activities of enzymes. However, after harvest or slaughter or disease, when the body system loses its defenses and balance, the enzymes will continue to act and facilitate reactions. Example is pepsin in the stomach of animals that aids in digestion of proteins which contribute to the proteolysis of the cells after slaughter and will continue unless it is inactivated by heat, chemical preservative, radiation or slowed down by use of low temperature in freezing or chilling or dehydration or reduction in available moisture (Uzoma, 2023).

The acidity of foods also affects the rate of deterioration, the type of microorganism that will be implicated, its deterioration and to some extent the type of preservative operation the food will undergo.

2.2 Food Classifications

Food products may be generally classified as:

- Foods of animal origin: which include beef, lamb/mutton, pork, poultry/poultry products, rare meats such as snails, fish and fish products, and milk and milk products.
- Foods of plant origin: which are made up of roots and tuber crops, fruits and vegetables, cereal grains and grain legumes, oil seeds and nuts, spices and herbs.
- Inorganic foods: these include salt, water, and some clays.

3.0 Food Deterioration

Food Deterioration occurs when microbiological, chemical, or physical changes occur in the food making to the food product unacceptable to the consumer (Benner, 2014). The deterioration affects the colour, texture, nutritional value acceptability (Karanth et al, 2023)

3.1 Physical basis of food deterioration

The major physical factors that affect food shelf life and deterioration are: temperature, moisture content, presence or absence of oxygen, light, time, handling of the food commodity (state at harvest whether whole, bruised, cut, broken, state of maturity).

- **Temperature**

It is also good to note that even after foods have been harvested or slaughtered the cells of the food continue to respire and perform fundamental metabolic processes. Temperature of food at harvest time

and storage can affect the shelf life of the food, this why it is necessary to cool a food product immediately after harvest or slaughter. Temperature is a very important factor affecting the quality and duration of foods storage and by extension the shelf life. The chemical and biological factors that affect foods are affected by temperature. High storage temperature condition increases the rate of biochemical reactions. At high storage temperatures, the rate at which the activities of enzymes that facilitate metabolic activities, is high. Also, the rate of reactions or activities of microbiological and other biological activities in/on food is higher at higher temperatures than at reduced temperatures.

Reduction in temperature results in reduced rate of activities of enzymes and microorganisms, leading to slowing down of the rate of metabolic activities such as ripening, respiration, transpiration, photosynthesis. Reduced temperatures affect the activities of microorganism by retarding their rate of metabolism and growth. Therefore, any temperature that will result in lowering the activities of enzymes and microorganism will result in shelf-life extension.

It is also important to know that every food product, especially plant food product has its optimum storage temperature beyond or below which the shelf life and quality of the food will be compromised.

When a plant food product is stored at the optimum storage temperature it remains good for longer time. When stored below, it results in a phenomenon referred to as chilling or freezing injury depending on the storage temperature. When a food product is being frozen it is necessary to do freezing at high speed to ensure that the food quality does not go bad due to fluctuation in temperature. It is necessary that after cooling or freezing, that the cold chain is maintained until it gets to the final consumer.

- **Moisture Content**

Water is a major solvent in foods in which substances (nutrients and anti-nutrients etc) are dissolved. Moisture content is a very important factor to consider in food processing and preservation.

Every food product has its moisture content. The moisture content of a food product may be high, intermediate or low. That a food is in liquid, semi liquid or solid in physical state may not determine its moisture content. Foods such as some fruits though in solid state contain a lot of moisture. Example water melon contains more than 92 percent moisture. Liquid food

such as honey has very low moisture.

Moisture content of a food determines the amount of water that will be available for biochemical and microbiological reactions in the food. The lower the moisture content the slower the rate of biochemical (metabolic) and biological reactions (microbiological activities) in the food, the longer the shelf life of the food.

There are food preservative operations that result in lowering of moisture content of foods. These include concentration, dehydration (as in use of raised temperature or removal of heat as in freeze concentration or freeze drying or osmotic dehydration).

Aside from the effects of moisture content on keeping the quality of foods, moisture content of foods may affect quality characteristics such as palatability, digestibility, physical appearance and handling (Ayo & Tehinse, 2006).

There are two forms of water in a food. These are Free and Bound water.

- **Free water**

This is the water that is available in excess in solution in the food. This water is the water that is available for reaction in the food. Free water can be removed by evaporation or sublimation.

- **Bound water**

This is water that is physically or chemically bound and unavailable for chemical or microbiological reactions. This water may be physically or chemically bound to constituents of the food such as proteins, carbohydrates, fats and mineral. They may be held as water of hydration by food constituents such as mineral salts, simple sugars or organic acids. Water may also be held as mono-layer to the surface of a food constituent. Bound water requires very high energy before it dissociates from the constituent of food.

Foods that contain bound water do not deteriorate as fast as those with large percentage of free water.

Excessive moisture loss can also affect the texture, appearance of foods and by extension the quality of the food. This may affect the perception of the food. In fruits and vegetables, it may lead to shriveling and withering. At high relative humidity, excessive moisture may lead to condensation of moisture on the surface of foods resulting in growth and multiplication of

microorganisms on the surface of the food. This may result in spoilage of the food (Potter & Hotchkiss, 2006).

- **Oxygen**

Oxygen is required for respiration and other oxidative reactions in foods. It has destructive effects on nutrients such as vitamins A and C, food colours, flavours, fats oxidation leading to rancidity. It is required for mould growth and all moulds are aerobic. It is necessary to exclude oxygen when food is to be packaged in order to assure shelf life of the food. When the oxygen level in the package of food is reduced or the air in the package is substituted with carbon dioxide or nitrogen in the process, known as modified atmosphere storage. The shelf-life extension that results is because at this condition the amount of oxygen available for metabolic activities by the food cells or microorganisms on it is reduced.

- **Light**

Light destroys some vitamins such as riboflavin, vitamin A and C and also causes deterioration of many food colours. Example; milk in bottles when exposed to sunlight develops off-flavour due to the exposure as a result of light induced oxidation and changes in proteins. Another one is surface discoloration of sausage meat pigment.

- **Time**

Time is a physical factor that affects foods. There is a time at which it is very good to harvest foods. At that time that quality characteristics of the food is at its optimum. For example, fresh corn and peas. Every crop or animal has an optimum time of harvest. When a product is left beyond the optimum harvest time the product may not be useful for the product to which it is to be applied. It should be known that the quality of majority of foods (colour, vitamin, aroma etc) decrease with time.

- **Handling**

The way foods are handled right from time of harvest through processing, warehousing and distribution affect the shelf-life. If the products are not handled properly example, if the produce was bruised or broken during harvesting, the shelf-life of the food will be reduced.

3.2 Role of acidity and water activity in food safety and quality

Intrinsic food properties (e.g. water activity, acidity, redox potential) can play a role in determining the extent of food processing operations needed to ensure food safety and minimize quality abuse. Higher acidity levels

($\text{pH} < 4.6$) do not favour growth of many spoilage microorganisms like certain bacteria. The use of some mild preservative treatment such as pasteurization may be enough. The microorganisms that may spoil foods in this category are fungi such as yeasts.

Low-acid foods ($\text{pH} \geq 4.6$) support the growth and toxin production of various pathogenic microorganisms, including *Clostridium botulinum*. Products such as milk, meat, vegetables and soups are examples of low-acid foods and require more severe heat treatment than acid foods such as orange juice or tomato products. pH of the food material affects food quality attributes such as color, texture, and flavour. For example, pH of the milk used for cheese manufacturing can help determine cheese texture (hard/soft). Similarly, pH of fruit jelly can determine gel consistency.

Knowledge of availability of water for microbial, enzymatic or chemical activity helps in predicting the stability and shelf life of processed foods. This is often reported as water activity (a_w), and is defined as the ratio between partial pressure of water vapor (p_w) of the food and the vapor pressure of saturated water (p_w) at the same temperature. The water activity concept is often used in food processing to predict growth of bacteria, yeast, and molds. Bacteria grow mostly between a_w values of 0.9 and 1, most enzymes and fungi have a lower a_w limit of 0.8, and for most yeasts 0.6 is the lower limit. Thus, food can be made safe by lowering the water activity to a point that will not allow the growth of dangerous pathogens. Foods are generally considered safer against microbial growth at a_w below 0.6. Salt and sugar are commonly used to lower water activity by binding product moisture. Water activity of food material can also influence various chemical reactions. For example, non-enzymatic browning reactions increase with water activity level of 0.6–0.7. Similarly, lipid oxidation can be minimized at about water activity level of 0.2–0.3 (Uzoma, 2023).

4.0 Food Systems

Food systems (FS) encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded (FAO, 2014). It is composed of sub-systems (e.g. farming system, waste

management system, input supply system, etc.) and interacts with other key systems (e.g. energy system, trade system, health system, etc.). Therefore, a structural change in the food system might originate from a change in another system; for example, a policy promoting more bio-fuel in the energy system will have a significant impact on the food system (FAO, 2014).

4.1 Sustainable Food System

A Sustainable Food System (SFS) is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised. This means that:

- a) It is profitable throughout (economic sustainability);
- b) It has broad-based benefits for society (social sustainability); and
- c) It has a positive or neutral impact on the natural environment (environmental sustainability) (FAO, 2014).

In order to have a sustainable food system, there is need for all the activities that lead to food production to be well coordinated, starting from the pre-harvest time to the post-harvest life of the food commodity.

4.2 Pre-Harvest and Postharvest Technologies

Food science and Technology is a programme that encompasses the study of food right from the pre-harvest time to the post-harvest time of foods.

- **Pre-harvest**

The pre-harvest period starts from when the food manufacturer contemplates on the type of food to produce. He decides to produce food of specific quality characteristics which may only be made from specific raw materials with certain quality attributes. He discusses with the farmer and may give him seeds that will produce raw materials he wants, that will grow for specific number of days and at specified conditions.

He may then specify the time of harvest for the crop so that the raw material will suit his purpose. He specifies the handling operations during harvesting, transportation, storage of the raw material before and after delivery to the processing plant.

The planting of appropriate raw materials with good characteristics in terms of texture/hardiness or resistance to handling stresses will result in crops with longer shelf life.

- **Harvest**

The use of appropriate harvesting tools and technologies result in produce that have good quality characteristics because it leads to products whose integrity is not compromised because they are free from bruises, cuts, and breakage; resulting in raw materials that are naturally stable, which are able to last out their normal natural shelf life and for produce with natural dormancy (some roots and tuber crops), they are stable and require less management operations and facilities.

- **Post harvest**

Transportation within the farm from point of harvest, stacking to packing house, within the packing house during operations such as cleaning, cooling, sorting and grading, packaging, loading and transit to processing factory or market until the food gets to the final consumer fall under post-harvest activities. The use of appropriate or inappropriate packaging materials, transit containers, transportation vehicles at required optimal temperature for the crops affect the shelf life of food raw materials.

In Nigeria, there are little or no packing house operations and activities taking place. Therefore, food products are not given necessary cleaning, field heat removal and initial packaging for transportation to processing facilities or markets. Some Food Technologists had in the eighties and early nineties in a bid to reducing post-harvest losses in the country designed transit returnable containers with right structural strength for maintenance of produce integrity (Olorunda and Tung, (1985), Aworh, (2023)) but these containers were not put to use. Horticultural produce are still stacked on one another with no form of primary packaging or secondary packaging (jute bags, cellophane bags, PET bags, raffia baskets etcetera) during transportation or storage



(a)



(b)

Plate 1: Stacking of horticultural food commodities for sale at Mile 12 International Food Market Lagos (16th August, 2025)



Plate 2: Stacking of horticultural food commodities for sale at Mile 12 International Food Market Lagos (16th August, 2025)



Plate 3: Stacking of horticultural food commodities for sale at Mile 12 International Food Market Lagos (16th August, 2025)

Jute bags, cellophane bags, PET bags, raffia baskets etc used as transit containers are inappropriate. They do not protect product integrity, resulting in most times avoidable food losses and wastages as products at the base are made to carry the weight of the entire stack throughout the journey and even while in storage at ware houses and retail display (Plates 1b, 2 and 3). The transit vehicles are not refrigerated; the roads are very bad resulting in elongated transit times and mechanical impacts on the food with all implications. Plate 1a shows a transit container which may slightly be able to protect the horticultural commodity placed inside it if not over filled. But the raffia baskets, PET or jute bags cannot do the same. This is because pressure varies from height to height and is greater at the lowest depth.



Plate 4: Loaded vehicle with a person on top of the food commodity that was packaged in PET bags (16th August, 2025)



Plate 5: Truck carrying food being off loaded at Mile 12 International Food Market Lagos (16th August, 2025)



Plate 6: Loaded food truck from Mile 12 International Food Market Lagos (16th August, 2025)

According to Studman, (1999), crop loss in the tropics vary from country to country. In less developed countries grain loss may be as much as 25 percent of yield and for fruits and vege-tables it may be up to 50% of production. These losses impact on prices of these commodities making them expensive as the few good ones pay for the bad ones.

Percentage crop losses in developing countries

Crop	Estimated loss of total crop (%)
Apples	14
Avocado	43
Bananas	20-80
Cabbage	37
Carrots	44
Cassava	19-25
Cauliflower	49
Citrus	20-95
Letus	62
Plantain	35-1005
Onions	16-35
Potatoes	5-40
Pawpaw	40-100
Sweet potatoes	35-95
Tomatoes	5-50
Yams	30-60
Grapes	27

Source: Studman, (1999)

To ensure sustainable food system in the country, there is need for the Food Scientist and Technologist to be involved in every aspect of the food chain. Food system should be properly regulated to ensure that only professionals and trained and certified persons are involved in the food value chain addition.

5.0 Food insecurity and hunger

Nigeria is facing food security problems with millions of her population facing limited access to food on day-to-day basis. According the United Nations Food and Agricultural Organization (FAO, 2003) there are many definitions to food security, these include:

“Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices”. This definition was given in 1974.

“Ensuring that all people at all times have both physical and economic access to the basic food that they need” (1983).

“Access of all people at all times to enough food for an active, healthy life” (1986).

By 1996 the definition changed to: “Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious foods to meet their dietary needs and food preferences for an active and healthy life”. By 2001, it became: “Food security is a situation that exists when 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” (FAO, 2003).

Recent report (Cadre Harmonise) by FAO in collaboration with the Nigerian government on the state of food security in the country revealed critical food and nutrition crisis across the country. The report showed that although there is slight reduction from 33.1 million people in 2024 at the brink of hunger and starvation, in 2025, 30.6 million people in 26 states and the Federal Capital Territory (FCT) are projected to face acute food and nutrition insecurity at Crisis (CH Phase 3) level and the situation may become worse between June and August of 2025. The prevalence is in the north eastern, north western and north central parts of the country but is gradually moving downward to some southern states like Cross River State (FAO, 2025).

6.0 Food Processing and Preservation

Food processing transforms animal, plant, and marine food raw materials into intermediate or finished value-added food products that are safer to eat (Park, et al, 2014). Food products are seasonal in nature, both in terms of demand for products and availability of raw material (Grandison, 2006). Food processing requires the application of labor, energy, machinery, and scientific knowledge to a step (unit operation) or a series of steps (process) in achieving the desired transformation (Heldman & Hartel, 1998) of the raw food into value-added ingredients or finished products that satisfy consumer needs and convenience. Most crops have well established harvest times, for example yams, are mature for harvest between late July to October every year, plantains are in abundance between December of every year and February and then they become less and less available as their volume decrease (Grandison, 2006).

According to Brennan *et al*, (2006) the suitability of a crop for processing is a balanced assessment of the properties of the crops. Properties such as availability (*a*), geometric properties (*g*), physical properties (*p*), functional properties (*f*), growth properties (*gr*), mechanical properties (*m*), thermal (*t*) and electrical properties (*e*) etc.

That is:

$$S = \varphi(a + g + p + f + gr + m + t + e + \dots) \quad 1$$

Brennan *et al* (2006)

In Nigeria foods have been known to be in abundance during their respective

seasons and they become very scarce after their season of abundance. While in season most of the harvested food crops are lost or wasted and totally unavailable for the final consumer due to inappropriate harvesting methods that may have been employed during harvest, handling, packing, transportation, temperature, stacking, duration, transportation system, road conditions etc), packaging (packaging integrity, methods, appropriateness/relevance etc) and unavailable or inappropriate processing and preservation technologies employed in processing and preservation (due to epileptic power supply, high cost of energy and processing and preservation equipment).

Food processing and preservation has evolved from:

1. Conventional Food Processing and Preservation Processes

- a) Thermal processing/processing by addition of heat
- b) Refrigeration/processing by removal of heat
- c) Concentration achieved by addition or removal of heat
- d) Dehydration by addition or removal of heat
- e) Fermentation by use of selected beneficial microorganisms or enzymes

to:

2). State-of-the-art Innovative and Emerging Technologies

- a) Food irradiation
- b) High hydrostatic pressure processing
- c) Ohmic heating
- d) Pulsed electric field processing
- e) Pulsed light processing
- f) Dielectric processing (microwave and infrared heating)
- g) Ultra-high temperature processing
- h) Magnetic resonance imaging (MRI)
- i) Ultra sound processing
- j) Nano-technology in food processing and preservation
- k) 3-D printing of foods
- l) Cold plasma technologies etcetera

These recent advances and emerging technologies are employed to produce foods that are, nearly as fresh as the unprocessed ones in terms of; texture, colour, flavour, aroma, taste and nutrients retention (Fellows, 2009; Neetoo & Chen, 2014).

In order to produce foods that are consistent in quality, process control is

applied. Process control is a tool that is used to prevent variability in final product quality. This has been done due to consumer expectation of having food products that are consistent in quality no matter where the same product brand is procured. Consumers expect to have consistent product with the one they may have procured previously may be from a different geographic location or same (Fellows, 2009; Neetoo & Chen, 2014).

Process control is applied in:

- i) Ordering and supplying raw materials,
- ii) Detailed production planning
- iii) Management of orders, recipes and batches
- iv) Controlling the flow of product through the process
- v) Controlling process conditions
- vi) Evaluation of process and product data (example monitoring temperature, pressure etc)
- vii) Control of cleaning in place
- viii) Packaging, warehouse storage and distribution

The need for process control is also applied due to the following:

- a) Competition among manufacturers to produce more products brand ranges in order to have a fair market share;
- b) Soaring cost of labour and raw material;
- c) International regulatory and legislative laws and standards that force manufacturers to obey laid down rules and regulatory standards for different products. No matter where the product is being manufactured in the world it must meet international set standards for products in its category (Fellows, 2009).

7.0 My Odyssey in Academia and Contributions to Knowledge

As a Food Technologist I have worked on different food classifications: fats and oils, fruits and vegetables, cereal grains and grain legumes, roots and tubers. Foods that are well known and lesser known and under-utilized ones, nutrition and dietetics. Due to time, I may not be able to go through them all but permit me to talk about a few.

7.1 Fats and Oil Products processing and preservation

7.1.1 Oil extraction and refining (Lesser known sources)

***Dacryodes Edulis* “Native Pear”**

Dacryodes edulis is also referred to as 'bush butter' and the mesocarp is eaten either; raw, boiled or roasted in fire or hot ash to soften (Okafor, 1983; Lam,

1985; Dupriez & Deleener, 1989).

The mesocarp and the seeds are also oily and edible. The mesocarp has mild turpentine smell, is rich in fats, vitamins, proteins, minerals and carbohydrates. Its oil is made up of 36.5% palmitic acid, 33.9% oleic acid, 24.0% linoleic acid, 5.5% stearic acid (Howes, 1974; Lam, 1985; Dupriez & Deleener, 1989).



Plate 7: *Dacryodes edulis* (Native pear)

- **Production and Refining of *Dacryodes Edulis* “Native Pear” mesocarp and Seed Oils.**

The suitability of native pear *Dacryodes edulis* seeds as a source of good quality vegetable oil was investigated. Oil was extracted from the dried seeds by simple solvent extraction process with hexane. Extracted oil was degummed using 0.2% H_3PO_4 or Na_2CO_3 solutions, and then bleached with activated carbon. Chemical (acid value (AV), saponification number (SN), peroxide value (PV), and iodine value (IV)) and physical (smoke point (SP), flash point (FP), melting point (MP) and freezing point) analyses were carried out on both the crude and refined oils. Results showed that the crude oil had AV of 9.6 mg KOH/g, SN of 72.8. Degumming (with 0.2% Na_2CO_3 and 0.2% H_3PO_4) and bleaching gave oils with lower AV (7.45 mgKOH/gfat) and higher acid value (9.4 mgKOH/gfat), respectively. Iodine

value (48.78 ml/g) of the 0.2% Na₂CO₃ degummed oil was higher than that of the seed oil degummed with 0.2% H₃PO₄ (25.35 ml/g). Bleaching of 0.2% Na₂CO₃ degummed oil resulted in oil with peroxide value of 20 mgEq/Kg which was higher than that of 0.2% H₃PO₄ degummed and bleached (19.4 mgEq/Kg) oil (Arisa & Lazarus, 2007).

Table 2. Chemical and Physical Characteristics of *Dacryodes edulis* Seed Oil

Parameter	Content
Oil content (%)	50.00±0.416
Iodine value (ml/g)	32.40±0.158
Acid value (mgKOH/g)	9.60±0.0 47
Saponification (mgKOH/g)	172.80±0.206
Peroxide value (meq/Kg)	6.00±0.047
Freezing point (°C)	21.00±0.163
Melting point (°C)	30.00±0.082
Smoke point (°C)	198.00±0.047
lash point (°C)	270.00±0.094

(Arisa and Lazarus, 2007)

- **Extraction and refining of oil from native pear (*Dacryodes edulis*) mesocarp**

Oil extracted with hexane from dried African pear (*Dacryodes edulis*) mesocarp was degummed with 1 or 5% NaOH or H₃PO₄, and bleached with fuller's earth. Degumming and bleaching produced lighter-colored oils with lower specific gravity and free fatty acid content. However, degummed oils had higher peroxide value (PV) (16.50 mEq/kg for 1% H₃PO₄ degummed oils) than crude oil (8.00 mEq/kg). Bleaching drastically reduced the PV of degummed oils, with oil degummed with 1% NaOH having the lowest value after bleaching (1.50 mEq/kg) (Arisa & Aworh, 2008).

Table 3. Percentage of composition and oil yield of *Dacryodes edulis* mesocarp

Sample	Percentage(%)
Whole native pear	100
Mesocarp(wet basis)	73
Seeds	26.52
Dried Mesocarp (in relation to whole pear fruit)	38.27
Dried Mesocarp (in relation to wet pear mesocarp)	52
Moisture loss of mesocarp	42
Oil yield of dried mesocarp	62

Arisa N. (1999)

From the table above it can be seen that the percentage oil content of dried native pear fruit mesocarp was 62% which is higher than percentage oil content of most oil-bearing seeds.

There is therefore the need for consideration of mass cultivation of the crop for its possible industrial application.

- **Palm Oil (PO), Palm Kernel Oil (PKO), and Groundnut Oil (GNO) Refining**

Three reagents (NaOH, Na₂CO₃ and H₃PO₄) were evaluated for their effectiveness in degumming three crude vegetable oils [(palm oil (PO), palm kernel oil (PKO), and groundnut oil (GNO)]. All chemical reagent were prepared at strengths of 0.5, 1, 2 and 5 % (w/v) and used for degumming. Degumming effected remarkable improvement in quality characteristics of the oil samples. Free fatty acids (FFA) were within standard specification (0.0-3-0.04%) and the peroxide values (PV) were very low, (0-1.0 meq/kg). The greatest yield after filtration (YAF), 88%, was obtained from 5% NaOH degummed PKO. Sodium hydroxide was found to be the best degumming reagent from the standpoint of oils with the least FFA, PV, dynamic viscosity (DV) and greatest YAF. In terms of % colour reduction (CR), H₃PO₄ was most effective in PKO only. Statistical analyses of the three-factor (oil type, degummer type and degummer strength) interactions (p=0.05) indicated that the parameter can be graded in order of significance thus: Smoke point > PV > FFA > CR > YAF. (Iwuoha *et al*, 1996).

7.2 Lesser known legumes

- **African Yam Beans (AYBs)**



Plate 8: African Yam Beans (*Sphenostylis stenocarpa*) (Odudu)

Sauces (15 and 20% brine solution) were made from African yam beans (AYBs) using a combination of solid and liquid state fermentations as practiced in Indonesia. They were analyzed to ascertain their nutritive value, microbiological safety and consumer acceptability. Results showed that the protein, fat, ash and carbohydrate contents were 4.85, 3.82, 11.82 and 16.75%, respectively, for 15% brine solution sauce after spicing and concentration. The total microbial load (bacteria) of the sauces was relatively low (20.0 and 18.0 cfu/g $\times 10^6$) for the two concentrations of sauces, respectively. At 0.05 confidence level, the t-tabulated value was greater than the t-calculated value (2.09>0.01), showing that there was no significant difference between the general quality characteristics of the AYB sauce and the conventional soy sauce (Arisa & Ogbuele, 2007).

Aside from production of sauce from (*Sphenosteliscenoscampa*), we have gone ahead to explore the possibilities of making boullion cubes from the fermented legume (Arisa & Idowu (2025).

- ***Mucuna flagellipes* (ukpo)**

Effects of soaking, boiling, autoclaving and roasting on the levels of certain antinutrients present in the seeds of *Mucuna flagellipes* were studied. Compared to other treatment, soaking had the least loss of trypsin inhibitor regardless of its duration. Soaking, boiling and autoclaving significantly ($P<0.05$) reduced (74.3–74.9%) the tannin content at 24hr, 120 min, and 90min respectively. The reduction in content of haemagglutinin was found to be greater with boiling and autoclaving (81.3 and 95.00%) at 90 min respectively than with soaking and roasting (42.0 and 67.8%) at 24hr and 120min respectively. Soaking (24hr) and roasting (120 min) markedly reduced hydrogen cyanide content by (64.5 and 58.8%) respectively. Comparable loss (52-55%) of phytate was noticed when the seeds were subjected to roasting, regardless of the duration of roasting time. Soaking and boiling significantly reduced stachyose and raffinose contents from 21.2 % to 51.2 % and 18.7% to 21.2 % respectively (Udensi, et al, 2008).

The effect of soaking and boiling, and autoclaving on nutritional factors (proximate and mineral) and anti-nutritional qualities of the legume, *Mucunaflagellipes* were studied. Batches of seeds were soaked for 6, 12, 18 and 24 h in distilled water at room temperature, then boiled in water for 30, 45, 60 or 90 min respectively. Another batch of *M. flagellipes* was autoclaved for different duration of 30, 45, 90 and 120 min respectively. Results showed that soaking followed by boiling produced products with lower crude fibre content (10% for soaking for 24 h followed by boiling for 90 min). However, it increased the

carbohydrates. Autoclaving resulted in products with lower mineral contents (1042.5 mg/100 g phosphorous for autoclaving for 120 min (Udensi, et al, 2010).

7.3 Fruits

Irvingia gabonensis just like other tropical crops are prone to high post-harvest losses due to mechanical and microbiological loss factors. *Irvingia gabonensis* seeds (*Ogbono*) were treated with 0, 5, 10, 15 and 20% *Aframomum danielli* extracts and were investigated for four weeks to ascertain the effects of *Aframomum danielli* extracts treatment on the proximate, microbiological and sensory characteristics of the treatments. *Aframomum danielli* treatments significantly improved the proximate composition of the seeds ($P>0.05$). Results also showed that nutritional composition increased as treatment levels increased and better quality of the stored product (from the first week to the fourth week). The 20% treatment level had the highest protein, fat and ash compositions after the fourth week of storage (7.94%, 17.52% and 17.10% respectively ($p<0.05$). The *Aframomum danielli* treatments had no significant effect ($P<0.05$) on the taste of *Irvingia gabonensis* seeds. Conversely, the flavour and overall acceptability were influenced significantly ($p<0.05$) as treatment levels increased, this can be seen from the fact that the 20% *Aframomum danielli* treated sample was the most consumers accepted sample (7.2). It was deduced from this research that the 20% treatment level had the most significant effect on the nutritional rate of microbial inhibition as well as the overall consumer acceptability of the treated product (Uzor-Peters et al., 2019).

Fresh kola nuts (*Cola nitida*) were thermally processed (blanched, boiled and roasted) for different periods of time (5, 10, 15 and 20 minutes respectively) at different temperatures (65, 75, 85 and 95°C). Boiling was done at 80°C while roasting was at 108.5°C, and steam blanching duration was 5, 7.5, 15 and 20 seconds respectively. The nuts were then diced, grated and stored for subsequent analysis in a Haier thermocool freezer. Subsequent study of the effects of the various treatments on the proximate and the caffeine contents of the kola nuts revealed that increase in temperature and duration of boiling resulted in product with lower caffeine content. However, product with the lowest caffeine content was produced during steam blanching at 108.5°C for 5 seconds. The various treatments also produced kola nut powder with darker colour but to varying degrees of darkness. These results are discussed in relation to the quality of kola nut powders for different product applications (Ogunmoyela, et al., 2011)

7.4 Fortification/Complementation/Enrichment

The effect of fortification of *gari* with different quantities of dehulled groundnut flour (10%, 15%, and 20%) on the sensory characteristics of *gari* was studied. Result showed that the chemical characteristics of the cassava mash started to change even after dewatering and fermentation (66.35% to 44.87% moisture for raw, dewatered and fermented cassava mash respectively). The ash content of the dewatered and fermented mash was also significantly higher (0.690%) than the raw sample (0.066%) at 0.05 significant level. The addition of the different levels of groundnuts also led to products with significant increase in the percentage fat content (6.65% for 10% groundnut fortified), slight increase in protein and ash contents, but reduction in percentage carbohydrates (91.65% for unfortified *gari* and 87.44% for 10% fortified one). However, the increase in the level of substitution resulted in gradual reduction of crude fibre content of the *gari* (0.650% for 10% fortification and 0.360% for 20% level of fortification). The carbohydrate content of the products was also reduced (Arisa, et al., 2011).

Kokoro, a local maize snack made from substitution of maize flour with either defatted soybean or groundnut cake flour (9:1, 7:3, 5:5, 3:7 and 1:9 substitution ratios) were evaluated for proximate and sensory qualities. Increase in substitution ratio produced kokoro with higher nutritional content (28.46 and 35.10 percent protein for those made from 1:9 substitution ratio respectively). Increase in substitution with the two substitutes progressively increased protein and fat content but reduced the ash, crude fibre and carbohydrate contents. Moreover, the crispiness and over all acceptability of the kokoro decreased with increasing substitution. Products made from 9:1 substitution were well accepted and compared favourably with whole maize product. (Uzor-Peters et al., 2008).

Trifoliate yam (*Dioscorea dumentorum*) is an underutilized yam specie which is highly nutritious, but cannot be stored for a long period like other yams because it hardens a few days after harvest especially if bruised, making it unavailable all year round. There is therefore the need for processing of the yam to stable product. Trifoliate yam flour was produced and enriched with pumpkin (*Telfaria occidentalis*) seed flour at three substitution levels (10%, 15% and 20%) and processed into chin-chin, this product was compared with chin-chin made from Irish potato (*Solanum tuberosum*) flour. The flour was analysed for physico-chemical, functional and pasting properties. The product made from the flour (chin-chin) was tested for proximate composition and sensory evaluation to determine its acceptability. Results showed that enrichment of trifoliate yam

flour with pumpkin seed flour increased the pH of the flour from 5.95 at 10% substitution to 6.03 at 15% substitution level, while the protein content also increased from 14.23% (10% substitution) to 16.53% (20% substitution). There was also an increase in fat content at the same substitution level. Peak viscosity of the flour decreased from 344.17RVU (10% substitution) to 269.25 (20% substitution). The overall acceptability showed that 10% substitution level had the highest rating and there was no significant difference in the chin-chin made from the enriched flour at the different substitution levels ($P>0.05$) (Adelekan, et al., 2016).

The use of African yam beans flour and shrimps flour in the production of different cereal blends were studied. African yam beans and shrimp flour were used to fortify maize flour in order to increase the nutritional value of the maize based cereal blends. Proximate, mineral, amino acid profile, anti-nutritional and sensory analyses were carried out on the six different blends (BC1-75% Maize, 10% African yam bean, 5% Shrimps; BC2-65% Maize, 20% African yam bean, 5% Shrimps; BC3-55% Maize, 30% African yam bean, 5% Shrimps; BC4-70% Maize, 10% African yam bean, 10% Shrimps; BC5-60% Maize, 20% African yam beans, 10% Shrimps; BC6-50% Maize, 30% African yam bean, 10% Shrimps). The results showed an increase in protein content of all the cereal blends as compared to the maize flour. The values ranged from 11.82% for BC1 to 16.96% for BC6, the protein content increased with increase in substitution level. Mineral content also followed similar trend. The amino acid profile showed that leucine content in BC6 had the highest value (9.38 g/16N) while BC1 had the lowest value (7.57 g/16N). Sensory evaluation showed that there was no significant difference between the organoleptic properties, but BC2 had the highest consumer acceptability in terms of colour, aroma and flavour (Adelekan, et al., 2012).

Composite flour blends of; wheat flour, benniseed flour and trifoliolate yam of ratios; 90:5:5(WBT1), 70:15:15 (WBT2) and 50:25:25 (WBT3) respectively were utilized in the production of biscuits; WBTB1, WBTB2, WBTB3 respectively. Increase in benniseed and trifoliolate yam substitution ensued improvements in; protein (0.78% and 3.49%, respectively), fat (5.47% and 2.79%, respectively), ash (0.89% and 0.80% respectively), and crude fibre (2.27% and 1.30% respectively) and decline ($P<0.05$) in; moisture (2.29% and 1.67%, respectively) and carbohydrate (7.08% and 6.24%, respectively) of both composite flours and biscuits. Magnesium (0.27%), manganese (0.07%), sodium (0.14%), Calcium (0.38%), Iron (0.09%) and copper (0.15%) contents of the composite flours were boosted with increase in beniseed and trifoliolate yam. WBT1 had the superior;

bulk density, water absorption capacity and swelling capacity (0.66g/ml, 149.92% and 6.85ml., respectively). WBTB1 was the most sensory accepted. This study further indicates the suitability of cereal-tuber based flours for the baking industry (Arisa, et al.,2017).

Trifoliate yam (*Dioscorea dumetorum*) is a tropical tuber crop that has found less food applications. This was therefore conducted to explore additional ways to utilize trifoliate yam in food product preparation. Peeled and properly cleaned samples of trifoliate yam or potatoes were either diced and boiled or cut into cubes and fried with refined vegetable oil. Another batch of cleaned cubed trifoliate yam or potatoes was made into pottage or diced and made into meat pie fillings using standard procedures. Products were analysed for some nutritional and sensory characteristics using standard methods. The fat content of boiled trifoliate yam was 0.95 and potato was 0.66 %, fried trifoliate yam had 15.29 % fat and potatoes had 14.39 % fat and meat pies made from trifoliate yam and potato had 8.82 and 8.32 % fat respectively. Trifoliate yam had alanine, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine and valine contents which were greater than those of potatoes. Meat pies made from trifoliate yam had score of 7.40 compared to that made from potatoes (7.30) in terms of appearance. Overall acceptability of potato pottage was higher than that of trifoliate yam. The study revealed that trifoliate yam can be eaten as boiled or fried yam, pottage and used for meat pie filling (Arisa et al., (2021)

Table 4: Sensory Characteristics of the Trifoliate Yam and Potato products

Treatment	Colour	Appearance	Taste	Texture	Mouth feel	Overall acceptability
FRIED						
FTY	6.60	6.70	6.10	6.25	6.05	6.40
FP	8.10	7.65	8.35	7.55	7.90	8.20
T-value	-1.923	-15.000	-3.889	-6.667	-5.000	-45.000
Sig. P	0.305	0.042	0.160	0.095	0.126	0.014
BOILED						
BTY	7.00	6.65	6.65	6.95	7.35	7.35
BP	7.25	6.95	7.00	7.15	7.45	7.80
T-value	-75.000	-23.750	-22.500	-43.333	-185.000	320.000
Sig. P	0.008	0.027	0.028	0.015	0.003	0.002

BAKED

MPTYF	7.05	7.45	7.05	7.25	7.007.30	
MPPF	7.05	6.90	7.20	7.05	7.60	7.40
T- value	13.933	13.750	-15.000	4.000	-12.000	730.000
Sig P	0.046	0.046	0.042	0.156	0.053	0.001
POTTAGE						
TYP	7.60	7.15	5.60	6.15	6.60	6.95
PP	7.35	7.05	7.05	7.10	7.85	8.00
T- value	2.778	10.000	-48.333	-15.833	-20.833	347.50
Sig F	0.220	0.063	0.040	0.040	0.031	0.002

TY: Trifoliate yam, P: Potato, BTY: Boiled trifoliate yam, BP: Boiled Irish potato, FTY: Fried trifoliate yam.

FP: Fried potato, MPTYF: Meat pie trifoliate yam filling, MPPF: Meat pie potato filling

TYP: Trifoliate yam pottage, PP: Potato pottage.

Bambara nut, an underutilized legume is rich in protein and can improve the nutritional quality of snacks. This study evaluates the nutritional and sensory properties of muffins produced from germinated maize and Bambara groundnut flours. Maize and Bambara groundnut seeds were germinated (72 hours), oven-dried and milled. The composite flours from the germinated flours were combined with soya oil, tiger-nut milk, date and carrot powder to produce four samples of muffins. The samples were chemically analyzed for proximate, mineral, beta-carotene, and anti-nutrient contents. Then, sensory evaluation was carried out among 20 mothers (20-30) using a 5 hedonic scale. ANOVA and Duncan Multiple Range Test were also used to analyze the data. Protein, fiber and carbohydrate contents of the muffins ranged from 7.63-9.23%, 0.05-0.08% and 70.63-71.55%, respectively. It was found that germination significantly increased protein and iron content of muffins but reduced zinc, calcium, and beta-carotene contents ($P < 0.001$). The muffins contributed above 22% of the RDA regarding energy for children. Muffins produced from the blends provided higher level of protein, calcium, iron and beta-carotene compared to those made from whole wheat flour. There was a significant reduction in anti-nutrient

contents of the muffins and germinated flours. The muffin produced from the 80% maize and 20% Bambara nut flour was rated best in terms of nutritional value, taste, and texture. Bambara nut flours could be used to produce nutritious snacks which would contribute to daily energy and protein needs of children (Anaemene, et al., 2024).

Consumption of foods high in fats contributes to increased blood fat level which has been linked to cardiovascular diseases. Replacement of shortenings in pastries with plant oils may reduce blood fat. This study evaluated the proximate, microbiological and sensory properties of cookies produced from blends of yellow maize (YMF) and *Dacryodes edulis* (DMF) flour as well as the functional properties of the flour blends. Cookies were produced from the blends of DMF and YMF. The protein, fibre, fat, ash and carbohydrate contents of DMF were 6.19%, 11.85%, 41.60%, 3.93% and 17.58%, respectively. Final viscosity (817.48- 333.28 RVU) of the flour blends reduced significantly with the addition of DMF. Except for protein (20.44-22.73%) and fat (20.08- 22.03%) contents, the ash (3.03-2.35%), fibre (1.98-1.48%), and carbohydrate (50.12-46.69%) contents of cookies without shortening decreased with increased DMF substitution. Cookies prepared with shortening had higher fat but lower ash, moisture, fibre, protein and carbohydrate contents than those without shortening. The total bacteria, fungi and coliform counts in cfu/g for cookies prepared with and without shortening ranged from 1.0×10^3 - 7.03×10^3 , 1.0×10^3 - 1.3×10^3 and 1.0×10^3 - 6.68×10^3 , respectively. There were no significant differences among the cookies in terms of aroma, crunchiness and overall acceptability. Cookies of good nutritional, microbial and sensory quality could be produced from yellow maize and African pear flour at less than 40% substitution level (Arisa, et al., 2021)

7.5 Traditional beverages

The nutritional, microbiological and sensory characteristics of improved *kunun-zaki* produced from malted cereals enriched with malted soymilk at different substitution levels (0%-30%) were investigated. Enrichment with soymilk and malting increased the protein, amino acid, ash and moisture content of the improved *kunun-zaki*. Malting resulted in a decrease in carbohydrate and fat content. The protein content of the malted samples ranged between 2.79% and 3.82% while that of unmalted was 2.36%. There was decrease in the concentration of phytic acid and trypsin inhibitor after malting but the concentration increased as soymilk was added. Microbiological analyses showed that microbial load of samples increased with the addition of soymilk.

There was a significant difference ($p < 0.05$) in the sensory attributes, acceptability decrease, with increase in soymilk addition because of the beany flavor (Adelekan, et al., 2013).

The effect of enrichment with fruits (orange, banana and pineapple) on the nutritional, microbiological and sensory properties of sorghum based *Pito* was studied. Proximate, physico chemical, microbiological, vitamin and mineral content of the fruity *Pito* were analysed using the standard procedures. Results showed a significant increase in protein, fat and carbohydrate content of *Pito* as the fruits were added. Enrichment with fruit also caused an increase in physico chemical, mineral and vitamin contents of *Pito*. The viscosity of *Pito* increased upon the addition of fruits with Banana *Pito* having the highest viscosity. (3.9×10^{-3} Pa.s), the Orange *Pito* had the highest vitamin C content (3.56mg/100g). The microbial load of *Pito* was affected by fruit addition, fungal and bacteria load increased significantly with the addition of fruits. As storage days increased, the control (Commercially purchased *Pito*) had the highest microbial load (9.80×10^{-6} cfu/ml). There were significance differences in the taste, aroma, appearance, colour, flavor, mouth feel and overall acceptability of all the *Pito* samples ($p < 0.05$), but the pineapple *Pito* had the highest overall acceptability (Adelekan, et al., 2013).

The nutritional characteristics of enriched *zobo* drinks produced from the extract of *Hibiscus sabdariffa* mixed with juices of some selected fruits was studied. The physiochemical, mineral, nutritional and sensory properties of the *zobo* samples were investigated. The addition of fruits increased the protein content of the drink with the *iyeyezobo* having the lowest protein content of 2.00%; pineapple pepper fruit *zobo* had the highest value of fat 19.85%. The moisture content of the enriched *zobo*, increased significantly with the addition of different fruits. The pineapple *zobo* had the highest moisture content of 86.95%. The phytate and tannin contents in all the samples were found to be less than one per cent ($< 1\%$). The *iyeye zobo* had the highest amount of vitamin C (34.88mg/100g), while the lowest value was found in pineapple ginger *zobo* (29.28%). The pepper fruit *zobo* had the highest vitamin A content (141IU). There were significant differences in aroma, taste, appearance, flavor, mouth feel, color and overall acceptability between the *zobo* samples ($p < 0.05$), but the *zobo* with the mixture of all the fruits had the highest overall acceptability (Adelekan, et al., 2014).

(Adelekan., et al., 2014)).



Plate 9: Ripe Pepper fruits (*mmimi*)



Plate 10: Cassava roots

7.6 Roots and Tuber Processing

- Cassava (*Manihot esculenta* Crantz)

Cassava roots are roots with no natural dormancy. Cassava begins to deteriorate immediately after harvest. After three days of harvest, it begins to develop blue black streaks as a result of biochemical and microbiological reactions taking place in it. It is necessary to harvest cassava whole without bruises and cuts for the roots to be able to store for up to seven days. The roots should also be stored in cool dry well-ventilated places. Due to very low shelf-life of cassava, it is stored in the following ways:

- a) Underground: to be harvested when needed. This mode of storage results in theft by both animals and man.
- b) Storage in trenches.
- c) Storage in baskets covered by moist soil or saw dust.
- d) Storage in refrigerated systems mostly frozen.
- e) Storage as processed food or semi processed industrial material.

It is an important widely cultivated crop in the tropics. The root is encased in a detachable peel made of two layers of varying thickness depending on variety. They have different morphological forms and this makes their peeling by mechanical means difficult, while manual peeling is slow and labourious. The effects of chemical peeling methods using NaOH/Citric acid and NaOH/NaCl solutions on the root cells were investigated with microscopy. Elongation and expansion of parenchyma and vessel members of the xylem were apparent in the chemically peeled samples (Plates 11a and b, 12 b and b). Conversely, the

materials peeled manually showed the presence of tyloses (starch storage structures) and the parenchyma cells were comparatively short (Plate13 a and b). Mean vessel pore diameter was 83.2 μ m in the manually peeled samples but it was 146.3 μ m in samples peeled with NaOH/Citric acid and 158.0 μ m in the samples peeled with NaOH/NaCl solution ($p < 0.05$). The peeling action of the two peeling agents resulted in the disruption of the integrity of the root cells (Arisa, et al.,2016).

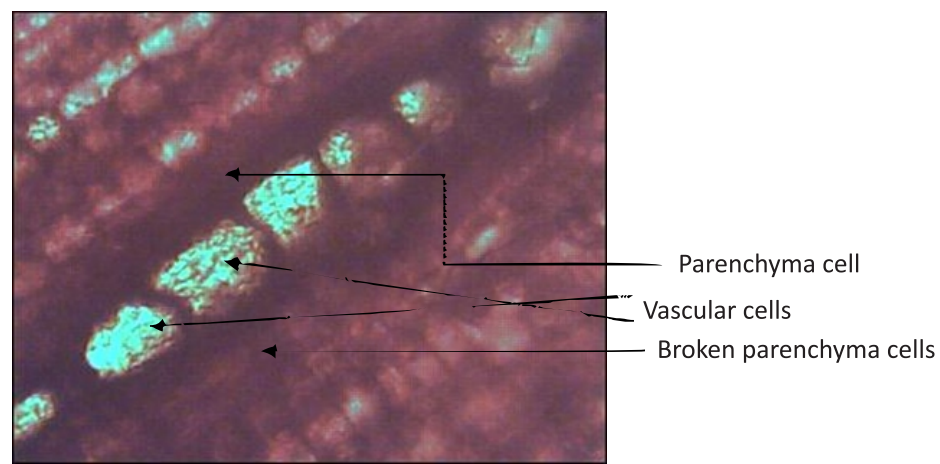


Plate 1a: Micro-structure of NaOH/NaCl peeled cassava root showing the vascular bundle

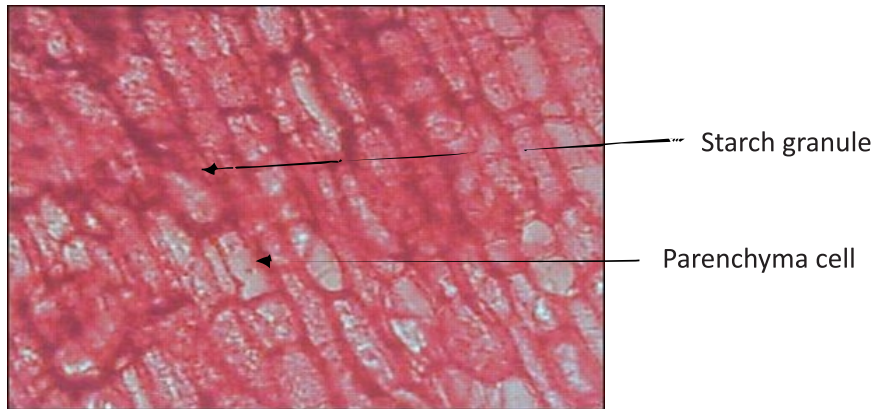


Plate 1b: Micro-structure of NaOH/NaCl peeled cassava root showing the Parenchyma cells

Note: Cell measured at X400 magnification

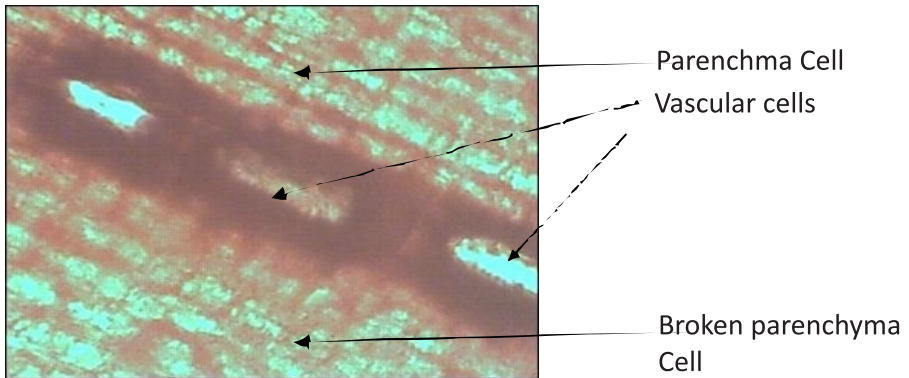


Plate 2a: Micro-structure of NaOH/citric acid peeled cassava root showing the vascular bundle

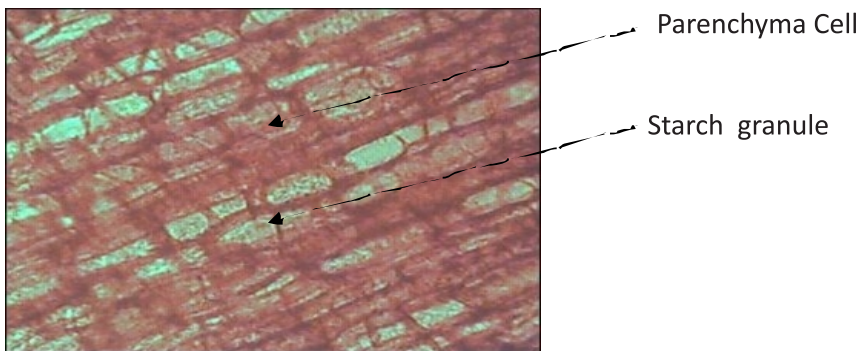


Plate 2 b: Micro-structure of NaOH/citric acid peeled cassava root showing Parenchyma cells

Note: Cell measured at X400 magnification#

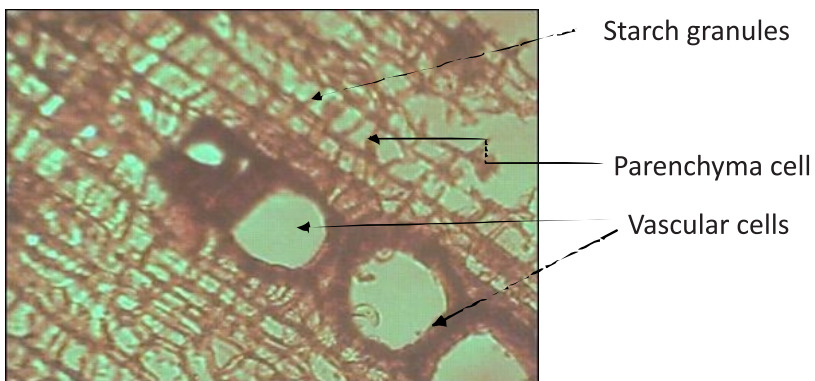


Plate 3 a: Micro-structure of cassava root showing the vascular bundle

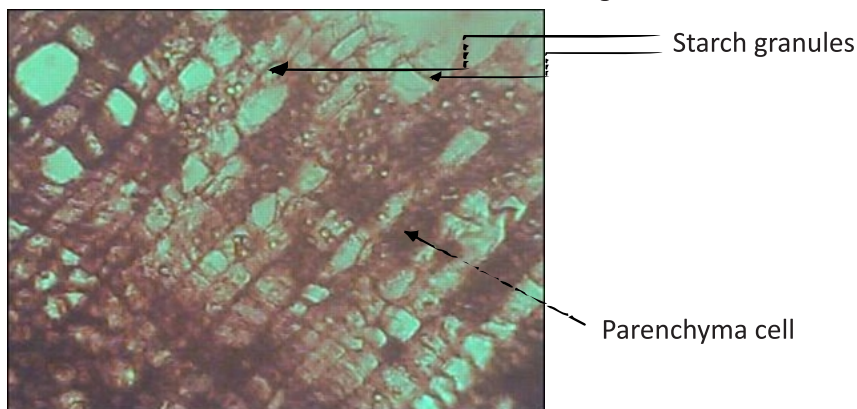


Plate 3b: Micro-structure of cassava root showing the Parenchyma cells

Note: Cell measured at X400 magnification

The effects of chemical peeling on some anti-nutritional and mineral contents of chemically peeled cassava flours and starches were studied. Batches of (TMS01/1371yr, TMS91/02324, TMS92/0326, TMS97/4763, TMS97/2205, TMS30572) roots were peeled using three different methods: manual peeling, chemical peeling with either 10% NaOH followed by treatment with 3% Citric acid, or 10% NaOH solution followed by treatment with 15% NaCl. Peeled roots were either chipped or processed into starch, and oven dried at 65°C. Dried chips were processed into flour. Flours and starches were analysed to determine some of their mineral and anti-nutritional characteristics. Results showed that phytate levels decreased from 6.28 mg/g for fresh cassava roots to 0.10, 0.13 and 0.10 mg/g in cassava flours obtained from manual, NaOH/Citric acid and NaOH/NaCl peeled TMS 30572 roots respectively. The HCN contents of the peeled cassava flour ranged between 9.06 to 16.56 mg HCN equivalent/kg. Peeling treatments resulted in reduction in the phytic and hydrogen cyanide contents of the cassava starches and significant increase in the Na content of some of the flours produced. Peeling with NaOH/Citric acid resulted in cassava starch with higher calcium content (14.85, 14.51, 25.9 and 58.31 mg/100g) for TMS 92/0326, TMS 97/2205, TMS 97/4763 and TMS 01/1371yr cassava cultivars respectively (Arisa & Aworh, 2016).

The variability in weight, size and shape of cassava roots which are encased in peel made up of a periderm (corky) and cortex makes peeling a major problem especially in large scale processing. Information on chemical peeling of cassava

and its effects on products are not common. This study investigated the effect of chemical peeling on the chemical and functional properties of some cassava products. Six cassava cultivars (two batches each) namely: TMS01/1371yr, TMS91/02324, TMS92/0326, TMS97/4763, TMS97/2205 and TMS30572 were immersed in 10% NaOH solution (1:2, w/v) at 96°C for 5 minutes, batches were either further immersed in 3% citric acid solution (1:2, w/v) at ambient conditions for 1 minute or immersed in 15% NaCl solution (1:2, w/v) at 96°C for 3 minutes. The softened peels of the pre-treated cassava roots were washed off under running water with hard brushing. Another batch was peeled using a stainless-steel knife. Peeled roots were processed into flours and starches, and analysed for chemical and functional properties using standard methods. Chemical characteristics of cassava roots were protein (0.11-0.16%), fat (0.05-0.32%), ash (0.73- 0.91%), fibre (0.24-0.29%), moisture (59.2-66.9%), sugar (0.28-0.50%) and starch (9.4-10.9 %). Protein content (1.15-2.05%) was highest in flours and starches made from cassava varieties peeled with NaOH/Citric acid. Water binding capacities (101.1-120.8%) was highest for NaOH/Citric acid pre-treated TMS92/0326. Swelling capacity ranged from 8.1 to 9.8% and solubility varied from 8.1 to 9.8% for the starches (Arisa & Aworh, 2018).

Cassava roots have domestic and industrial importance in the tropical and sub-tropical countries. This study investigated the effect of chemical peeling on the physical and sensory characteristics of cassava composite bread. Roots from six cassava cultivars namely: TMS01/1371yr, TMS91/02324, TMS92/0326, TMS97/4763, TMS97/2205 and TMS30572 were immersed in 10% NaOH solution (1:2, w/v) at 96°C for 5 minutes; batches were either further immersed in 3% citric acid solution (1:2, w/v) at ambient conditions for 1 minute or immersed in 15% NaCl solution (1:2, w/v) at 96°C for 3 minutes. The softened peels of the pretreated cassava roots were washed off under running water with hard brushing. Another batch was peeled using a stainless-steel knife. Peeled roots were processed into flour and flours were made into composite bread containing 10% cassava flour. Physical characteristics of bread loaves were evaluated using standard methods. Sensory attributes of loaves were determined using trained panelists. The loaf density of all wheat bread (0.13 g/mm³) was significantly lower than that of the composite bread (0.16-0.20g/mm³). There were no significant differences between the composite bread loaves and all wheat bread loaf in terms of crust colour, crumb colour, texture, flavour, aroma and eating quality ($p < 0.05$) (Arisa & Aworh, 2019).

Cassava roots peeling remains a serious global challenge due to their varying

sizes and shapes. This results in over or under-peeling during mechanized and automated operations. This study was carried out to investigate the effect of chemical peeling on physiochemical, microbiological and functional characteristics of some cassava products. Yellow-fleshed cassava (IITA-TMS-IBA070593) was peeled by immersing the roots in 15% NaOH solution (lye) for 5 minutes. Softened peels were removed with brush under running water and neutralized with 3% citric acid solution at 30°C. Cassava peeled with sharp stainless-steel knife was used as control. Peeled roots were fermented into stiff dough mill known as *Gari* and *Fufu* after 72 and 96 hours respectively. pH, total titratable acidity (TTA) and total plate count (TPC), bacterial and fungal counts were determined on fermenting mash at 0, 24, 48, 72 and 96 hours respectively. Results showed that pH of submerged state fermenting mash for *fufu* and solid-state fermenting mash for *gari* decreased as TTA increased during fermentation. pH decreased from 8.29 at 0 hour to 5.34 at 96 hours, while TTA increased from 0.20 at 0 hour to 1.60 at 96 hours. TPC increased from 0.5×10^4 CFU/g to 1.7×10^4 CFU/g, lactic acid bacteria count (LABC) increased from 1.9×10^4 CFU/g to 20.8×10^4 CFU/g, while fungal count increased from 1.8×10^4 CFU/g to 8.4×10^4 CFU/g. Dispersibility ranged from 40.50% to 75.50%, bulk density ranged from 0.59g/ml³ to 0.78g/ml³, water absorption capacity varied between 1.80g/g and 6.00g/g, while swelling power ranged from 14.39% to 15.50%. Products made from chemically peeled cassava compared favourably with knife peeled ones (Arisa & Daramola, 2020).

Cassava is an important root crop cultivated mainly because of its carbohydrate rich flesh encased in a corky periderm and smoother cortex which together make up the peel. The relationship between some physical characteristics (peel thickness, length of root, peel percentage, width, proximal, distal and middle diameters of cassava cultivars (TMS 01/1371yr, TMS 91/02324, TMS TMS 30572, TMS 92/0326, TMS 97/4763 and TMS 97/2205) and effectiveness of some chemical peeling agents were studied. Respective cassava roots were either manually peeled or chemically peeled using 10% NaOH solution at 96°C followed by treatment with 3% citric acid at ambient temperature or 15% NaCl (96°C). Effectiveness of peeling treatments was determined. Results were statistically analyzed Results confirmed the fact that cassava has non-uniform shapes and sizes as cassava variety TMS 97/4763 had 6.43cm distal, 3.75cm proximal and 5.823cm middle diameters, TMS 01/1371yr and TMS 97/2205 varieties had 5.64cm distal, 4.87 proximal and 5.48cm distal, 7.29cm middle and 4.18cm proximal diameters respectively. It was found out that TMS 97/2205 had highest

peel thickness (0.57) and TMS 91/02324 had thinnest peel thickness. Peeling effectiveness ranged from 52.7 to 98.4% and 42.6 to 95.6% for NaOH/NaCl and NaOH/Citric acid peeled samples. Peel thickness, peel texture and type of chemical peeling agent affected the effectiveness of peeling process (Arisa, 2019).

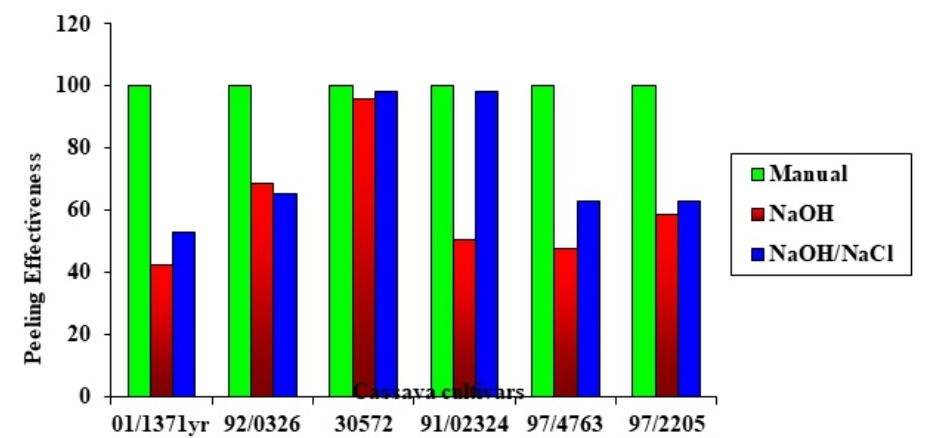


Figure 1: Peeling Effectiveness of the Various Peeling Treatments

Source: (Arisa, 2019).

- Trifoliolate Yam (*Dioscorea dumetorum*) Ona

Trifoliolate yam, a fleshy potato-like tuber is used for food in some areas of the tropics. In order to add variety to ways in which trifoliolate yam is utilized, this work was done. Peeled and properly cleaned samples of trifoliolate yam or potatoes (3710 g) were either diced and boiled in 2000 ml water or cut into cubes and fried in 2000 ml refined vegetable oil. Another batch (2190 g) of cleaned cubed (moderately medium) trifoliolate yam or potatoes was made into pottage or diced and made into meat pie fillings. Products were analysed for some nutritional and sensory characteristics using standard methods. The fat content of boiled trifoliolate yam was 0.95 and potato was 0.66 %, fried trifoliolate yam had 15.29 % fat and potatoes had 14.39 % fat and meat pies made from trifoliolate yam and potato had 8.82 and 8.32 % fat respectively. Trifoliolate yam had alanine, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine and valine contents which were greater than those of potatoes. Meat pies made from trifoliolate yam had score of 7.40 compared to that made from potatoes (7.30) in terms of appearance. Overall acceptability of potato pottage was

higher than that of trifoliate yam. The study revealed that trifoliate yam can be eaten as boiled or fried yam, pottage and used for meat pie filling (Arisa *et al*, 2021)



Plate 14: Trifoliate yam *Dioscorea dumetorum* Three leaved yam (*Ona*)

Roots and tubers, essential food crops with substantial industrial potential in Sub-Saharan Africa, face underutilization in Nigeria, where only approximately 5 % of the produced root and tuber crops find industrial applications. This study explored the physical, thermal, mechanical, and electrical properties of white yam (*Dioscorea rotundata*), water yam (*Dioscorea alata*), bitter yam (*Dioscorea dumetorum*), cocoyam (*Colocasia esculenta*), and sweet potato (*Ipomoea batatas*). The weight of the roots varied widely, ranging from 41.22 g to 1169.80 g for cocoyams and white yams, while density varied from 1332.99 g/mm³ to 1990.35 g/mm³ for cocoyam and bitter yam, respectively. Thermal conductivity of the products ranged from 0.4042 to 0.4729 Wm⁻¹K⁻¹, while specific heat capacity, latent heat of fusion, and thermal diffusivity measured between 0.4042 to 0.4729 Wm⁻¹K⁻¹, 2.777 to 3.303 S/cm, 167.44 to 228.54 kJ Kg⁻¹K⁻¹, and 6.414 to 9.933 kJ K⁻¹, respectively. Compressive and tensile strengths varied from 0.609 to 2.354 kN and 0.091 to 0.822 kN, respectively, showcasing notable differences among the root and tuber crops

Volume

The unit volume (V) of individual roots and tubers was estimated from the

values of length (L), width (W) and thickness (T) using the method of Mohsenin, (1970) as

$$V = \frac{\pi(LWT)}{6}$$

Density

The density of 10 pieces of white yams and water yams, 20 pieces of bitter yams, and 50 pieces of sweet potatoes and cocoyams were estimated according to the method of Rahman (1995). This was done by dividing individual mass by unit volume. The average of total individual values was then recorded as the density value.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Weight

The weight of the roots and tubers crops were determined by weighing 10 randomly selected samples using Ohaus analytical balance (Model: ACS-50) and average weights were calculated. Thermal Conductivity

The thermal conductivity (K) of food materials is related to the composition of the material and was estimated using the empirical method described by Sweat (1986) as

$$K = 0.25mc + 0.155mp + 0.16mf + 0.135ma + 0.58mm \quad 4$$

Where, mc = mass of carbohydrate; mp = mass of protein; mf= mass of fat; ma = mass of ash and mm = mass of moisture present in the food material.

Specific Heat Capacity

The specific heat capacity of the roots was estimated using the method of Miles et al., (1983) as

$$C_p = M_w C_w + M_s C_s \text{ (KJ Kg}^{-1}\text{K}^{-1}\text{)} \quad 5$$

Where, Cp = specific heat capacity; M_w = mass fraction of water, C_w= specific heat capacity of water (4.18 KJ Kg⁻¹k⁻¹), M= mass fraction of solids, and C_s = specific heat capacity of solids (1.46 KJ Kg⁻¹K⁻¹).

Latent Heat of Fusion

The method of Lamb, (1976) was used to estimate the latent heat of fusion as

$$L = 335 M_w \text{ (KJ Kg}^{-1}\text{)} \quad 6$$

Where, M_w= mass fraction of water.

Thermal Diffusivity

The thermal diffusivity was estimated as described by Lewis, (1987) as

$$a = \frac{K}{\rho C_p}$$

Where:

A= thermal diffusivity, K= thermal conductivity, ρ - density, cp= specific heat capacity.

Mechanical Properties of the Selected Roots and Tubers Crop

Samples	Compressive	
	Strength	Tensile Strength
RHY	0.609± 0.09 ^c	0.091± 0.01 ^e
RWY	1.307± 0.07 ^b	0.275± 0.03 ^d
RBY	1.609± 0.14 ^b	0.562± 0.07 ^b
RCY	1.466± 0.20 ^b	0.480± 0.03 ^c
RSP	2.354± 0.33 ^a	0.822± 0.04 ^a

Means with the same superscript in the same column are not significantly different at P≤0.05.

Legend

RHY: Raw Water Yam, RWY: Raw White Yam, RBY: Raw Bitter Yam, RCY: Raw Cocoyam Corm, RSP: Raw Sweet Potato

Furthermore, the electrical conductivity ranged from 1145 to 1701 μS/cm. This study underscores the significant variations in the physical characteristics of root and tuber crops. Notably, the thermal properties, mechanical properties, and electrical conductivity of these crops exhibit interdependence, likely influenced by moisture content. The study showed the disparities in the physical attributes of the root and tuber crops studied. The thermal characteristics, mechanical properties, and electrical conductivity have a noticeable association with their moisture level. The correlation between these features and moisture content emphasizes the significant impact of moisture on the overall characteristics of roots and tubers. Notably, the different crops displayed significant variations in weight, length, densities, thermal conductivities, specific heat, and latent heat. The diversity of root and tuber varieties is evident

in their distinct composition and structural characteristics. Additionally, the fact that these qualities are linked to moisture content shows how important it is to study and understand how moisture affects the physical, thermal, and mechanical properties of different agricultural goods (Arisa *et al.*, 2024).

Table 6. Physical Characteristics of the Selected Roots and Tubers Crops

Samples	Weight (g)	Length (mm)	Width (mm)	Area (mm ²)	Volume(mm ³)	Density(g/mm ³)
RHY	697.54± 4.55 ^b	143.55±1.51 ^b	75.68±0.52 ^a	430644.24±21.3 ^b	398.38±2.43 ^b	1619.76± 9.92 ^c
RWY	1169.80±24.94 ^a	338.71±1.48 ^a	70.33±0.83 ^b	877571.73±16.7 ^a	804.97±1.84 ^a	1332.99±18.24 ^c
RBY	57.47 ± 0.83 ^d	48.37 ± 1.18 ^c	33.77±1.03 ^d	28894.26±8.34 ^c	28.46± 0.89 ^d	1990.35 ± 7.78 ^b
RCY	41.22 ± 0.95 ^d	60.53± 1.54 ^d	29.82±0.38 ^c	28194.17±8.9 ^c	25.82± 0.51 ^d	1462.01±24.17 ^d
RSP	456.21±0.15 ^c	127.24±1.00 ^c	57.97±0.90 ^c	233977.11±10.2 ^d	206.52±2.83 ^c	1949.81±14.14 ^a

Means with the same superscript in the same column are not significantly different at P≤0.05.

Legend

RHY: Raw Water Yam, RWY: Raw White Yam, RBY: Raw Bitter Yam, RCY: Raw Cocoyam Corm, RSP: Raw Sweet Potato

7.7 Nutrition and Dietetics

Malnutrition is prevalent in infants during complementary feeding in parts of developing countries. This is especially so, due to the high cost of infant formulas and other weaning foods in this region. This study compounded and evaluated some quality characteristics of complementary foods made from combinations of an underutilized root crop (trifoliolate yam) and some readily available food materials. The complementary foods were made from trifoliolate yam, kidney beans, tilapia fish, vegetable oil, sugar and either date and carrot (TKDC) or tiger nut and pawpaw (TKTP) in ratios of 60:10:10:5:5:7:3 or 60:10:10:5:5:5:5, cooked in stainless- steel pot, dried, milled and analyzed for proximate, minerals, beta-carotene, tannin, amino acids profile, characteristics and impact on growth upon consumption. Proximate, minerals, vitamin, tannin and amino acid profile and sensory characteristics of complementary foods

varied significantly ($P<0.05$) from one another with TKTP having higher protein (12.32%), fats (21.87 %), ash (5.2 %) contents than TKDC. However, in terms of overall acceptability (8.10) taste (8.10) and aroma (8.00), TKDC was better accepted than TKTP. Feeding of test animals with complementary foods resulted in weight gains of between 60.96g to 113.62g (TKTP) and 57.32 to 105.92 (TKDC). The complementary foods were comparatively nutritious (Arisa et al., 2024).

Table 7. Amino Acid Profile of the Complementary foods

Samples	TKTP	TKDC
Isoleucine	2.75 ± 0.0212	2.67 ± 0.0141
Lysine	2.95 ± 0.0283	2.87 ± 0.0283
Histidine	3.34 ± 0.00212	3.25 ± 0.0212
Phenylalanine	3.13 ± 0.0283	3.07 ± 0.0283
Leucine	5.44 ± 0.0283	5.35 ± 0.0568
Tryptophan	1.26 ± 0.0212	1.20 ± 0.0353
Methionine	1.54 ± 0.0141	1.33 ± 0.0212
Threonine	2.52 ± 0.0212	2.41 ± 0.0212
Valine	8.25 ± 0.0212	8.13 ± 0.083
Ornithine	0.35 ± 0.0283	0.30 ± 0.0141
Alanine	2.16 ± 0.0212	2.04 ± 0.0141
Arginine	6.45 ± 0.0736	6.30 ± 0.0141
Aspartic acid	2.15 ± 0.0212	2.09 ± 0.021
Cysteine	4.09 ± 0.0212	4.00 ± 0.0353
Glutamicacid	11.66 ± 0.0212	11.57 ± 0.0253
Glycine	3.06 ± 0.0141	2.95 ± 0.0283

Proline	4.65 ± 0.0283	4.54 ± 0.0283
Tyrosine	3.28 ± 0.0212	3.20 ± 0.0283
Serine	1.91 ± 0.0424	1.81 ± 0.0212
Cystine	2.03 ± 0.0283	1.93 ± 0.0212

Means ± standard deviation

LEGEND

TKTP: Trifoliate yam kidney beans tiger nuts and pawpaw

TKDC: Trifoliate yam kidney beans dates and carrots

Table 8 Effect of Consumption of the Complementary Foods on Weight Gain

SAMPLE	WEEK0 (g)	WEEK 1(g)	WEEK 2 (g)	WEEK 3 (g)
TKTP	60.96 ± 0.10	74.380 ± 16.16	95.293 ± 15.83	113.62 ± 13.58
TKDC	57.32 ± 0.40	64.640 ± 17.12	85.507 ± 20.07	105.92 ± 15.98
CERELAC	52.62 ± 0.20	55.420 ± 11.13	79.147 ± 17.45	99.167 ± 16.36
CONTROL	56.6 ± 0.30	64.353 ± 12.33	81.433 ± 12.66	100.13 ± 13.60

Means ± standard deviation

LEGEND

TKTP: Trifoliate yam kidney beans tiger nuts and pawpaw

TKDC: Trifoliate yam kidney beans dates and carrots

A study was carried out to determine the prevalence of overweight, obesity and dietary habits of undergraduate students of Lagos State University. The study was a descriptive cross-sectional survey carried out at Lagos State University, Lagos, Nigeria, between June 2016 and July 2016. 150 undergraduate students were selected through multistage random sampling. Information on socio-demographic characteristics, dietary habit and physical activity was obtained using structured questionnaire. Weight, height, Percentage Body Fat (PBF), waist and hip circumferences were measured according to standard procedures to compute Body Mass Indices (BMI), Waist Hip Ratio (WHR) and finally determine nutritional status. The data were presented as frequencies, percentages, mean and standard deviations. Chi square was used to test for significant differences and level of significance set at 0.05. The mean BMI, PBF

and WHR of the participants were $23.4 \pm 2.3 \text{ kg/m}^2$, $23.1 \pm 5.0 \%$ and 0.83 ± 0.09 , respectively. Majority of the participants (86.7%) were of normal weight while 8% (10.4% males and 5.5% females) and 5.3% (5.2% males and 5.5% females) were overweight and obese, respectively. Using WHR, more number of students were overweight/obese (34%) compared to BMI (13.3%) and PBF (8.7%), all indicated higher abnormal status among males than females. Few students exhibited poor eating (15%) and physical inactivity (16%) habits. Majority of the students (75.3%) skipped breakfast and the least daily consumed food group was legume/nut group (0.5%). Snacks (42%) and processed (20%) foods were consumed more than roots/tubers (14%) which are staple foods. Central obesity was high among undergraduate students of Lagos State University. Breakfast skipping and low legume meal consumption were major dietary problems. Healthy lifestyle should be promoted among the university students to prevent overweight/obesity and its associated diseases. (Arisa et al., 2020)

7.8 Animal foods

- **Milk Product**

This study was carried out to optimize the production process and assess the quality parameters and shelf-life of cheese product obtained from cow milk using *Moringaoleifera* seeds extract as a coagulant. Optimum processing conditions were determined using response surface methodology (RSM). The optimum conditions established showed 1.5% concentration of *M. oleifera* seed extract and 55°C coagulation temperature. Cheese made was subjected to physicochemical, sensory, and microbiological analyses and compared with cheese produced using *Calotropisprocera* extract as a coagulant (CPC1). Shelf-life studies were carried out by subjecting them to storage at ambient and refrigeration temperatures for 10 days. Results showed that cheese produced using *M. oleifera* seed extract as a coagulant (MOC) had the highest protein and fat contents of 28.14% and 17.68%, respectively. The sensory attributes were improved and it had the longest shelf-life of 8 days at ambient temperature ($28 \pm 2^\circ\text{C}$). This study showed that optimization of the cheese production resulted in cheese with better proximate characteristics, sensory attributes, and longer shelf stability. This research showed that *Moringaoleifera* seeds extract has better coagulating and antioxidant properties when compared with the conventional extract (*Calotropisprocera*) used in the production of local cheese. The cheese produced with the former had a better yield, proximate

characteristics, sensory attributes, and longer shelf stability. Basically, the preservative ability of this natural extract is very commendable as it does not have any side effects unlike other synthetic preservatives used in dairy products and is also readily available (Adesina et al, 2021).

- *Pomo/Kanda/akpukpoanu*

Cowhides commonly referred to as *Ponmo* (Yoruba), *Kanda* (Hausa) and *Akpukpoanu* (Igbo) are relished in several parts of Africa. Fresh cowhide with fur (9064g) was either dipped in 10000 ml hot water (85°C for 30 seconds) or placed in a fire made by burning fire wood until the hair was charred. Hair on the skin was carefully scraped off with a sharp new stainless- steel knife or charred hair was scrubbed off with an iron sponge under running water. *Ponmo* made was analysed for proximate, mineral, amino acid profile and microbiological characteristics using standard procedures. Results showed that the protein content of the edible hides and skin (cow) produced using the different processing methods varied from 5.38% (brown *ponmo*-singed market-bought) to 7.34% (white *ponmo*-lab processed). Crude fibre content of the edible hides and skin (cow) produced using the processing methods varied from 3.5% (brown *ponmo*-singed market-bought) to 3.75% (white *ponmo*-lab processed {control}). The amino acid profile of the *ponmo* samples was lower than that of beef. Market-bought *ponmo* (Brown) had a microbial load of 2.5×10^6 cfu/ml, Lab-Processed *ponmo* (Brown) had 1.7×10^6 cfu/ml and the Market-bought *ponmo* (White) had a microbial load of 2×10^6 cfu/ml.

Table 9 Amino acid profile of the edible cowhides (*ponmo*)

SAMPLES	BPMB	I P	W PMB	BPLP(Control)	W PLP(Control)
Alanine	1.67	1.14	2.87	1.78	2.91
Aspartic acid	3.28	3.05	4.11	3.49	4.29
Lysine	0.87	0.69	1.13	1.02	1.25
Methionine	1.05	0.92	1.24	1.25	1.52
Cysteine	1.46	1.35	1.89	1.72	1.98
Tryptophan	1.27	1.14	1.65	1.51	1.81
Cysteine	2.66	2.43	2.86	2.72	2.95
Valine	0.92	0.81	1.08	0.99	1.37
Leucine	3.78	3.54	4.63	3.94	4.78
Isoleucine	2.94	2.79	3.26	3.17	3.52

Arginine	2.53	2.36	3.18	2.66	3.38
Threonine	1.79	1.65	1.94	1.92	2.05
Phenylalanine	3.43	3.24	4.49	3.82	4.82
Serine	3.95	3.83	4.36	4.05	4.85
Glutamine	2.25	2.17	3.44	2.72	3.78

Legend

IP-IjebuPonmo,

BPM B-Brown PonmoMarket Bought,

BPLP- Brown PonmoLab Processed(Control),

WPM B-WhitePonmoMarketBought,

WPLP-White PonmoLab Processed (Control)

Table 10. Microorganisms present in the edible cowhides (*ponmo*)

Colony	Organism
1	<i>Staphylococcus aureus</i>
3	<i>Bacillus subtilis</i>
7	<i>Staphylococcus spp.</i>
10	<i>Staphylococcus mitis</i>
11	<i>Escherichia coli</i>

8.0 Conclusion and Recommendations

Prior to now, I had believed and said that Nigeria produced more than adequate quantities of food she requires to feed her teeming population. I had in several occasions opined that post-harvest losses due to wrong post-harvest handling and low value addition was responsible for food insecurity in the country.

Recent events and occurrences in the country have shown that activities beyond inappropriate pre and post-harvest activities are responsible for food shortage and food insecurity in the country. As it is, the country does not produce adequate food for her population due to insurgencies that have led to insecurity, poorly implemented food and agricultural policies and poor infrastructure.

- There is need for Federal and State governments to take all necessary steps, as a matter of urgency to end insecurity in the country. The root causes of the spate of insecurity that has chased farmers from their farm lands should be tackled to reduce inflation of prices of food and food insecurity in the

country. The displacement of farming communities that is still going on by herders and bandits must be brought to an end for the sake of the future of the country and her existence as a country with sustainable food system.

- The government should bring up deliberate policies that will make farming interesting and a veritable lucrative economic venture. This cannot be achieved except there is security. Farming settlements with housing, modern schools, markets, hospitals, adequate power supply and information and communication technology facilities should be established. This will reduce urban migration, youth unemployment and ultimately the insecurity.
- The Government of Nigeria should assist farmers and primary food processors in procuring needed food preservation facilities such as refrigerated storage facilities, refrigerated transportation vehicles and distribution and retail display equipment.
- The roads to farming areas should be rehabilitated. There should be provision of social amenities in the rural areas where the farms are located to encourage rural dwelling of both farmers and processors.
- There is need to set up food processing plants near areas of food production (in the past we had factories like Vegefru: a tomatoes processing plant which was located in the north near where tomatoes were grown, there was also a company that produced sugar (Tate), in the recent times Erisco foods and Dangote sugar have taken their places, there is also a company that produces a range of tomato products in Jos referred to as Tomato Jos). There is need for more.
- There may be need to re-establish marketing boards for the farm produce that will be produced in order to control price and assist the farmers to make profits to encourage them to continue farming.
- Farmers should be encouraged to form co-operatives to enable them have a pool of resources that they can use to procure basic food processing and preservation equipment they may not be able to afford individually. Equipment such as large refrigerators, driers, freezers etc.
- The government may establish food processing hubs in the farming zones where farmers may take their products to be processed into shelf stable products for later sale.
- Establishment of food storage banks with the right storage conditions: refrigerated systems, silos.

- It should be made compulsory for food commodities to be handled at regulated storage temperature conditions throughout their post-harvest life. That is, the produce field heat should be removed immediately after harvest or slaughter, during transportation the optimum temperature to which the food has been cooled to should be maintained, while in storage the optimum temperature should be maintained and while on retail display, the conditions should also be maintained.
- The study of Food Science and Technology should be encouraged. This will produce more professionals that are knowledgeable in the science and technology of food for better processing and preservation of foods that the farmers produce.
- A policy makes it compulsory for Food Scientists to hold very important positions in food industries should be established and implemented.
- Technical committee on food related issues, to be made up of Agriculturists and Food Scientists and Technologists and Agricultural Engineers should be set up to draw up a workable food policy for the country, should be constituted.

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References

- Adebayo, Y. O., Adelekan, A. O., Arisa, N. U., Alamu, A. E. & Olabode, G. O. (2018). Assessment of anthropometric status & food habits of a private university students in Ogun State, Nigeria. *Nigeria Journal of Nutritional Science*, 39 (2). 106-113.
- Adelekan, A. O., Arisa, N. U., & Laguda, O.O, (2012). The use of African Yam Beans & shrimps in the production of maize based cereal blends. *Journal of Nutrition & Food Science*, 2(8). doi:10.4172/2155-2-8-1000155J
- Adelekan, A. O., Arisa, N. U., Alamu A, Adebayo Y.O., Oderinde O., (2013). Effect of enrichment trifoliate yam flour with pumpkin seeds on the pasting characteristics & acceptability of its products. *Food Processing & Technology*. 4 (11), 1-5.
- Adelekan, A. O., Arisa, N. U., Alamu A, Adebayo Y.O., Oderinde O. (2013). The effect of some fruits addition on the nutritional, microbiological & sensory qualities of sorghum (*Sorghum bicolor*) based pito. *International Journal of Food Science, Nutrition & Dietetics*, 2,701.
- Adelekan, A. O., Arisa, N. U., Alamu, A., Adebayo Y. O. & Dosa, A. S., (2013). Nutritional, microbiological & sensory characteristics of malted soy-kunun zaki: An improved traditional beverage. *Advances in Microbiology*, 3, 389-397.
- Adelekan, A. O., Arisa, N. U., Alamu A. E., Adebayo Y.O. & Popoola G.J.T., (2014). Production & acceptability of fruits enhanced zobo drink. *Food Science & Technology Letters*, 5 (1), 46-51.
- Adelekan, A. O, Arisa, N. U., & Ogunseye, F. R. (2016). Physico-chemical, nutritional & sensory characteristics of chin-chin made from trifoliate yam (*Dioscorea dementorum*) flour enriched with pumpkin seeds (*Telfaria occidentalis*) flour. *Applied Tropical Agriculture*, 21 (2), 44-52.
- Adesina, A. R., Ogunmoyela, O. A. B., Arisa, N. U., & Ololade, Z. S. (2021). Optimization of the production of local cheese from cow milk processed with the seed of *moringa oleifera*. *Journal of Food Processing & Preservation*, 00, e16189. Retrieved from <https://doi.org/10.1111/jfpp.16189>
- Anaemene, D. I., Arisa, N. U. & Adeoti, D. (2024). Nutritional, anti-nutritional & sensory evaluation of snacks produced from germinated maize/bambara groundnut (*Vigna Subterranean*) Flours. *Journal of Nutrition & Food Security*. 9 (3), 519-528.
- Arisa, N. U. & Ogbuele, O. C. (2007) Production, quality assessment & acceptability of African yam bean *sphenostylis stenocarpa* sauce. *Journal of food processing & preservation*, 31 (6), 771-778.

- Arisa, N. U. & Lazarus, A., (2007). Production & refining of *dacryodes edulis* "native pear" seeds oil. *African Journal of Biotechnology*, 7 (9), 1344-1346.
- Arisa, N. U. & Aworh, O. C. (2008). Effects of refining on quality attributes of African pear (*Dacryodes Edulis*) Oil. *Journal of food processing & preservation*, 32 (6), 946-950.
- Arisa, N. U., Omosaiye, O. B., Adelekan, A. O. & Alabi-MacFoy, A., (2011). Chemical & sensory qualities of gari fortified with groundnut flour. *African Journal of Food Science & Technology*, 2 (5) 116-119.
- Arisa, N. U., Aworh, O. C., & Kadiri, A. (2016). Comparative anatomical evidence of the effects of two peeling methods on cassava (*Manihot Esculenta* Crantz) Roots. *Journal of Industrial Research & Technology*, 5 (1), 93-102.
- Arisa, N. U., Adelekan, A. O., Malomo, O.O. & Dudu, O. E. (2017) Physicochemical & sensory properties of blends from beniseed, trifoliate yam & wheat flours. *African Journal of Food Science & Technology*, 8 (5), 67-73.
- Arisa, N. U. & Aworh, O. C. (2018). Chemical & functional characteristics of some chemically peeled cassava cultivars' products. *International Journal of Development & Sustainability*, 7 (11), 2622-2636.
- Arisa, N. U. (2019). Effects of some physical characteristics & peeling agents on effectiveness of peeling of selected cassava cultivars. *Journal of Industrial Research & Technology*, 8 (2), 84-94
- Arisa, N. U. & Aworh O. C. (2019). Physical & sensory characteristics of composite bread made from chemically peeled cassava cultivars. *Nutrition & Food Toxicology*. 3 (5), 731-740.
- Arisa, N. U., Anaemene D. I. & Mekwuye W. (2020). Assessment of overweight, obesity & the dietary habits of Undergraduate Students of Lagos State University. *European Journal of Nutrition & Food Safety*. 12 (5), 25-34.
- Arisa, N. U. & Daramola B. E. (2020). Effect of chemical peeling on microbiological quality, functional characteristics & yield of some fermented cassava products. *Nigerian Journal of Microbiology*, 34 (2).
- Arisa, N. U., Adelekan, A. O., Alake O., & Anaemene D. I. (2021) Proximate, microbiological & sensory properties of cookies made from blends of African pear (*Dacryodes edulis*) & yellow maize (*Zea Mays*) flour. *NIPES-Journal of Science & Technology Research*, 3 (1).
- Arisa, N. U., Daramola, B. E. & Fanimokun O. S., (2021). Comparative evaluation of some nutritional values & acceptability of trifoliate yam & potato products. *NIFOJ*, 39 (1).

- Arisa, N. U., Daramola, B. E. & Fanimokun O. S. (2021). Comparative evaluation of some nutritional values & acceptability of trifoliate yam & potato products. *Nigerian Food Journal*, 39 (2), 19-32.
- Arisa, N. U. & Daramola, B. E. (2021). Production & evaluation of selected chemical properties of some selected chemically peeled yellow-fleshed cassava products. *Food Science & Nutrition Technology*. 6 (1), 000250.
- Arisa, N. U., Olutayo, K. O., Igbokwe, C. C. & Abba, K. I. (2024). Production & evaluation of complementary foods made from selected local food materials. *Nigerian Agricultural Journal*, 55 (1), 281-285. Retrieved from <http://www.ajol.info/index.php/naj>
- Arisa, N. U., Olurin, T. O. & Ajibode, O. O. (2024). Thermal, mechanical & electrical properties of selected tropical roots & tubers crops. *Journal of Food Technology Research*. 22 (2), 38-48.
- Aworh O.C. (2023). *African Traditional Foods & Sustainable Food Security*. Food Control.,
- Ayo, J. A. & Tehinse, J. F. (2006). *Food Dehydration: Principles & Practice*. Amana Printing & Advertising LTD, Kaduna.
- Benner, R.A. (2014). Food Spoilage: An Overview. In: Encyclopedia of Food Safety Food Spoilage - an overview | ScienceDirect Topics. Accessed 090925
- Brennan G. J. (2006). Evaporation & Dehydration. In: Food Processing Handbook. Ed. J.G. Brennan. pp 71-121. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany
- Dupriez & Deleener, (1989) *African Gardens & Orchards: Growing Vegetables & Fruit (Land & Life Series)*: Macmillan Education
- FAO (2003). Trade reforms & food security: Conceptualizing the linkages. FAO, Rome, Italy. Retrieved from www.fao.org
- FAO (2014). Developing Sustainable Food Systems & Value Chains for Climate-Smart Agriculture. In: *Climate Smart Agriculture Sourcebook*. FAO, Rome, Italy.
- FAO (2025). Food & Agriculture Organization of the United Nations in Nigeria FAO, Rome Italy.
- Fellows P. J. (2000) *Food Processing Technology: Principles & Practice*. Cambridge: CRC Press LLC/Woodhead Publishing, pp. 196–208.
- Grandison, A. S. (2006). Postharvest Handling & Preparation of Foods for Processing. In: *Food Processing Handbook*. Ed. J.G. Brennan. Pp 1-30. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany

- Heldman, R.W. & Hartel, D. R. (1998). *Principles of Food Processing*. New York: Springer
- Iwuoha, C. I., Ubbaonu, C. N., Ugwo, R. C. & Okereke, N. U. (1996). Chemical & physical characteristics of palm, palm kernel, & groundnut oils as affected by degumming. *Food Chem*, 55, 29-34.
- Karanth S., Feng S., Patra D., Pradhan A.K (2023). Linking microbial contamination to food spoilage and food waste: The role of smart packaging, spoilage risk assessment and date labeling. *Frontiers in Microbiology*, 14. <https://doi.org/10.3389/fmicb.2023.1198124>
- Lam, H. J. (1985). *Dacryodes edulis*. In: The Useful Plants of West Tropical Africa. Burkill, W.M. Ed. I. Royal Botanic Gardens. Kew. 307-308.
- Lamb, J. (1976). Experimental study: Influence of water on the physical properties of foods. *Chem. Ind.* 24: 1046. *Chem. Industries*, 24, 1046.
- Lewis, M. J. (1987). *Physical properties of foods & food processing systems*. Ellis Horwood Ltd.
- Mohsenin, N. N. (1970). *Physical Properties of Plant & Animal Materials* (1st edition). Gordon & Breach Science Publishers.
- Neetoo, H, & Chen H. (2014) Alternative Food Processing Technologies. In: *Food Processing: Principles & Applications*. Ed. Clark, S. A., JUBG, S. & Lansal, Wiley Blackwell, 137-169
- Ogunmoyela, O. A. B., Arisa, N. U. & Anyanwu, N. U., (2011). Effect of some thermal processing methods on the caffeine content & colour absorbance of kola nuts. *NIFOJ*, 29 (2), 28-32.
- Olorunda A.O. & Tung , M. A. (1985). Simulated transit studies on tomatoes; effects of compressive load, container, vibration & maturity on mechanical damage. *International Journal of Food Science & Technology*, 20 (6), 669-678.
- Okafor, J. C., (1983). Varietal Delimitation *Dacryodes edulis* (G. DON) H.J.LAM
- Potter, N. and Hotchkiss, J., (2006). Food Deterioration & Control In: *Food Science*. 5th Ed. Springer.
- Rahman, S., (1995). *Food Properties handbook (Thermal conductivity of foods)*. CRC Press Boca Raton, USA. 275-335
- Sweat, V. E. (1986). Thermal properties of foods. In: *Engineering properties of foods (Rao M.A., Rizui S.S.H (Ed.), p. 49)*. Marcel Dekker Inc.
- Studman, C. J. (1999). Fruits & vegetables postharvest systems in the tropics. In: *CIGR Handbook of Agricultural Engineering. Vol IV: Agrprocessing Engineering*. Ed CIGR- The International Commission of Agricultural

- Engineering. Bakkar-Arkema, F.W., Debaerdemseker, J., Amirante, P., Ruiz-Altisent & Studman, C.I., (1999) 380-393. American Society of Agricultural Engineers (ASAE).*
- Udensi, E. A., Arisa, N. U. & Maduka, M. (2008). Effects of processing methods on the levels of some antinutritional factors in *Mucuna flagellipes*. *Nigerian Food Journal*, 26 (2).
- Udensi, E. A., Arisa, N. U. & Ikpa, E. (2010). Effects of soaking & boiling & autoclaving on the nutritional quality of *mucuna flagellipes* ("ukpo"). *African Journal of Biochemistry Research*, 4 (2), 47-50.
- Uzoma, A. A., (2023). Food Chemistry & Analysis. In *Fundamentals of Food Science & Technology*. Ed. IgeneJ.O. & AbuJ.O. TETFUND. Abuja, Nigeria.
- Uzor-Peters, P. I., Arisa, N. U., Lawrence, C.O., Osondu N.S. & Adelaja, A.(2008). Effect of partially defatted soybeans or groundnut cake flours on proximate & sensory characteristics of kokoro. *African Journal of Food Science Research*, 8 (2), 098-101.
- Uzor-Peters, P. I., Arisa, N. U., Lawrence, C.O., Osondu N.S. & Adelaja, A. (2018). Production of Kokoro with better nutritional content & sensory quality from maize flour. *African Journal of Food Science Research*, 6 (3), 267-270.
- Uzor-Peters, P., Arisa, N. U., Dudu, O.E. (2019). Effect of *aframomium danielli* extracts treatment on proximate composition, storage stability & sensory properties of *irvingia gabonensis* seeds. *Journal of Industrial Research & Technology*. 8 (1) 50-58.

INAUGURAL LECTURE SERIES

(June 25, 2015 - September 24, 2025)

1. The 1st Inaugural Lecture titled: "Food Product Development, Quality Assurance and Nutrition: Whither the Humane Senses?" by Professor Olugbenga A. Ben Ogunmoyela of the Department of Food Sciences and Technology. June 25, 2015.
2. The 2nd Inaugural Lecture titled: "Crisis in Forest Conservation in Nigeria: Threats to Livelihoods and Human Survival" by Professor Gbadebo Jonathan Osemeobo of the Department of Biological Sciences. January 13, 2016.
3. The 3rd Inaugural Lecture titled: "Minerals, Metals & Materials: The Hidden Wealth of A Nation" by Professor Gabriel Oladipo Oluwadare of the Department of Biomedical Engineering. May 18, 2016.
4. The 4th Inaugural Lecture titled: "Fungal Impact on Man: From Waste to Health" by Professor Olubukola Kuforiji of the Department of Biological Sciences. March 8, 2017.
5. The 5th Inaugural Lecture titled: "Chemistry is Reaction: Reaction is Chemistry" by Professor Violette Nkechi Atasie of the Department of Chemical and Food Sciences. March 7, 2018.
6. The 6th Inaugural Lecture titled: "Man and Materials: The indivisible Entities" by Professor Ojo Sunday Fayomi of the Department of Mechanical Engineering. March 14, 2025.
7. The 7th Inaugural Lecture titled: "My Nigeria Food Story: Scarcity in the Midst of Plenty" by Professor Ngozi Ugo Arisa, Department of Food Science and Technology. September 24, 2025.

