CITATION OF PROFESSOR JOHN OLURANTI OLAJIDE

John Oluranti Olajide was born about five and a half decades ago in the Olumo rock city of Abeokuta, Nigeria to the family of Pa. and Maddam Joseph Ogunrinde Olajide (now of blessed memory)

Young Oluranti's first educational stride was taken at the highly reputable Christ the King Catholic Primary School, Odo-ona, Ibadan between 1971 and 1976. He thereafter proceeded to the world famous Lagelu Grammar School, Ibadan, where he obtained with distinctions the West African School Certificate (WASC) in the year 1981.Our erudite scholar immediately gained admission into the legendary University of Ife, Ile-Ife (now Obafemi Awolowo University) where he obtained his first degree in Agricultural Engineering in 1986. His next port of call was the premier university, University of Ibadan, for his Masters of Science degree also in Agricultural Engineering which he dutifully completed in the year 1991. John Olajide's tenacious quest for scholastic excellence continued with his acquisition of PhD in Agricultural Engineering also from the University of Ibadan in the year 2000. He was a Postdoctoral fellow at the Procter Department of Food Science, University of Leeds, Leeds, United Kingdom between 2007 and 2008.

The Inaugural Lecturer of today joined the services of the iconic Ladoke Akintola University of Technology as Assistant Lecturer in August 1992, and rose through the ranks by dint of hardwork to the exalted position of a Professor on 1st October 2008.

Professor Olajide has served this great University in various capacities. He was the Dean, Faculty of Engineering and Technology for two consecutive terms between September 2011 and July 2015;

Member, University Senate (August 2002 - July 2005 and Oct 2008 till date; Chairman, Board of Survey (September 2011-July 2014); Member, Board of Postgraduate School (Sept. 2011- July 2015); Deputy Dean, Faculty of Engineering and Technology also for two consecutive terms (September 2005 - July 2007); Acting Head, Department of Food Science and Engineering (August 2002 - July 2005); Faculty Representative on the Boards of College of Basic Medical Sciences, Postgraduate School, University Admissions Committee, Examinations and Time-Table Committee, all between 2005 and 2007. He was the Chairman, Faculty of Engineering and Technology Lecture Series Committee (2005- 2007); Member, Research and Equipment Committee of the Faculty of Engineering and Technology (1999 – 2001); Faculty Representative on University's Ad-hoc Committee on the Establishment of Academic Planning Unit (2001); Member, Faculty of Engineering and Technology's Accreditation Committee (1999 – 2007); Staff Adviser, Food Science and Engineering Students (1992 –till date), just to mention a few.

Prof Olajide is an academic mentor per excellence. He has successfully supervised/co-supervised several PhD students, many Masters Dissertations and numerous undergraduates of Agricultural Engineering. Supervision of several PhD and M.Tech research works are on-going with him. He is a highly prolific writer as an academic as he is credited with about fifty (50) journal articles and research publications in reputable outlets, and he has participated and presented academic papers in about thirty (30) conferences both local and international, engineering professional workshops and assemblies inclusive.

The unassuming scholar has served as External Examiner for the B.Sc., M.Sc. and Ph.D. degrees and as External Assessor of candidates for professorial positions in many Universities within and outside the country, including University of Ghana, Legon, Ghana; UNIUYO, OAU, FUNAAB, FUTA, among others.

Prof. Olajide is a registered Engineer with COREN and a member of many reputable professional bodies such as Nigerian Society of Engineers (NSE); American Society of Agricultural and Biological Engineers (ASABE); World Solar Society (WSE); Nigerian Institution of Agricultural Engineers (NIAE); Nigerian Institute of Food Science and Technology (NIFST), among others. He is a Reviewer of many academic and professional journals. He has led and participated as a member of the National Universities Commission (NUC) and Council for the Regulation of Engineering in Nigeria (COREN) Accreditation teams to many Federal, State and Private Universities .

He was the Coordinator of the Task Force that developed the Academic Standard Template for Food Engineering programme in Nigerian Universities October, 2002.

As a notable scholar, Professor Olajide is a recipient of many scholarships and awards both within and outside Nigeria. Some of these include the Federal Government of Nigeria Scholarship for Post Graduate Studies, M.Sc. (1990 – 1991); Postdoctoral Commonwealth Fellowship at the Procter Department of Food Science, University of Leeds, Leeds, United Kingdom (October 2007 – March 2008); Fellowship Award of the Nigerian Association of Technologists in Engineering (2014) etc. His research interest is ***development of machinery for food processing,*** and in this he has distinguished himself and has made indelible impacts both locally and internationally. His hobbies include reading and traveling.

Professor Olajide is a God-fearing gentleman; he is an ordained Deacon of the Redeemed Christian Church of God. He is happily married to Mrs. Folake Aderonke Olajide, a beautiful and an adorable medical practitioner, and the union is blessed with promising children.

COURTESIES

The Vice-Chancellor,

Deputy Vice-Chancellor,

Registrar and other Principal Officers of the University,

Provost, Deans, Directors and Heads of Departments

Professors, and other members of the University Senate,

My Academic and professional Colleagues

Members of Administrative and Technical Staff of the University,

Family Members,

All Invited Guests,

Gentlemen of the Press,

Great Ladokites,

Ladies and Gentlemen,

PREAMBLE

My profound gratitude goes to God Almighty, for empowering me to deliver the 34th Inaugural Lecture of this great University, the 9th from the Faculty of Engineering and Technology and the 2nd from the Department of Food Engineering. I sincerely appreciate the Vice Chancellor, Professor Michael O. Ologunde, the University

Management and the Dean, Faculty of Engineering and Technology, Professor Simeon O. Jekayinfa, for giving me the opportunity to present this lecture.

Presentation of inaugural lecture is a University tradition of “Gown meets Town.” It is an opportunity granted Professors to make public pronouncements on their contributions to the body of knowledge through research findings before a multi-disciplinary audience. Realizing that an Inaugural Lecture is one in a lifetime opportunity, the Inaugural Lecturer tries to showcase what he/she professes, and the extent to which his/her works over many years has imparted positively on the lives of people in the society and the area he wishes to make impact in the future.

Mr. Vice Chancellor Sir, though I was trained as an Agricultural Engineer, my expedition into Food Engineering was not an accident. After my Master's degree in Agricultural Engineering (Crop Processing and Storage option), I was offered appointment as an Assistant Lecturer in the Department of Food Science & Engineering, LAUTECH in 1992, as a foundation staff member for the Food Engineering programme. I enrolled for my doctoral programme under the supervision of Engr. Professor Emeritus J.C. Igbeka, a Professor with vast expertise in Food Engineering, at the Department of Agricultural Engineering, University of Ibadan. This was to lay a solid foundation for my career in Food Engineering, which then was one area of specialization under Agricultural Engineering.

Over the better part of nearly three decades, my research foci has been within the umbrella of the development of machinery for food processing in three complementary thematic areas, Vis: study of physical properties of food materials, design of food equipment and machinery, and the optimization of food processes for the valorization of tropical crops.

Recent reports of the Food and Agriculture Organization (FAO) of the United Nations indicated that about 1.3 billion metric tons of foods are wasted globally and annually along the food chain (FAO, 2019). Larger proportion of these losses are recorded in Nigeria and other developing countries due to ineffective or inappropriate processing technologies, poor or non-existent infrastructure, poor post-harvest handling and lack of efficient value-addition chain (Asogwa *et al.,* 2017). With the current global food crisis in the world, especially in Nigeria and other developing countries, minimizing post-harvest food losses through efficient value-addition via food processing and preservation is highly imperative. This will assist in improving food availability, creating employment and reducing poverty. To achieve this task, the indispensable contributions of the food engineers engaged in designing and optimizing food processing systems are required. Therefore the title of this lecture is: **Value addition in Post-harvest Food Processing: The Food Engineers’ *Onus***

INTRODUCTION

Engineering is one of the oldest professions created by God and from Biblical accounts recorded in the Holy Bible it can be inferred that God is not only the first but also the master engineer.

According to Genesis-1:1: "In the beginning, God created the heaven and the earth”. This Biblical account shows God engineering the earth we live in. In His crowning work, God created man "in His image" in the exercise of His divine creative powers. Therefore, the engineering community has made a career out of exercising this God-given creative power. Thus, creating the physical environment in which we live and work. It can rightly be said that engineers have established for themselves, a veritable legacy of following in their Creator's footsteps, thinking God's creative and analytical thoughts after Him.

The word engineering emerged from Latin words "i*ngeniu,*" meaning cleverness, and "*ingeniare*", meaning to contrive or devise. Thus, Engineering is the application of scientific, social, economic, and practical knowledge in order to invent, design, build, maintain, and improve structures, machines, devices, systems, materials and processes. According to Wikipedia (2019): "the discipline of engineering is very broad, encompassing a wide range of highly specialized fields of engineering endeavour, each with specific emphasis on particular areas of applied science, technology and typologies of application."

Engineering has evolved as a profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to economically utilize the materials and forces of nature for the benefit of mankind. Different fields of Engineering practice include Agricultural Engineering, Aeronautical Engineering, Biochemical Engineering, Biomedical Engineering, Chemical Engineering, Civil Engineering, Computer Engineering, Food Engineering, Industrial Engineering, Materials Engineering, Industrial Engineering, Mechanical Engineering, Mechatronics Engineering etc.

Food Engineering is a comparatively new discipline in Nigeria. It evolved from Agricultural Engineering, Civil Engineering, Chemical Engineering Electrical and Mechanical Engineering. The first B.Sc. programme in Food Engineering started in the United States of America at the University of Massachusetts in 1974 under the leadership of Professor J.T. Clayton. Prior to that time, there were earlier efforts in England and Europe to develop the discipline in the nature of so called "Taught M.Sc." courses in Food Engineering.

B.Sc. courses in Food Engineering commenced later in Israel, Great Britain, France, Germany, The Netherlands, Czechoslovakia, Brazil and Chile. The Food Engineering degree programmes at LAUTECH and University of Uyo (UNI-UYO) were the first of their kind not only in Nigeria but also in the whole of Africa. The programmes in Nigerian Universities date from the mid-1990s. The first set of Food Engineers was produced from LAUTECH in 1997. Those from UNI-UYO graduated in 2003. The Council for Regulation of Engineering in Nigeria (COREN) accredited (albeit, partially) the LAUTECH programme in 2003.

Mr. Vice Chancellor Sir, Food Engineering as a discipline sets out to play the same indispensable role in the development of the food and allied industries which engineering of various specializations played in all industries with respect to human welfare. With the accelerated food shortages in many parts of the world including Nigeria and the rest of Africa, it is no longer possible to over exaggerate the critical roles which Food Engineers can play to increase the availability and quality of food supplies, worldwide. *Food Engineering provides the technological knowledge essential for the cost-effective production and commercialization of food products and services.*

Unfortunately, Food Engineering is not a universally understood profession. As noted by Jowitt (2002), it means little or nothing to most people. To help educate people, more generally, the following definition was suggested:

Food Engineering is that branch of engineering that deals with the design and implementation of technologies of large-scale handling, storage, processing, preservation and distribution of agricultural and food products.

Earle (1966) defined Food Engineering as the study of the processes that transform agricultural food raw materials into finished products or preserved foods so that they can be kept for longer periods. According to Heldman and Lund (2011), one of the earliest definitions of Food Engineering, attributed to Parker *et al.,*(1952) is that, it is "concerned with the design, construction and operation of industrial processes and plants in which intentional and controlled changes in food materials are performed with due consideration to economic aspects ".

Heldman and Lund, however, concluded that "Food Engineering embraces both the identification and creation of physical principles associated with foods and ingredients, and the application of the principles to the handling, storage, processing, packaging and distribution of consumer food products". It is interesting to note that the former definition deals with practical aspects such as design, construction and operation, while the latter definition emphasises the "physical principles" underpinning the delivery of consumer food products. Food Engineering is neither exclusively about processes and operation; nor is it exclusively about the physical principles underlying such processes since all of these aspects are important.

In his series of undergraduate and postgraduate lectures at LAUTECH and UNI-UYO, Ngoddy (2004-2018) sought to define the discipline within the existential province of the typology of Food Engineering tailor-made and suited to address the peculiar technical challenges of its practice in Nigeria and sister countries of sub-Saharan Africa. In a thought-provoking phraseology that contextualizes it within a triangular model-system consisting of three interacting and complementary engineering-activity-poles by which skills of food process design and those of food machine design find expression in convergent skills of food plant design. The systematic triangulation of these three interlocking engineering skills backstopped with research-and-development capacities, empower design-and-implementation of processes, equipment-and-machinery and manufacturing-plants and appurtenances required to foster the rapid development of efficient postharvest handling, storage, preservation, processing, packaging, distribution, marketing and utilization of agricultural and food products.

Principles underpinning Food Engineering cover an expanding range of enabling sciences that transcend the applied physical, biological and engineering sciences to also embody health and environmental sciences. Clearly, they include subjects such as economics, psychology, law, and societal values and ethics. Thus, it is arguable that, while none of the definitions given above is wrong, they are glaringly inadequate for scoping the discipline. A new definition which, while addressing the range of challenges hitherto adduced, could capture the practical essence of the discipline, is proposed here:

"*Food Engineering is the work of designing and implementing, formulating and manipulating agricultural raw materials into edible food products which meet the desired responses of sensorial acceptance, satiety, health and overall well-being of the human organism. It seeks to straddle various* scales of *operation and aims to avert or minimize negative environmental impacts of food handling, processing, packaging, storage, distribution, marketing and utilization systems.*"

Food Engineers are employed in the academia, by government and industry, as consultants to analyze and assess problems concerning food production, food quality, processes and plant design and operation, and food regulation. They conduct research and develop unit operations such as sterilization, irradiation, drying, concentration, extrusion, and freezing. Food Engineers have been instrumental in transforming ancient technologies like milling, drying, and fermentation in response to the increasing demands of the food supply chain into mechanized and automated systems.

The Emergence of the First Food Engineering Undergraduate Programme in Africa

The Food Engineering Programme in LAUTECH is the first undergraduate programme in Nigeria and in Africa. The Department of Food Science and Engineering is one of the academic departments established at the onset of this great University in 1990. The focus of the founding father of the Department, Prof. Isaac Adebayo Adeyemi, was to produce Food Engineers who by virtue of their training would have knowledge about the nature and properties of food and will be more suitable in serving the Nigerian food industry better than other categories of Engineers. The general philosophy therefore is to produce technically skilled graduates with high academic standard to provide services for the food industries and allied institutions at all levels in food process design, food equipment design and fabrication, maintenance and evaluation of food processing equipment and plants.

The primary objectives of the Food Engineering programme are to train Food Engineers specifically for the following purposes:

(i) to design and fabricate machinery and develop processes for food processing and preservation
(ii) to develop systems for storage and packaging of food materials
(iii) to develop new techniques for utilizing presently unused food resources and by-products of food manufacturing for direct human consumption
(iv) to develop man power that can work in higher educational institutions, research institutes, national and international agencies

With these objectives in mind, Prof. Isaac Adebayo Adeyemi, the pioneer Head of Department of Food Science and Engineering, encouraged the pioneer staff of the Food Engineering Programme with agricultural engineering background to focus their doctoral programmes in the following areas of Food Engineering namely*: food equipment design, fabrication and evaluation, food packaging and food rheology*. Being new, the Food Engineering programme had initial problem of accreditation with the National Universities Commission (NUC) and Council for the Regulation of Engineering in Nigeria (COREN) due to lack of an academic template required for the exercise. However, with the guidance, professional advice and assistance offered by Engr. Prof. Patrick. Obi, Ngoddy, the first Professor of Food Engineering in Nigeria to the then University Administration under the leadership of Prof. A.M. Salau of blessed memory, a tripartite committee of NUC, COREN and Universities offering Food Engineering Programmes was convened, hosted and funded by LAUTECH in October 2002. The resulting Food Engineering academic template was adopted by NUC and COREN and is being used for accreditation exercises in universities since then.

Engr. Prof. P.O. Ngoddy later joined the services of the University in 2003 and further assisted to strengthen the Food Engineering programme at undergraduate and postgraduate levels. He developed the curriculum for postgraduate studies in Food Engineering and helped to improve the existing undergraduate curriculum. He encouraged the department to become a centre of excellence for food process and equipment design through the development of work stations for the training of doctoral students. Work stations on Osmotic dehydration, Tunnel drying, Food Extrusion and Canning were designed for teaching, research and, in due course, to be scaled-up for commercialization purposes especially for small and medium-scale food processing.

The following were the first set of doctoral students involved with the scheme:

(i) Dr. O. Duduyemi who worked on Osmotic Dehydration under the supervision of Profs. P.O. Ngoddy and B.I.O. Ade-Omowaye
(ii) Dr. A.S. Ajala worked on Tunnel Drying under the supervision of Profs. P.O. Ngoddy and J.O. Olajide;
(iii) Dr. O.A. Abioye worked on Extrusion under the supervision of Profs. P.O. Ngoddy and J.O. Olajide.

Mr. Vice Chancellor Sir, the University over the years has provided and is still providing conducive environment for the training of Food Engineers. Requisite facilities and equipment for teaching and research are being provided. By the grace of God, my colleagues and I have trained and graduated more than 1,500 food Engineers (undergraduate and postgraduate) since 1997. These engineers are making positive contributions in the food industry, research institutes, relevant national and international agencies as well as the academia. Many of them have been registered and licensed to practice as Food Engineers by Council for the Regulation of Engineering in Nigeria (COREN).

Food is the most basic of all human needs for survival. Food raw materials are usually obtained from plant and animal sources and because of their biological nature they are perishable and deteriorate soon after harvesting or slaughtering, respectively. Supplying safe, nutritious and wholesome food to an ever-increasing world population projected to become 9 billion by the year 2050 (Parfitt *et al.,* 2010), is one of the greatest challenges facing the world today. While considerable attention has been directed toward increasing food production by 50-70% to address this challenge, one important and complementary factor that is often not giving adequate attention, is reducing post-harvest losses (Hodges *et al.*, 2011). The expected benefit of increasing food production is often offset by the tremendous losses incurred after harvest. Reducing post-harvest losses is among the most sustainable alternatives for increasing food availability and is a sure way to advance food security as well as to feed the hungry (UNEP/GRID-Arendal, 2010).

The post-harvest food supply chain is a series of interconnected activities from the time of crop harvest, life animal sale at the farm gate, and milk at immediate post-milking stage, or fish capture up to the delivery of the food to the consumer. The nature of activities involved varies considerably according to the type of food and there are major differences among plant products (e.g. grains, roots and tubers, fruit and vegetables and pulses), livestock products (meat, dairy, hides and skins) and fish. Food materials travel along the food supply chain from harvest to consumption. As a product moves along the chain, Post-Harvest Losses (PHLs) may occur from a number of causes. These losses can be grouped into three main categories: (i) physical losses which manifest as loss in weight of the product; (ii) loss of quality which changes the appearance, taste or texture that may cause food to be rejected by potential buyers and (iii) loss of nutritional value (FAO, 2013).

Post-harvest losses manifest in economic, quantitative, qualitative and nutritional terms and have consequences to the farmer, the buyer/consumer, the society and the nation as a whole. For example, it was estimated that about one third of the food produced globally is lost or wasted annually in a world where over 870 million people go hungry (Olajide and Oyelade 2003; Gustavsson *et al.,* 2011; Prusky, 2011). It was also shown that, significant volumes of food are lost annually after harvest in Sub-Saharan Africa (SSA), the value of which is estimated at USD 4 billion for grains alone and such losses are estimated to be equivalent to the annual caloric requirement of 48 million people. For these reasons, experts now agree that investing in PHLs reduction can be the quickest impact- intervention for enhancing food security (Akinwande *et al.*, 2013; GIZ, 2013a).

It has been approximated that up to 47% of USD 940 billion needed to eradicate hunger in SSA by 2050 will be required in the postharvest sector. Investment in efforts to save food after harvest is less costly than that required to increase production by an equivalent amount (FAO–World Bank, 2010). Reducing food losses therefore offers an important pathway for availing the society of more food, alleviating poverty, and improving nutrition. Moreover, reducing PHLs has positive impacts on the environment and climate as it enhances farm-level productivity and reduces the utilization of production resources and expansion into fragile ecosystems to produce food that will be lost if not consumed (Hodges *et al.,* 2011, GIZ, 2013b).PHLs still remain a persistent problem in Nigeria and other African countries and present an enormous and growing threat to food security. With the surge in food prices that began in 2006, temporarily peaked in mid-2008 and resumed with its rising trend in 2011, a renewed attention to address food security is imperative.

The American Society of Agricultural and Biological Engineers (ASABE) in 2016, set up a global initiative to address three new challenges (food insecurity, water insecurity, and energy insecurity, all in the context of sustainability and climate change) facing our fast-growing global population which requires new solutions. The society assembled agricultural, biological engineers and other international experts from academia, government, and industry to meet with local stakeholders to address the challenges.

The initiative proposed engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, and a healthy environment**.** Reducing postharvest food losses and wastes was one of the strategies recommended towards achieving global food security. This is to be achieved through designing scalable, nationally and regionally appropriate harvesting, drying, storage, processing, and handling systems to minimize food losses.

Food Processing

Processing of foods is the segment of the food manufacturing industry that transforms animal, plant, and marine materials into intermediate or finished value-added food products that are safer to transport, store and eat. This requires the application of labour, energy, machinery, and scientific knowledge to a step (unit operation) or a series of steps (process) in achieving the desired transformation (Heldman and Hartel, 1998). Value-added ingredients or finished products that satisfy consumer needs and convenience are thereby achieved from otherwise primordial raw materials. The aims of food processing include (i) extending the period during which food remains wholesome (microbial and biochemical), (ii) providing (supplementing) nutrients required for health, (iii) providing variety and convenience in the diet, and (iv) adding value (Fellows, 2009). Food materials’ shelf- life extension is achieved by preserving the product against biological, chemical, and physical hazards.

The scope of food processing is broad. It embraces unit operations applied after harvest of raw materials on the farm until they are transformed into food products, packaged, and shipped for retailing. Typical processing operations may include raw material handling, ingredient formulation, heating and cooling, cooking, freezing, shaping, and packaging (Heldman and Hartel, 1998). These could broadly be categorized into primary and secondary processing. Primary processing is the processing of food raw material that occurs after harvesting or slaughter, near its sources to make food ready for consumption or to stabilize or render it more conducive for processing into other food products. Primary processing ensures that foods are easily transported and are more ready to be sold, eaten or processed into other products. Primary processing refers to on –farm drying of grains, palm oil extraction (without refining), fish chilling or icing etc.

Secondary processing converts raw materials and ingredients into other food products. It ensures that foods can be used for a variety of purposes that it does not spoil quickly, are healthy and wholesome to eat, and are available all year round (e.g. seasonal foods). Baking of the pie is a secondary processing step, which utilizes ingredient from preliminary processing (e.g. sliced apple).

In Nigeria, the food processing sector is dominated by small and medium scale enterprises with few multinational food companies.

While the large food multinationals play unique roles in promoting industrial development in West Africa through employment generation, value-added processing and training of skilled manpower, their impact is mostly felt in the urban areas. Small and medium scale food industries that involve lower capital investment and that rely on traditional food processing technologies are crucial to rural development in Nigeria and other Africa countries. By generating employment opportunities in the rural areas, small-scale food industries reduce rural urban migration and the associated social problems. They are vital to reducing post-harvest food losses and increasing food availability.

Several African nations including Nigeria currently depend on importation of foreign food processing facilities which drains a lot of the foreign exchange of the nations. Such food industries established with imported technology may not function for a long period of time because of lack of spare parts, inadequate maintenance and inability to adapt to some local conditions. It is essential to evolve indigenous technology to address the issue of food processing operations in Nigeria. Many authors have reported on the need to develop indigenous technology for the various aspects of food processing (Ademosun *et al.*, 2003).

Value Addition

Value-addition is defined as bringing changes in the physical state or form of a product (such as by milling wheat into flour or making strawberries into jam) in a way that increases its economic value (Pant and Chinwan, 2014)

Any product manufacture that requires some degree of processing involving the use of raw materials, labour and technology is referred to as a processed product, regardless of whether the degree of processing is minor such as for grading of eggs, or more complex, such as for canned foods. Value-addition encompasses any process or service e.g. packaging in the food supply chain that adds to, or enhances the market- value of product to customers.
Value-adding activities which result in a change in the form of the product can be classified as including; partial or early stage processing involving minimal or simple transformation of the raw produce, further processing involving elaborate transformation of the raw produce into an intermediate product to be used as an input in another production process or into a ‘manufactured’ product for consumption and improvements in utilization, such as recovery of whey protein during cheese processing from milk, which otherwise might have been discarded. In the international commodity market, primary raw material producers have no influence on the trend of prices in the commodities exchange. But value added products enjoy more stability, since end-products prices are generally stable and well-fixed in advance, while commodity (raw materials) prices are usually unstable.

Processing of primary produce into semi-processed form, or final product results in increased in earnings as a result of value addition. For example, as a result of value addition on castor seeds, India alone contributes about 65% of world’s total castor seed production being the largest producer, but it ranks very low when it comes to value addition. However, Brazil with only 7% share of the global castor seed production is probably the world’s largest exporter of value added castor products (Onwualu, 2009). Wealth is created when value is added to agricultural food raw materials through food processing into safe, edible and commercial products. Agricultural production of food raw materials without value addition propagates poverty because what brings the huge revenue is the value added.

In 2017 Europe imported soybeans worth USD 14.2m from Nigeria and processed it into oil and made USD 42.6 m. Cote d'Ivoire, realized USD 3.7bn from the sale of cocoa beans but Switzerland by processing cocoa into chocolate made USD 72 billion from it (FAOSTAT, 2018). Hence producing food raw materials without manufacturing for value-addition propagates poverty. Processing also expands the horizon of human participation in the production process and therefore creates awareness for employment generation in the downstream activities such as packaging, marketing, retail, exports, etc. Value addition provides opportunities for developing countries to work out economic strategies for competing successfully on the global scene.

Role of Food Engineers in Food Value-Addition

The contributions of Food Engineers in improving food quality, nutrition security, food safety, food handling, food packaging and distribution, product's shelf-life and reduction of post-harvest losses in Nigeria can be felt in the area of the mechanization of unit operations in food processing, development of new and existing technologies, design and development of machinery and systems for processing and preservation. There are many different unit operations and technologies associated with the conversion of raw food materials to consumer products. Some of them include drying, canning, sterilization, pasteurization, blanching, freezing, heating, irradiation, extrusion, deep fat frying, non- thermal processing etc. The problem of post-harvest food losses can be addressed by establishing food processing companies. Food processing can be done using simple equipment and technologies at cottage industry level or employing sophisticated technologies at a larger scale of manufacturing e.g. food drying can be done at two levels. One in which foods such as grains and pulses are sun dried in large quantities to preserve them. This adds little or no value (the objective being to provide food security). Secondly a fuel-fired drier can be used to dry smaller amounts of high value foods such as spices, which are sold in attractive packaging. This requires technical know-how and higher financial commitment. Over the years, there has been a great need to provide expertise that can serve the Nigerian Food Industry adequately in the area of designing of food processes and food equipment (Olajide, 2012). It was in mid-1990s LAUTECH produced the first set of Food Engineers that were trained specifically for this purpose because they have adequate knowledge about food processes, nature and properties of food raw materials which are prerequisite for effective design of food processes and machinery.

Overview of Agricultural Food Raw Materials Potentials of Nigeria

It is an established fact that Nigeria is richly endowed with vast agro ecological and human resources. In terms of human resources, it has a large population of over 200 million people that could be trained in order to build the capacity for transforming the natural resources and their utilization for sustainable development. In terms of environmental resources, it has about 79 million hectares of arable land, of which 32 million hectares are cultivated, 12 million hectares of fresh water and 960 km of coast line. Over 90% of agricultural production is rain-fed. Smallholders, mostly subsistence producers account for 80% of all farm holdings. Wind and solar energy resources are also available with almost 12 hours of sunshine every, day all year round. Nigeria's wide range of climate variations allows her to produce a variety of food and cash crops**,** livestock and fishery (FAO, 2019)**.** The staple food crops include cassava, yam, corn, cocoyam, cowpea, bean, sweet potato, millet, plantain, banana, rice, sorghum, variety of fruits and vegetables, herbs, spices, essential oils and others. The leading cash crops include cocoa, citrus, cotton, groundnuts (peanuts), palm oil, palm kernel, benniseed, and rubber (Onwualu,2009).

Judging from the agricultural raw materials with which Nigeria is endowed, it can be deduced that the country has a sound resource base for successful industrialization through the creation of thousands of small and medium scale food processing companies. Nigeria has the potential to create a niche in the global trade of different commodities judging by the favourable climatic conditions and arable land (Onwualu, 2009). It is worthy of note that that the major reason for the divergence in the rate of economic growth and development between developed and developing economies, has been attributed to the differentials in their ability to optimize the exploitation and utilization of their raw material resources. The developed nations through efficient application of their resources have raised the real income of their population on a sustainable basis thereby alleviating mass poverty, misery and diseases**.**

Small and Medium-Scale Food Processing Companies as Bedrock for National Economy and Development

Small and medium- scale food processing enterprises are playing very important role in the development of the economy of most developed and developing countries like China, India, Malaysia and others. Their role in terms of reduction of post-harvest food losses and increasing food availability, employment- generation, contribution to export earning opportunities is very critical. In Malaysia for example, the food industry plays a major socioeconomic and strategic role. This industry is contributes more than 10% of Malaysian manufacturing output and increases employment by 1.4% annually. The food processing sector is dominated by Small and Medium Enterprises constituting about 98% which produces processed foods that are exported to more than 80 countries, with annual export value of more than US$ 1.7 billion (MGCC, 2010; Alam *et al.,* 2011).

Sustainable economic and national development in Nigeria can be achieved by following the examples of countries like Malaysia and others through the development of Small and Medium- scale Food Processing Enterprises (SMFPEs). SMFPEs are the modern engine needed to minimize post-harvest food losses through the conversion of agricultural food raw materials into edible products. Creating them in hundreds of thousands (even millions) and growing them constitute the most potent weapon to tackle the problem of food insecurity in Nigeria and other African countries who experiences high post-harvest food losses.

Having adequate number of SMFPEs to process food raw materials during period of gluts will minimize postharvest losses significantly. SMFPEs have the potentials to create employment, generate income and combat poverty which in turn permits greater food security, good nutrition and health. The single most challenging problem confronting SMFPEs in Nigeria is the high cost of processing equipment that is imported and unaffordable to processors. Food engineers have the capacity to design indigenous, effective, appropriate and affordable processes, machinery and plants to address this problem.

MY MODEST CONTRIBUTIONS

Mr. Vice-Chancellor Sir, having highlighted the importance of Food Engineering and Engineers to adding value to food raw materials, permit me to present my modest contributions in the following areas of food engineering over the past two and half decades:

(i) determination of physical and engineering properties of foods and their associated raw materials
(ii) design, fabrication and performance-testing of machinery, devices and processes for small and medium-scale food manufacturing and
(iii) process optimization in transforming raw food materials into edible food products

Determination of Physical Properties of Foods and Their Associated Raw Materials

Raw food materials are biological in nature. As such, they have certain unique characteristics which distinguish them from other engineering materials. These peculiarities derive from the following; (i) irregular shapes commonly found in naturally occurring raw materials; (ii)inherent property patterns with non-normal frequency distribution; (iii) heterogeneous composition; (iv) composition that varies with variety, growing conditions, maturity and other factors; and (v) they are affected by chemical changes, moisture content, respiration, and enzymatic activity.

Knowledge of a food's physical properties is necessary for defining and quantifying the description of the food material, providing basic data for engineering design of unit operations, and predicting behaviour of food materials. Often the physical properties of food change during processing operations. Not recognising these changes can lead to potential processing failure.

Physical properties are an important aspect of food quality and relate to food safety. Understanding these properties is essential for the design, control and optimization of food processing operations. Food properties are of utmost importance to understanding and optimizing food systems and food supply. Physical properties of foods are of the utmost interest to the Food Engineer, mainly for two reasons: many of the characteristics that define quality (e.g. texture, structure, appearance) and stability (e.g. water activity) of a food product are directly linked to its physical properties while quantitative knowledge of many of the physical properties, such as thermal conductivity, density, viscosity, specific heat, enthalpy and others, is essential for the rational design and operation of food processes, equipment and for the prediction of the response of foods to processing, distribution, and storage conditions.

Mr. Vice Chancellor sir, these reasons led me, in collaboration with other researchers, to determine physical properties of some known and underutilized food raw materials with the view to developing a formidable data- base that will reduce their post-harvest losses and invariably make them more available for human consumption and industrial use. I have worked extensively and made contributions in the determination of the physical properties of some Nigerian/African food raw materials, namely: locust bean seed, sheakernels, Aackee apple, groundnut kernels, eggplant and pumpkin seeds. Highlights of these studies are as presented here under.

Selected Physical Properties of Locust Bean Seed

Locust bean seed (*Parkia Fillicoidea*) is a popular legume with very high food, industrial and medicinal values. It is used to produce '*iru*' an important food flavouring condiment in West Africa. Unavailability of this produce all the year round has been linked to post-harvest losses, importantly its age- long traditional processing method demands mechanization: an onus of Food Engineers. Thus, baseline design data to assist food engineers are required in order to design processes and appropriate processing equipment to facilitate commercial production of *'iru'* from locust bean.

Olajide and Ade-Omowaye (1999) determined some physical properties of locust bean seed (Figure 1) such as linear dimensions, geometric mean diameter, sphericity and static coefficient of friction

(Table 1). These properties are very essential for designing small and medium scale equipment or improvement of sub unit operations involved in the processing of the locust bean harvest from harvest to point of sales to consumers and industries. This effort will enhance the quantity and quality of the product and increase the income of small-holder farmers and the Food Engineers involved.

Figure 1: Locust bean seeds

Table 1: Selected physical properties of the locust bean seed

Physical properties	Number of observations	Mean value	Minimum value	Maximum value	Standard deviation
Length, mm	100	10.80	9.11	12.96	0.76
Width, mm	100	8.42	7.00	10.63	0.85
Thickness, mm	100	4.64	3.15	5.96	0.60
Geometric mean diameter, mm	100	7.47	6.66	8.41	0.45
Sphericity	100	0.69	0.62	0.83	0.09
Surface area, mm^2	100	175.40	128.68	220.00	21.43
Mass, g	100	0.29	0.16	0.38	0.04
Volume, cm^3	100	0.23	0.12	0.32	0.04
Density, g/ cm^3	100	1.15	1.06	1.22	0.18
Static coefficient of friction on Galvanized steel	100	0.38	0.33	0.42	0.03
Glass	10	0.36	0.32	0.40	0.03
Plywood parallel to grain	10	0.44	0.36	0.49	0.03
Plywood parallel to grain	10	0.62	0.58	0.65	0.06
Plywood perpendicular to grain	10	13	13	13	0.04
Angle of repose, deg	10	13	13	13	-

Source: Olajide and Ade-Omowaye (1999)

Selected Physical Properties of Shea kernel

Shea kernels produced the shea tree *(Butyrospermum Parkii)*processed to obtain a vegetable fat called "Shea butter", which is an important raw material used in cosmetic, food and pharmaceutical industries. Despite the potential of sheabutter as a good source of export earnings, the traditional method of processing it is cumbersome, time consuming and above all, its extraction efficiency (about 15%) is very poor. This limits its availability for wider utilization and application, locally and internationally. **Olajide *et al.*, (2000**) generated some baseline design data that are required to design processes and appropriate processing equipment to enhance the production of sheabutter by processors. Essentially, the average values of the physical size- dimensions of shea kernels (Figure 2) at different moisture contents were investigated (Table 2). The study indicated that length (L), width (W) and thickness (T) of the shea kernel increased with increase in moisture content. Each of the dimensions was moisture-dependent. By linear regression, the linear dimensions bear the following relationship with moisture content:

$$L = 24.888 + 0.149M_c \quad (r = 0.889) \qquad (1)$$

$$W = 17.274 + 0.107M_c \quad (r = 0.809) \qquad (2)$$

$$T = 14.112 + 0.082M_c \quad (r = 0.931) \qquad (3)$$

Where M_c = Moisture content and r = coefficient of determination

Figure 2: Shea nut and Shea kernels

Table 2: Size and shape distribution of shea kernels in relation to moisture content

Moisture Content	Length (mm)	Width (mm)	Thickness (mm)	Geometric mean Dia (mm)	Sphericity (%)
5.18	25.71 (0.76)	17.66 (0.86)	14.55 (0.60)	18.67 (0.45)	73.00 (0.09)
7.18	25.99 (0.74)	18.11 (0.84)	14.76 (0.52)	18.99 (0.43)	72.50 (0.07)
9.18	26.01 (0.73)	18.43 (0.85)	14.77 (0.51)	19.07 (0.39)	73.5 (0.08)
11.18	26.77 (0.75)	18.51 (0.68)	14.96 (0.54)	19.34 (0.38)	73.2 (0.06)
13.18	26.81 (0.68)	18.53 (0.82)	15.27 (0.62)	19.58 (0.36)	73.08 (0.08)

Source: Olajide *et al*., (2000)

(Figures in parenthesis are standard deviation)

Selected Physical properties of Aackee apple (*Blighia Sapida*) seed

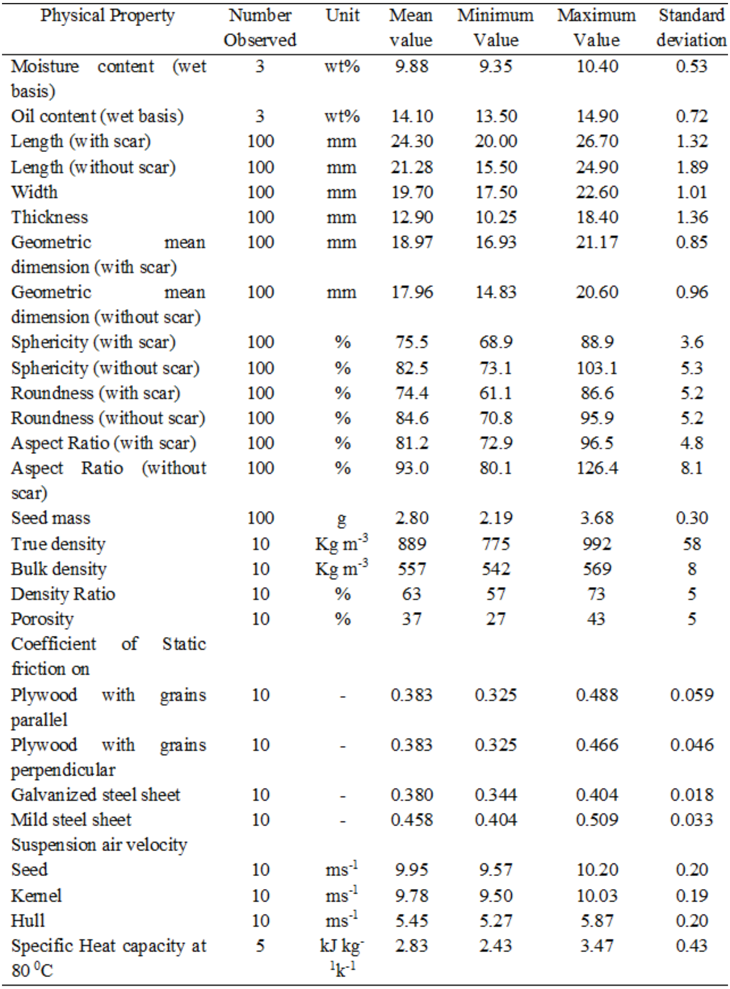
Aackee apple (*Blighia Sapida*) seed (Figure 3) is an underutilized crop native to West Africa and widespread in tropical and subtropical environments. It is useful in the food, cosmetic, pharmaceutical, paint (vanish), coating and oleochemical industries. Large quantities of these seeds rot under the parent tree because of poor handling processes that would make them suitable grades for industrial use. In view of the enormous potential of Aackee apple, the required baseline data needed by food engineers to design processes and machinery for its processing were lacking in the literature. I worked with other researchers **Omobuwajo *et al.*, (2000)** andgenerated some of these design data which are presented in Table 3.

Figure 3: Ackee apple seed

Selected Physical Properties of Groundnut kernels

Groundnuts (*Arachis hypogeal*) provide food for humans and livestock. It contains a large proportion of valuable dietary protein which can serve as alternative to animal protein. The nuts are harvested and then cracked to remove the kernels which are used mainly for the production of vegetable oil while the resulting cake is used as protein source to enrich livestock feeds. Despite the potential of the groundnut kernel as a good source of oil, yield and quality are poor for the oil extracted by the traditional methods limit its utilization, locally and internationally.

Table 3: Some physical properties of Aackee apple (*Blighia sapida*) seed



Physical Property	Number Observed	Unit	Mean value	Minimum Value	Maximum Value	Standard deviation
Moisture content (wet basis)	3	wt%	9.88	9.35	10.40	0.53
Oil content (wet basis)	3	wt%	14.10	13.50	14.90	0.72
Length (with scar)	100	mm	24.30	20.00	26.70	1.32
Length (without scar)	100	mm	21.28	15.50	24.90	1.89
Width	100	mm	19.70	17.50	22.60	1.01
Thickness	100	mm	12.90	10.25	18.40	1.36
Geometric mean dimension (with scar)	100	mm	18.97	16.93	21.17	0.85
Geometric mean dimension (without scar)	100	mm	17.96	14.83	20.60	0.96
Sphericity (with scar)	100	%	75.5	68.9	88.9	3.6
Sphericity (without scar)	100	%	82.5	73.1	103.1	5.3
Roundness (with scar)	100	%	74.4	61.1	86.6	5.2
Roundness (without scar)	100	%	84.6	70.8	95.9	5.2
Aspect Ratio (with scar)	100	%	81.2	72.9	96.5	4.8
Aspect Ratio (without scar)	100	%	93.0	80.1	126.4	8.1
Seed mass	100	g	2.80	2.19	3.68	0.30
True density	10	Kg m^{-3}	889	775	992	58
Bulk density	10	Kg m^{-3}	557	542	569	8
Density Ratio	10	%	63	57	73	5
Porosity	10	%	37	27	43	5
Coefficient of Static friction on						
Plywood with grains parallel	10	-	0.383	0.325	0.488	0.059
Plywood with grains perpendicular	10	-	0.383	0.325	0.466	0.046
Galvanized steel sheet	10	-	0.380	0.344	0.404	0.018
Mild steel sheet	10	-	0.458	0.404	0.509	0.033
Suspension air velocity						
Seed	10	ms^{-1}	9.95	9.57	10.20	0.20
Kernel	10	ms^{-1}	9.78	9.50	10.03	0.19
Hull	10	ms^{-1}	5.45	5.27	5.87	0.20
Specific Heat capacity at 80 ^{0}C	5	kJ kg^{-1}k^{-1}	2.83	2.43	3.47	0.43

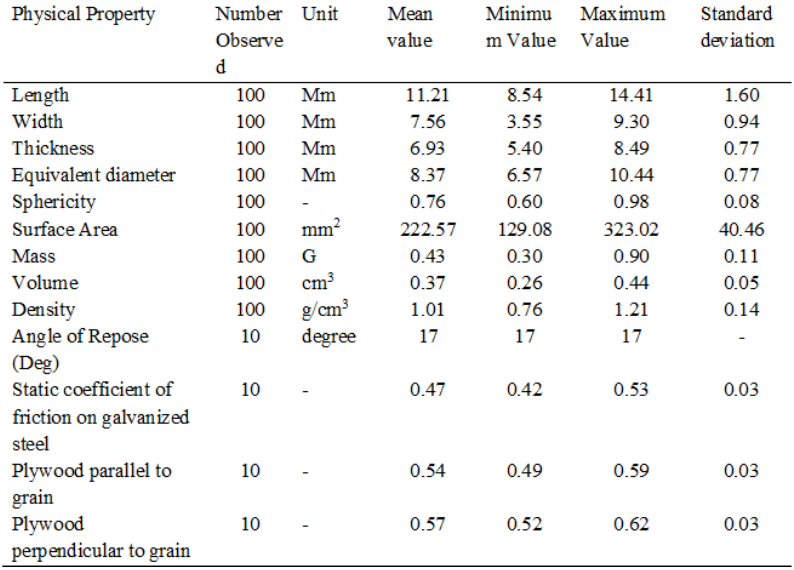
Source: Omobuwajo *et al.*, (2000)

Olajide and Igbeka (2003) evaluated some physical properties of groundnut kernels (Figure 4a and b) in order to make data available for designing equipment and facilities for handling, storage, mechanical oil expression and other processes for the kernels (Table 4). These physical properties are very essential for Food Engineers for design purposes which in turn influence the degree of value addition to the crop made possible by processing.

Figure 4a: Groundnut

Figure 4b: Groundnut Kernels

Table 4: Some Physical properties of Groundnut Kernels



Physical Property	Number Observed	Unit	Mean value	Minimum Value	Maximum Value	Standard deviation
Length	100	Mm	11.21	8.54	14.41	1.60
Width	100	Mm	7.56	3.55	9.30	0.94
Thickness	100	Mm	6.93	5.40	8.49	0.77
Equivalent diameter	100	Mm	8.37	6.57	10.44	0.77
Sphericity	100	-	0.76	0.60	0.98	0.08
Surface Area	100	mm^2	222.57	129.08	323.02	40.46
Mass	100	G	0.43	0.30	0.90	0.11
Volume	100	cm^3	0.37	0.26	0.44	0.05
Density	100	g/cm^3	1.01	0.76	1.21	0.14
Angle of Repose (Deg)	10	degree	17	17	17	-
Static coefficient of friction on galvanized steel	10	-	0.47	0.42	0.53	0.03
Plywood parallel to grain	10	-	0.54	0.49	0.59	0.03
Plywood perpendicular to grain	10	-	0.57	0.52	0.62	0.03

Source: Olajide and Igbeka (2003)

Selected Physical and Chemical Properties of three varieties of Egg Plant *(Solanum melongena)*

Eggplants, belong to the family *solanacea*. They are vegetable-fruits and characterized by high nutritional values. The rate of consumption of eggplant in Nigeria is low compared to other fruits and vegetables. This is partly due to low level of awareness about its nutritional value. To encourage consumers to increase their consumption and effectively utilize its potential in food product development, **Olajide *et al.*, (2003)** investigated three varieties of eggplant (*Solanum melongena*) (Figure

5) produced within the vicinity of Ogbomoso and Ilorin for their physical and chemical properties. Baseline data required for the design and fabrication of processing equipment were generated. The potential of the egg plant varieties for jam production was established because of the relatively high pectin content found in the study as compared to pectin reported in other common fruits. **Pectin** is a fiber found in fruits with a demonstrated health benefits such as the ability to lower glucose and blood cholesterol. These benefits suggest that **pectin** may help in prevention and treatment of diseases such as diabetes, obesity, colon cancer and prostate cancer (Majee et al., 2018).

Data obtained (Tables 5-6) on the strength and firmness of the outermost covering of the fruit and its high carbohydrate content suggest its potential for pickling.

Figure 5: Varieties of Nigerian Eggplant

Table 5: Influence of varieties on Proximate Composition vitamin, mineral and pectin contents of three Nigerian eggplants

Property	Parameters	Eggplant Variety		
		Zebrina Variety	Ogbomoso Local	Ilorin Local
Proximate composition	Moisture	7.40± 0.26	7.40 ± 0.28	8.20 ± 0.24
	Crude protein	1.31± 0.06	0.88 ± 0.08	1.75 ± 0.12
	Fat/Oil	10.40 ± 0.48	12.80 ± 0.52	4.80 ± 0.04
	Ash	4.30± 0.33	4.10 ± 0.28	7.00 ± 0.60
	Crude fibre	1.31 ± 0.86	1.68 ± 0.82	1.76 ± 0.96
	Carbohydrate	76.59 ± 1.43	74.82 ± 1.50	78.25 ± 1.20
Vitamins (mg/100g)	A	0.034 ± 0.001	0.042± 0.01	0.036± 0.03
	C	4.40 ± 0.26	2.50± 0.01	3.10± 0.03
Minerals (mg/100)	Iron(Fe)	1.40± 0.04	1.70± 0.02	1.50± 0.03
	Magnesium(Mg)	2.62± 0.02	3.18± 0.01	3.26± 0.03
Pectin (%)		7.36± 0.04	8.19± 0.03	9.26± 0.02

Source: Olajide *et al.*, (2003)

Table 6: Some physical properties of three Nigerian egg plant

Physical property	Number of observation	Zebrine	Ogbomoso local	Ilorin local
		Mean values		
Length (mm)	100	34.2+ 0.24	35.0+ 0.12	45.3+ 0.13
Width (mm)	100	25.0+ 0.02	4.05+ 0.07	32.4+ 0.13
Thickness (mm)	100	22.1± 0.04	39.3± 0.08	30.4± 0.14
Sphericity (%)	100	0.86± 0.01	0.92 ± 0.01	0.77± 0.00
Geometric mean Diameter (mm)	100	27.3± 0.05	38.3 ± 0.04	34.2± 0.03
Surface area (mm^2)	100	2341.74± 0.04	4608.97 ± 0.03	3675.00± 0.05
Fruit mass (g)	100	30.23± 2.75	27.74 ± 3.70	18.67± 3.86
Density (g/cm^3)	100	1.01 + 0.004	0.99 + 0.005	0.95+ 0.012
Colour	100	White/green strips	Green/white strips	White

Source: Olajide *et al.*, (2003)

Selected Physical Properties of Pumpkin Seeds

Pumpkin fruit (*Cucurbita* spp.) is a gourd-like fruit that is widely grown in Nigeria and extensively used as vegetable. It is used medicinally to help improve bowel function. The pumpkin fruit contains seeds (Figure 6) are rich in minerals such as iron as well as vitamins A, B, and C. The seeds contain more than 55% oil and 30% protein and can be considered as a potential source of edible oil and protein which can be used in food and allied industries. This development attracted the interest of **Olajide *et al.*, (2008**) to evaluate some physical properties of pumpkin seeds in order to make data available for designing equipment and facilities for handling, storage, mechanical oil expression and other processes for the seeds. The ranges of the average length, width, thickness, and diameter, sphericity surface area, mass, true density, bulk density, porosity and angle of repose were 12.06-12.2 6 mm, 8.36-8.70 mm, 2.00-2.06 mm, 5.86-6.01 mm, 0.48-0.54%,106.41-113.48 mm^2, 91-104 g, 416-453 kg/m3, 1116-1149 kgm^3, 64.63-60.58% and 28.80-40.54% respectively, for the ranges (7.8-23.8%)of moisture content. Similarly, the static coefficient of friction properties such as plywood, mild steel and stainless steel were in the range 0.52-0.74, 0.46-0.73 and 0.43-0.73, respectively (Table 7).

Figure 6a: Pumpkin Fruit **Figure 6b: Pumpkin Seeds**

Table 7: Some Physical properties of Pumpkin Seed

	Length, width , geometric mean diameter, sphericity , surface area and volume						Thousand seed mass, bulk density , true density , porosity and angle of repose					Static coefficient of friction		
Moisture content% (dry basis)	Length (L) mm	Length (W) (mm)	Thickness (mm)	mean diameter (mm)	Sphericity (%)	Surface area (S) (mm^2)	Thousand seed mass g	True Density kg/m^3	Bulk Density kg /m^3	Porosity %	Angle of repose^0	Plywood	Mild steel	Stainless steel
7.8	12.06	8.36	2.00	5.82	0.48	106.41	91	416	1176	64.63	28.80	0.52	0.46	0.43
11.8	12.19	8.14	2.01	5.87	0.49	108.25	93	427	1169	63.36	29.62	0.55	0.54	0.53
15.8	12.31	8.48	2.01	5.92	0.50	110.10	94	435	1159	62.45	30.44	0.64	0.64	0.62
19.8	12.36	8.49	2.11	5.93	0.53	110.47	97	451	1153	60.84	34.92	0.70	0.69	0.69
23.8	12.37	8.70	2.16	6.01	0.54	113.48	104	453	1149	60.58	40.54	0.74	0.73	0.73
Mean	12.26	8.49	2.08	5.91	0.51	109.74	96	436	1161	62.39	32.86	0.63	0.60	0.60
Standard Deviation	0.96	0.63	0.27	0.37	0.15	0.14	4.94	15.77	11.69	1.79	1.04	1.02	1.14	1.23

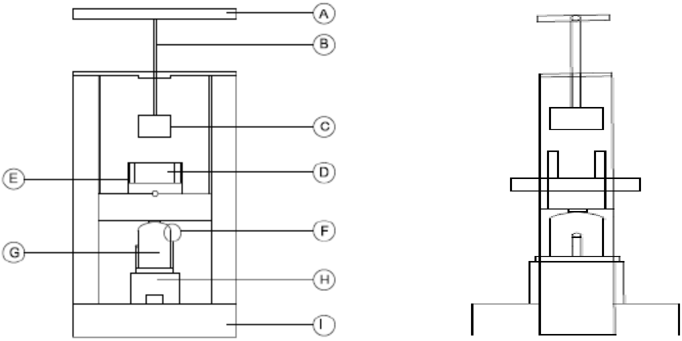
Source: Olajide *et al.*, 2008

Design, Fabrication and Performance Testing of Food Processing Machinery

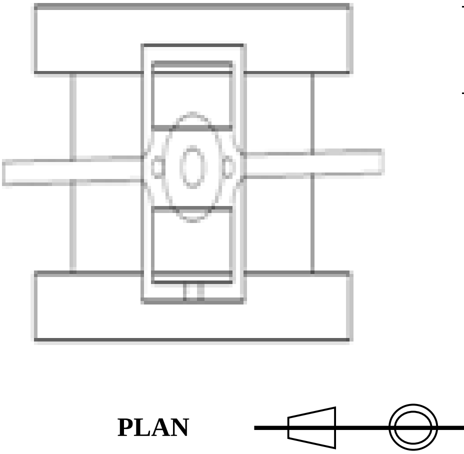
The development of locally fabricated and low cost equipment for processing of food raw materials at small and medium scale levels is essential for job and wealth-creation and subsequent reduction of poverty. This will promote industrialization in the rural and semi-urban areas as well improve the quality and commercial value and quality of the processed food materials. I have been privileged to be involved in the development of food processing equipment for some food products. The items of equipment are peculiar for use in developing countries and are locally available, relatively low-cost, easy to use, environmental friendly and gender friendly. Examples of these efforts are as profiled here-under.

Design of a kneading press for sheabutter processing

In order to improve the low fat extracting efficiency of the traditional method of sheabutter processing which is about 15%, Olajide *et al.,* 2001developed and evaluated a medium scale kneading press to improve the kneading process so as to remove drudgery , increase yield and improve quality. The press components are the frame, the turning bar, the press block and the collection tray. It has a processing capacity of 12 kg sheabutter/hr. The effects of some processing variables on the yield of sheabutter from the press were investigated. Maximum fat extraction efficiency of 64.24% was obtained when finely milled sheakernels conditioned to a moisture content of 12% (dry basis) was heated at 120 °C for 65 minutes and expressed at 387.8 kN/m^2. The construction of the press shows three views (Figure 7).



FRONT **SIDE**



PLAN

ORTHOGRAPHIC PROJECTION

S/N	PART NAME
A	Turning bar
B	Screw bar
C	Press Block
D	Perforated Press Cylinder
E	Guide for press block
F	Pressure gauge
G	Hydraulic Jack
H	Table for hydraulic jack
I	Base

Figure 7: Orthographic view of the developed kneading press for Sheabutter processing

Development of Fruit juice extractor

Fruits are important part of the human diet as they are sources of vitamins, minerals and dietary fibre. They also serve as raw materials in food and beverage industries. In many developing countries as much as 50% of fruits harvested are lost because of lack of adequate processing and storage facilities after harvest (Prusky, 2011). The initial capital cost of most of the fruit juice processing machines is high and not readily affordable by small and medium scale processors. **Olajide *et al.*, (2002**) designed, fabricated and tested a simple low-cost portable extractor to express juice from soft fruits like cashew, pineapple and orange so as to preserve them and reduce post-harvest losses.

Some of the considerations in designing the machine were: cost of the machine, requirement of the end product, selection of materials of construction that are available locally and will not contaminate the product, ease of dismantling, portability, ability to use the machine in areas where there is no electricity supply and use of bushing instead of ball bearing so as to prevent lubricant from contaminating the juice (Figure 8). The fruit juice extractor was tested to express juice from soft fruits like cashew, pineapple and orange. The rate of juice extraction for cashew, pineapple and orange fruits were 16.87 kg/hr., 21.12 kg/hr. and 24.20 kg/hr., respectively, while the corresponding values using hand reamers were 4.80 kg/hr., 6.45 kg/hr. and 8.10 kg/hr., respectively. The extractor had over 220% advantage over the hand reamer.

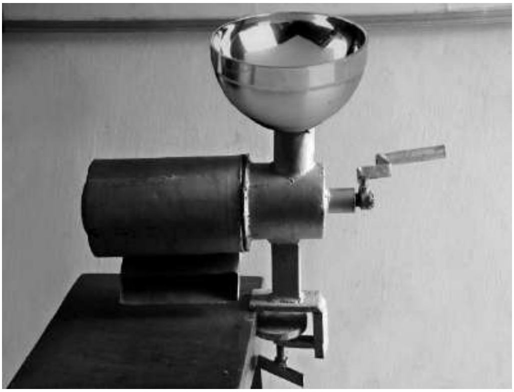


Figure 8: The developed Juice Extractor

The machine saves time, reduces wastage and contamination either through corrosion or otherwise. It is generally portable and hygienic in operation. The extractor is suitable for improved utilization and preservation of fruits by small and medium scale processors in less developed areas.

Development of a Doughnut Filling Machine

Over the years, in the bid to improve the flavour and other desirable quality characteristics of doughnut, several attempts have been made to fill jams into doughnut. Jam is usually introduced by rolling out a moulded portion of the dough tightly, before introducing the jam with the use of spoon. The edges are then gathered over the jam, pressed and the final moulding follows. The jam under this condition rises with the dough. This method is strenuous and time consuming. Automation in food processing is very essential since food processing objectives are to produce foods in the required quality and quantity. In the search for process instrumentation for dispensing jam into the already prepared dough, research showed that processors adopt this means so as to reduce the time spent on filling jams into the doughnut. However, the capacity of the syringe is small and unsuitable for mass production.

To avoid the bottleneck in producing jam - filled doughnut, processors have resorted to producing round and caked doughnuts. Consequently, consumers are deprived of essential nutrients that would have been obtained from jam- filled doughnut. Availability of doughnut filling machine capable of large - scale production is therefore required for doughnut producers. **Olajide *et al.*, (2004)** developed a doughnut filling machine as shown in Figure 9. The dough filler was able to fill 48 doughnuts per minute and an average of 1.7 cm^3 of jam per dough.

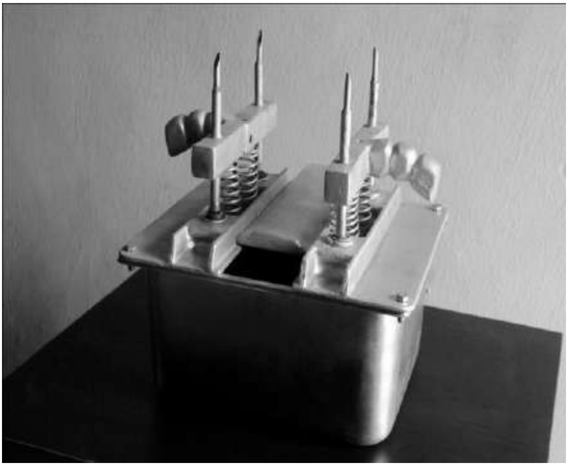


Figure 9: Doughnut filling machine

Development of food dryers

Drying is one of the most important post-harvest processes used to preserve, retain quality and add value to food products. Over the years, different types of dryers have been designed and fabricated and tested to cater for the need of small and medium - scale processors. Olajide *et al.*, (2003) developed a cabinet tray dryer for small and medium-scale food processors. The dryer has the potential of reducing postharvest spoilage of food raw materials, better utilization of farm produce and enhancement of farmers' income through optimized marketing of high quality products. It consists of a heating unit, drying unit and exhaust unit; was designed and fabricated with locally sourced materials. The dimensions of the drying chamber and trays are 565 mm x 356 mm x 412 mm and 500 mm x 300 mm x 30 mm respectively. A 1.5 kW rated heating element capable of producing a surface heating temperature of 107 ^{o}C was used while the blower selected has a speed of 1,300 rpm and can deliver free air of 7.84 m^3/s capacity. The performance test recorded moisture removal and air heater efficiencies of 83.75% and 77.07% respectively. The cabinet tray dryer is as shown in Figure 10.

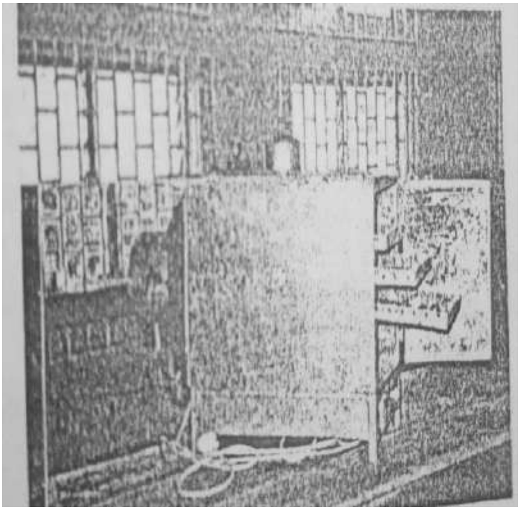


Figure 10: Cabinet tray dryer for small and medium scale food processors

Olajide *et al.*, (2009) also developed a tray dryer for fruits and vegetables using zigzag air flow configuration. The dryer was designed to address the problem of non-uniformity in drying along the length and height of trays when using traditional air flow patterns. Different types of air flow configuration are as shown in Figure 11a-c. The non-uniformity in drying allows microorganisms to grow better in foods with high moisture; such products tend to spoil at a short period of time. The zigzag air flow reduces the problem of non-uniformity thereby increasing the shelf- life of the dried products. The efficiency of the dryer when tested was 70% compared to 22% obtained for parallel air low pattern. The schematic diagram of the dryer is as shown in Figure 12a-b.

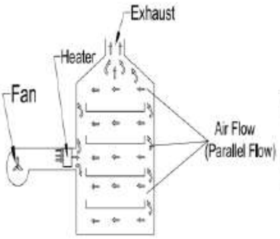


Figure 11a: Tray Dryer with Parallel Flow

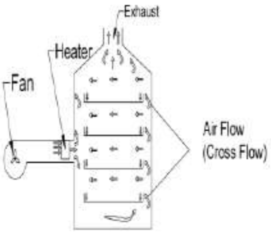


Figure 11b: Tray Dryer with Cross-flow configuration

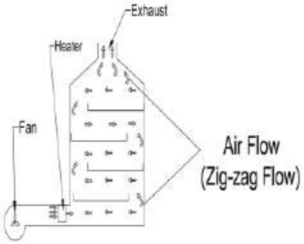


Figure 11c: Tray Dryer with Zig-Zag Air-flow

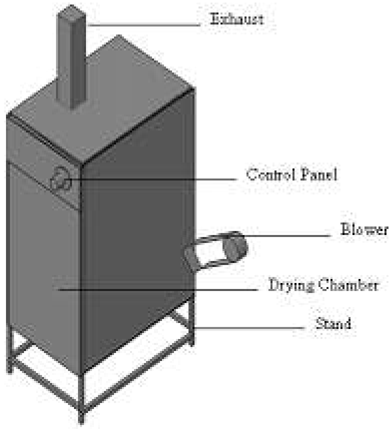


Figure 12a: Schematic diagram of the developed Dryer

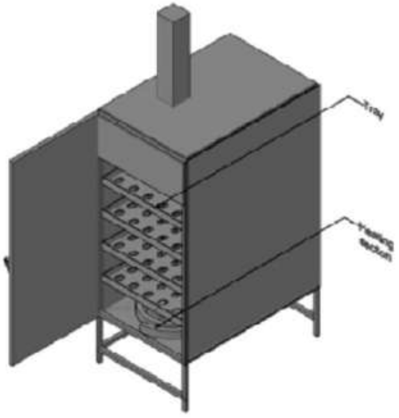
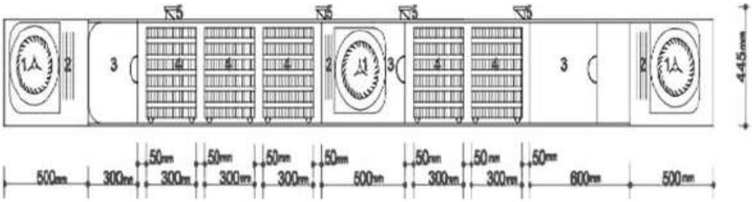


Figure 12b: Schematic diagram of the Developed Dryer

Design and Construction of a Tunnel Dryer for Food Drying

The drying of food products is a major step in food processing that goes beyond a mere reduction of moisture (Kiranoudis *et al.,* 1993). To address the problem of larger scale drying of piece-form food products in affordable equipment, in conjunction with other researchers (Ajala *et al.,* 2018) we designed, fabricated and tested a tunnel dryer for cassava chip dehydration, in conjunction with other researchers (Ajala, *et al.,* 2018).

The tunnel dryer was developed in two modes of operation (co-current and counter-current) with a capacity of 35 kg of cassava chips per batch. It was designed, fabricated and tested. The dryer had a chamber volume of 0.408 m^3. The number of trucks in the tunnel was 6, each truck contained 6 trays. The operating temperature of the pilot dryer ranged from 50 to 150 °C and air velocity ranged from 2 to 8 m/s, respectively. Schematic diagram and the tunnel dryer developed is as shown in Figures 13 and 14. Cassava chips were used to test the dryer, co-current form of drying was used throughout the drying operation. The drying rate pattern in the dryer is shown in Figure 15. The drying rate exhibits a falling rate profile. It is obvious from the graph that at the 4th hour, it exhibits a second falling rate before it stops at the 8th hour. Some agricultural products occasionally have second falling rate period as a result of the plane of evaporation which slowly receded from the surface and all evaporation occurred at the interior of the foods.



1- Centrifugal Fans, 2-Electric Heaters, 3-Doors, 4-Trucks, 5-Exhaust

Figure 13: Front view of the Tunnel Dryer with six trucks

Source: Ajala et *al.,* (2018)

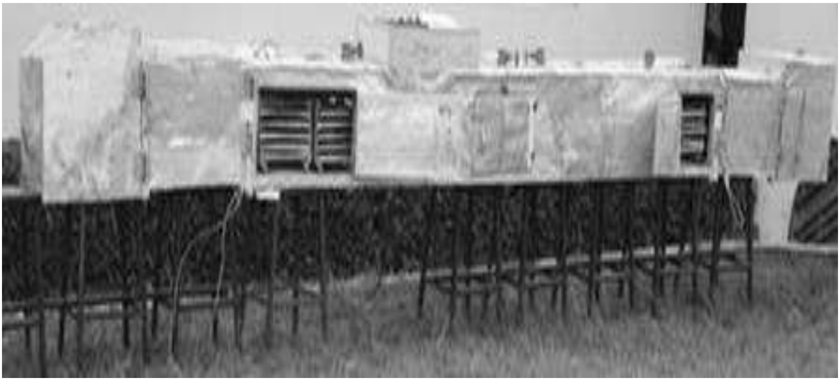


Figure 14: The Developed Tunnel Dryer

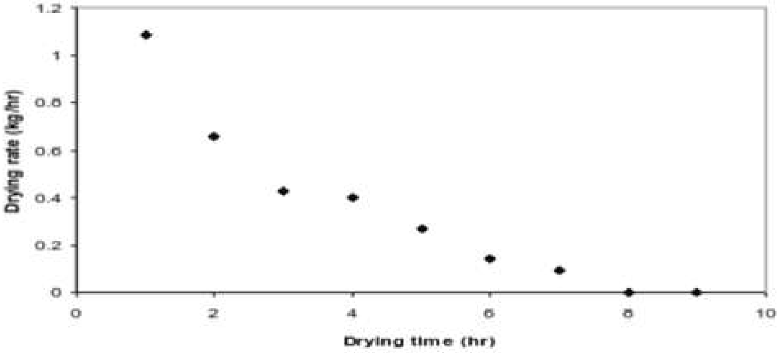


Figure 15: Drying rate against temperature

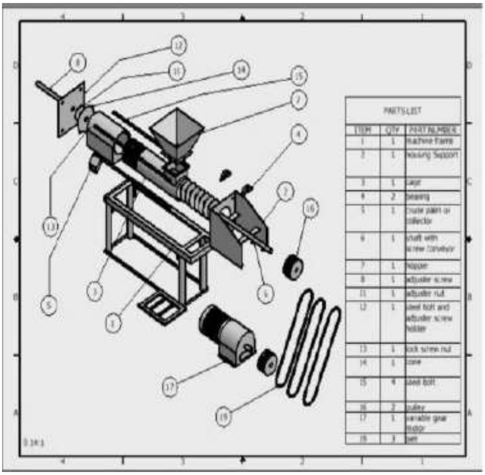
Development of a Screw Press for Palm Oil Extraction

Industries established with imported technology do not function for a long period of time because of lack of spare parts, inadequate maintenance and inability to adapt to some local factors (Ademosun, 2002). It is essential to evolve indigenous technology to address the issue of food processing in Nigeria. Many authors have reported on the need to develop indigenous technology in various aspect of agricultural and food processing (Olukunle, 2002; Ademosun *et al.*, 2003; Agbetoye, 2004). Several African nations including Nigeria are currently developing oil palm plantations so as to produce palm oil on a commercial scale in order to eradicate poverty and diversify the economy. Production of indigenous machinery to process the expected boom in palm fruits to palm oil is imperative.

I worked with a team of researchers Adetola, *et al.*, (2014), with a view to facilitating the application of indigenous technology to improve post-harvest challenges designed and constructed a domestic palm oil screw press for small and medium scale palm fruit processors to extract crude oil from oil palm effectively. The screw press consists of the following components: worm shaft, cylindrical barrel, feeding hopper, electric motor, pulley, cake outlet, oil outlet and main frame. The cylindrical barrel was made from a mild steel pipe of length 650 mm of inside diameter 166 mm and thickness of 10 mm. The worm shaft was made from a mild steel solid rod of diameter 80 mm and length 900 mm, which was machined on the lathe at a decreasing screw pitch and decreasing screw depth. The worm shaft was housed in the cylindrical barrel with a clearance of 1.5 mm between the screw diameter and barrel wall. In operation, the digested palm fruit is introduced into the machine through the feeding hopper; the machine convey and presses the digested palm fruit inside the cylindrical barrel with the aid of the worm shaft until crude oil is pressed out of the mash.

The crude oil extracted is drained through the oil channel into the oil tray where it is collected; the residual cake is discharged at the cake outlet and collected at the cake tray. The machine is powered by a 5 hp three phase electric motor and has production cost of USD 650 with the construction materials being locally available at affordable price. The exploded view of the palm oil screw press showing the component parts is shown in Figures 16 and 17.

The average oil extraction ratio, oil extraction efficiency, material discharge efficiency and machine capacity are 17.90, 79.56, 96.92% and 0.532 tons of bunches/hr., respectively. The machine operates smoothly during testing without frequent jamming. The screw press can be used for small scale palm fruit oil extraction in the rural and urban communities. A palm fruit oil processing plant based on this technology can provide employment for at least two persons at the same time provide palm oil at affordable costs for rural and urban communities.



PARTS LIST

ITEM	QTY	PART NUMBER
1	1	Machine Frame
2	1	Housing Support
3	1	Cage
4	2	Bearing
5	1	Crude palm oil collector
6	1	shaft with screw Conveyor
7	1	Hopper
8	1	adjuster screw
11	1	adjuster nut
12	1	steel bolt and adjuster screw holder
13	1	lock screw nut
14	1	cone
15	4	steel bolt
16	2	pulley
17	1	variable gear motor
19	3	belt

Figure 16: The exploded view of the palm oil Screw Press

Figure 17: The Developed Oil Palm Screw Press

Food Extrusion

Food extrusion also called extrusion- cooking is a commonly used processing technology in the food industry with a wide number of applications. It utilizes a single screw or a set of screws to force food materials through a small opening. While food is being forced through the extruder, foods are cooked by the high pressure, high shear, and high temperature environment created by the screws, encased in the barrel. Upon exiting, materials often puff due to the release of pressure and conversion of water into steam. The entire process is continuous and capable of happening in less than a minute. The most commonly used extruders in the food industry include single-screw and twin-screw systems, with twin-screw systems more widely used because of their flexibility (Harper 1996).

Extrusion cooking has gained popularity in the food industry because of its many advantages over conventional food processes such as its ability to handle various food ingredients, reduced processing costs, enhanced productivity, improved product quality and the absence of process effluents (Weidman and Strobel, 1987).In spite of the numerous merits of extrusion technology, the major factor militating against its wider use by local food processors in developing countries (DCs) is the high cost of importation of extruders (Adekola, 2014).

In order to explore the potentials of extrusion cooking in food processing in developing countries like, Nigeria, we developed a low-capacity laboratory-scale, single-screw cooking extruder for the manufacture of expanded snacks (Abioye *et al.*, (2019). It was designed on the basis of theoretical models, guided operating data and practices of existing cooking extruders. Construction of the machine was carried out using locally available engineering materials in machine shops satisfying sanitary design criteria and tested using blends of cassava and defatted soybean flours. The extruder developed has throughput, screw speed, barrel diameter, length-to-diameter ratio, power requirements and specific mechanical energy of 13.0 kg/h, 200 rpm, 40 mm and 12:1, 1.908 kW and 0.15 kWh/kg, respectively. Extrudates had expansion ratio and trypsin inhibitor reduction which ranged from 1.82 to 2.98 and 61.07 to 87.93 %, respectively across all treatments. The cost of the extruder developed was estimated US$ 1850(#650,000.00) as at 2016. This cost is low when compared with US$ 4,000 for importation of a twin-screw extruder and US$ 20,000 Brabendar extruder of similar capacity

This study demonstrated that low-capacity and affordable experimental single-screw extruders can be designed and built domestically, providing something of the experience required for possible scale-up to pilot and industrial level machine follow-up and applications for the production of expanded snacks. Sectional and plan views of the laboratory extruder showing major components are as shown in Figures 18 and 19. The assemblage of the extruder is shown in Figure 20. The extruder is being used for instructional purposes in the Owodunni Food Processing Laboratory attached to Food Engineering Department, LAUTECH.

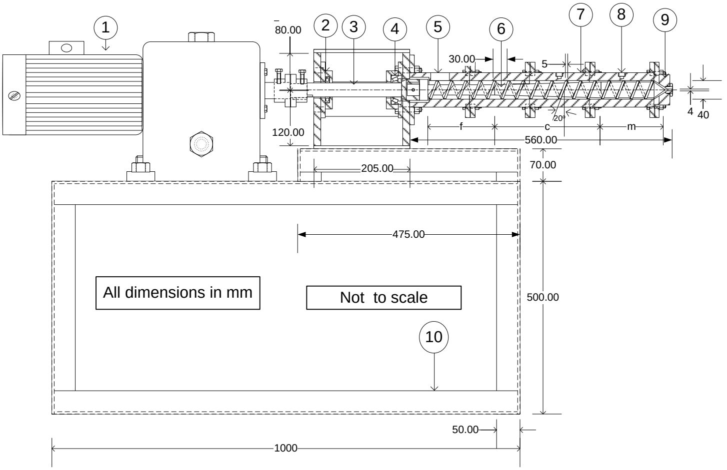


Figure 18: Semi-sectional view of the laboratory extruder developed showing major components.

(1) Gear motor, (2) ball bearing, (3) shaft, (4) taper roller (thrust) bearing, (5) inlet opening that receives improvised screw feeder, (6) screw, (7) barrel (8) thermocouple port, (9) die assembly, (10) stand (11) Flange, (12) die.

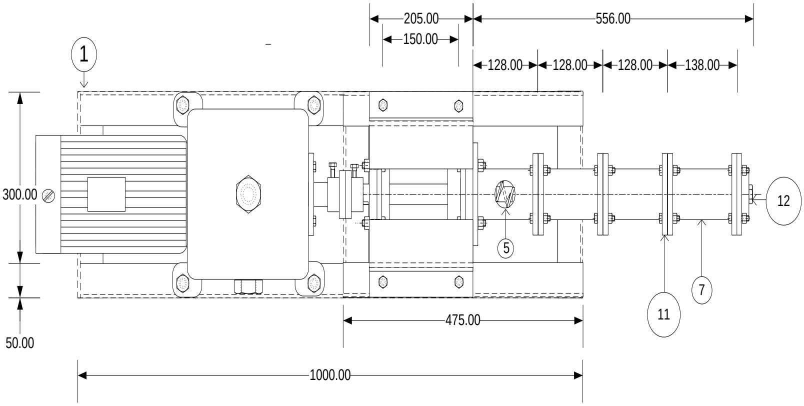


Figure 19: Plan view of the developed laboratory extruder showing major components

Figure 20: The Laboratory extruder developed

Process Optimization of Food Materials

From the aforementioned reports, my research efforts have attended to the responsibility resting on the shoulders of Food Engineers' to add value to post-harvest processing of food materials and reduction of PHLs.

Mr. Vice Chancellor sir, these efforts, has brought a great relief to small and medium scale processors yet they are left with the challenges of cost, quality and efficiency. These challenges thus push me to the third aspect of my research endeavour which addresses optimization of processes for food materials with a view to improve the process, save cost in terms of material and energy and eventually improve efficiency in order to compete with imported food processing machines.

A unit operation employed in handling and value-addition to a value to a food product in the post-harvest chain involves various processes that may be run concomitantly or intermittently. However, the basic aim is to improve the efficiencies of evolving process factors and qualities of the food product under investigation. Achieving a nexus for all the factors for the set objectives have been very challenging in most unit operations. The crux of this is to operate the factors at synthetic realm or regions that will facilitate optimum conditions for optimum achievement of the desired goals.

There are numerous techniques that can be used to improve the efficiency of the processes without resulting in extra energy cost or compromising the quality of the food product. Experimentation is not always the correct method for determining these optimum parameters because experiments consume a large amount of time, materials, energy and invariably, cost. Thus, process models are introduced as one way to ameliorate these challenges to the extent that full- scale experimentation, laboratory scale or on the actual unit, may not need to be conducted.

Typical procedures are achieved in phases. The first phase is to 'Identifying and define the problem statement' with a view of formulating the basic objective of the process model and determine the necessary questions that the model has to address. The second phase is the 'Model generation' phase, where the actual model is put together (Figure 21). It could be a mathematical model for a single unit or process or it could be the model for the entire process system. A large amount of data is necessary for implementing this step.

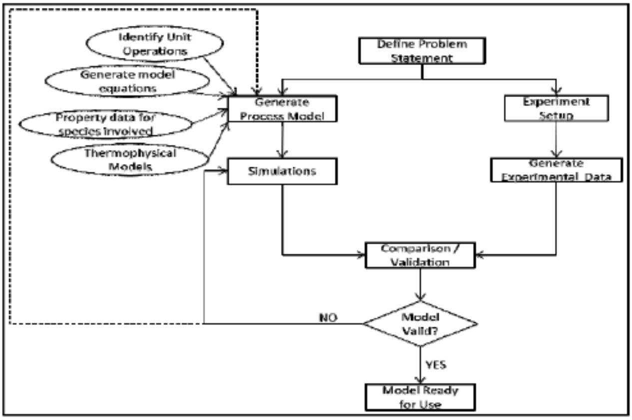


Figure 21: The major steps involved in process modelling and simulation

Data about the actual unit operation and process involved in the system could be based on physical and chemical data of the food material and/or the thermo-physical model that are necessary to predict the behavior of the species in different phase or as a mixture. The model developed is then simulated with all the data fed into it using pre-developed computer simulation engines to give the resultant model output. The model result can be compared to experimental data previously generated and if the model fits, it can be sent for further implementation. Otherwise, the parameters of the model are changed and it is re-simulated till a valid model results. On the other hand, existing and formulated mathematical models can be used to generate solution which can be compared with experimental data to check the validity of the model. Such models are needed to simulate an entire process flowsheet and are used for validating or analyzing the feasibility of a particular process.

These are generally referred to as process models, and in various engineering fields as ‘Mathematical models’, ‘empirical models’, etc. In order to make the application of the existing mathematical or empirical models easy to use for effective applications, various process simulators, such as ASPEN, ChemCAD, HYSYS, PRO-II, and Matlab etc. are available commercially. These simulators contain predefined subroutines which can be used to create the necessary process flow diagram. The user needs to select the appropriate process units, chemical species involved, thermodynamic model, type of solving approach to be used (sequential or modular) and also needs to specify the necessary process streams and unit information such as temperature, pressure, composition, conversion (for reactors), etc.

One of these simulators that have a relative ease of application and robustness in the designing experiments and subsequently facilitating process optimization via inbuilt empirical equations is the Design

Experts Software which has run from its initial version (6.0.8) to an advanced version (11.0.1). Its facility offers the Food Engineer the wherewithal to improve various factors to achieve maximum conditions that would entrench optimum results for the value-addition process of a targeted food product.

Effect of Processing Conditions on Yield of Screw Press Expressed Palm Oil

In oil palm processing the crude palm oil yield and quality is measured by the content of the solid impurity. Therefore, there is need to determine the appropriate processing conditions required for optimum oil yield and screw press operation which will in turn give maximum oil yield and more profit for palm oil processors and farmers. We (Adetola *et al.*, 2014) carried out investigations on the effect of processing conditions (sterilization time, digestion time and screw speed) on the efficiency of the screw press machine that we developed. Palm fruits were collected, cleaned and sterilized for 30, 60 and 90 min, then digested for 4, 7 and 10 min and later pressed at a screw speed of 4, 10 and 16 rpm.

Performance Evaluation Parameters

The Oil Extraction Ratio (OER) was calculated using equation (1).

$$\text{OER} = {}^{M7}\!/_{M1}\, x\ {}^{100}\!/_{1}\ (\%) \text{(PORIM, 1985)} \quad (1)$$

The oil extraction efficiency (OEE) was calculated using equation (2).

$$\text{OEE} = {}^{OER}/_{AEO}\, x\ {}^{100}/_{1}\ (\%)(\text{PORIM, 1985}) \quad (2)$$

The percentage solid impurity content was calculated using equation (3).

$$\text{SIC} = {}^{SIC}/_{M5}\, x\ {}^{100}/_{1}\ (\%)(\text{PORIM, 1985}) \quad (3)$$

The results obtained shows that increase in sterilization time and digestion time at optimum screw speed of 10 rpm generally increased the oil yield (Figure 22a-d). The solid impurity content of the oil at 30 and 90 min sterilization was observed to be generally high. The solid impurity at 60 min sterilization time was observed to be low. Increase in digestion time increased the solid impurity at all sterilization times. The highest oil extraction ratio of 17.90% and oil extraction efficiency of 79.56% were obtained at the sterilization time of 60 min, digestion time of 10 min and screw speed of 10 rpm.

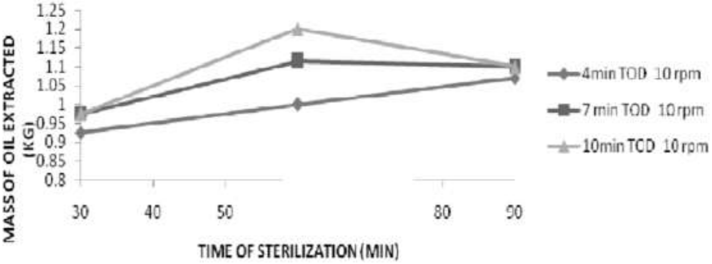


Figure 22a**: Effect of time sterilization on mass of oil extracted at screw speed of 10 rpm**

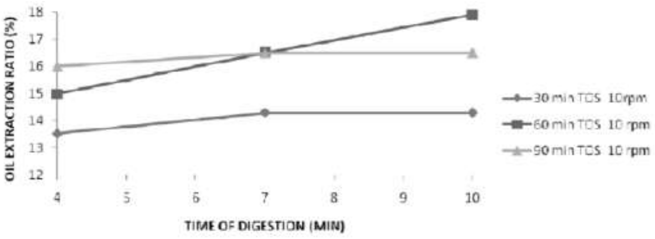


Figure 22b**: Effect of time of digestion on oil extraction ratio at screw speed 10 rpm**

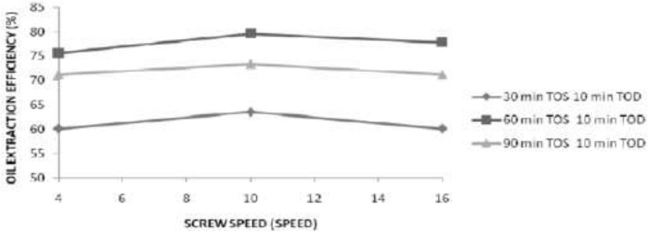


Figure 22c**: Effect of screw speed on oil extraction efficiency at 10 min time of digestion**

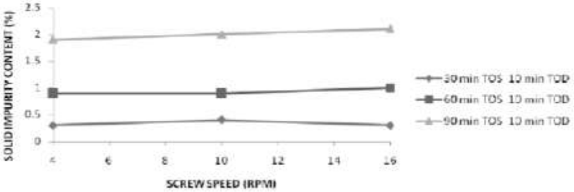


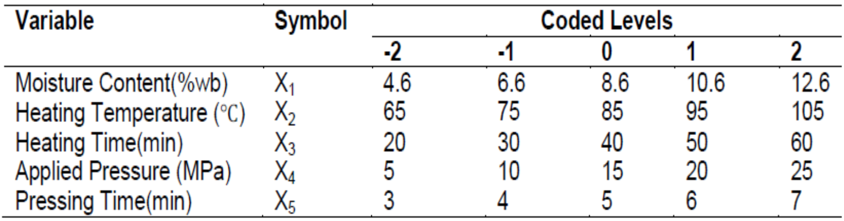
Figure 22d**: Effect of screw speed on solid impurity content at 10 min time of digestion**

Optimization of Oil Yield from Groundnut Kernel (*Arachis hypogeae*) in a Hydraulic Press using Response Surface Methodology (RSM)

Groundnut otherwise known as *Arachis hypogeae* is regarded as the fifth most important protein-rich oil seed crop globally grown after soybean, cotton seed, rape seed and sunflower seed (Davies, 2009). It is regarded as one of the world's most cultivated crops as it is native in the tropical and sub-tropical regions as an oil seed crop (Ingale and Shrivastava, 2011). Nigeria has been ranked as the third major producer of groundnuts in the world after China and India (Nwokolo, 1996). Commercial production of oil from oil seeds like groundnut is usually based on mechanical pressing and extraction as established by Olajide *et al.,* 2007. Mechanical pressing is preferred to other conventional methods because it is impossible to obtain solvent-free products from the solvent extraction process and also there is chemical modification of the oil produced. Steam distillation and hydro distillation (Rezzoug *et al.*, 2005; Evangelista *et al.*, 2009; Evon *et al.*, 2013).

Oil produced from groundnut kernels are used in the production of wide range of products. Process parameters have been found to have effects on the extraction of oil from groundnut kernel (Alonge and Olaniyan, 2009). In order to obtain optimum yield, it is imperative to investigate the best processing conditions for the extraction of oil from the kernel. **Olajide *et al.*, (2014)** investigated the effect of operating parameters on the mechanical extraction of oil from groundnut kernel using hydraulic press. A Central Composite Design (CCD) of the RSM was adopted to study the interaction effects of five factors namely: moisture content, heating temperature, heating time, applied pressure and pressing time which are denoted as X_i(i=1, 2, 3, 4, 5), respectively (Table 8).

Table 8: Factors and levels for central composite design



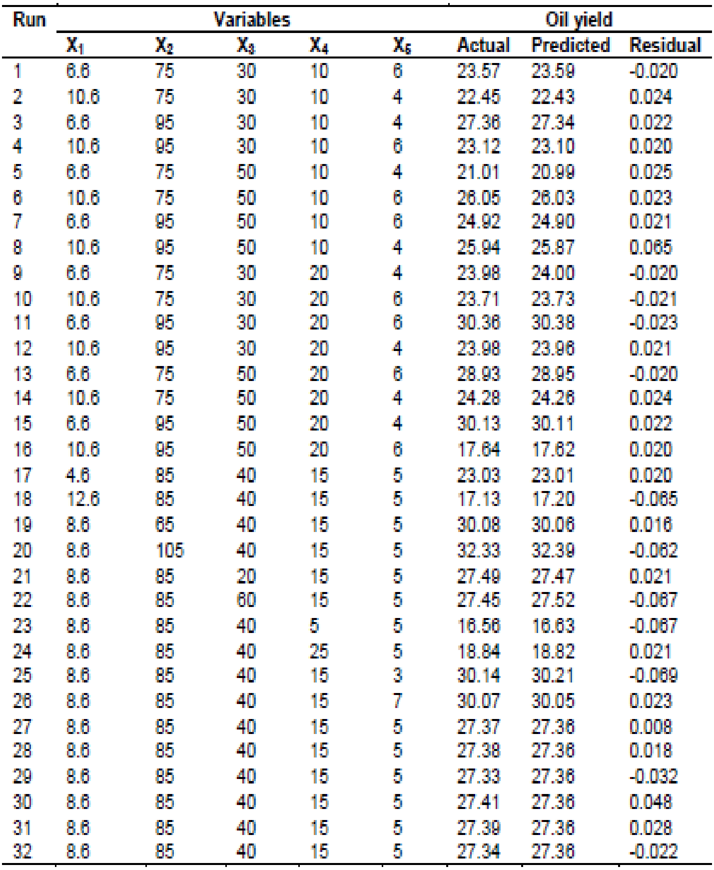
Variable	Symbol	Coded Levels				
		-2	-1	0	1	2
Moisture Content(%wb)	X_1	4.6	6.6	8.6	10.6	12.6
Heating Temperature (°C)	X_2	65	75	85	95	105
Heating Time(min)	X_3	20	30	40	50	60
Applied Pressure (MPa)	X_4	5	10	15	20	25
Pressing Time(min)	X_5	3	4	5	6	7

Source: Olajide *et al.*, 2014

It has been reported in the literature that the most important process parameters during oil expression are the moisture content of the feed materials, temperature, pressing time, applied pressure and the heating time (Zaher *et al.*, 2004; Mpagalile *et al.*, 2007; and Kasote *et al.*, 2013). The factors and their levels were chosen based on the recommendation of Olajide *et al.*, (2007). These parameters were selected and response surface methodology (RSM) was used to determine the effect of independent variables on product quality. A second degree polynomial equation was fitted in each response to study the effect of variables and to describe the process mathematically. The experimental results, the predicted values and the residuals are presented in Table 9. The effects of the factors considered: the moisture content, heating temperature, heating time, applied pressure and pressing time) on the response (% oil yield) were shown in Figure 23a-j.

Results of optimization by RSM showed that extraction factors influenced the yield of oil from groundnut kernels. The most important variables were moisture content and heating temperature. Heating temperature had the most influence while pressing time had the least. Optimum oil yield of 32.36 % was obtained when the moisture content, heating temperature, heating time, applied pressure and pressing time were 8.13%, 81.93 ºC, 7.03 mins, 15.77 Mpa and 6.69 mins, respectively. The coefficient of determination (R^2) of the model analysis was found to be 0.99. The experimental values were very close to the predicted values and were not statistically different at $p<0.05$. The regression model obtained provided a basis for selecting optimum process parameters for the recovery of oil using mechanical press and this can be manipulated in future studies.

Table 9: Experimental design matrix and Results for oil yield



Run	Variables					Oil yield		
	X_1	X_2	X_3	X_4	X_5	Actual	Predicted	Residual
1	6.6	75	30	10	6	23.57	23.59	-0.020
2	10.6	75	30	10	4	22.45	22.43	0.024
3	6.6	95	30	10	4	27.36	27.34	0.022
4	10.6	95	30	10	6	23.12	23.10	0.020
5	6.6	75	50	10	4	21.01	20.99	0.025
6	10.6	75	50	10	6	26.05	26.03	0.023
7	6.6	95	50	10	6	24.92	24.90	0.021
8	10.6	95	50	10	4	25.94	25.87	0.065
9	6.6	75	30	20	4	23.98	24.00	-0.020
10	10.6	75	30	20	6	23.71	23.73	-0.021
11	6.6	95	30	20	6	30.36	30.38	-0.023
12	10.6	95	30	20	4	23.98	23.96	0.021
13	6.6	75	50	20	6	28.93	28.95	-0.020
14	10.6	75	50	20	4	24.28	24.26	0.024
15	6.6	95	50	20	4	30.13	30.11	0.022
16	10.6	95	50	20	6	17.64	17.62	0.020
17	4.6	85	40	15	5	23.03	23.01	0.020
18	12.6	85	40	15	5	17.13	17.20	-0.065
19	8.6	65	40	15	5	30.08	30.06	0.016
20	8.6	105	40	15	5	32.33	32.39	-0.062
21	8.6	85	20	15	5	27.49	27.47	0.021
22	8.6	85	60	15	5	27.45	27.52	-0.067
23	8.6	85	40	5	5	16.56	16.63	-0.067
24	8.6	85	40	25	5	18.84	18.82	0.021
25	8.6	85	40	15	3	30.14	30.21	-0.069
26	8.6	85	40	15	7	30.07	30.05	0.023
27	8.6	85	40	15	5	27.37	27.36	0.008
28	8.6	85	40	15	5	27.38	27.36	0.018
29	8.6	85	40	15	5	27.33	27.36	-0.032
30	8.6	85	40	15	5	27.41	27.36	0.048
31	8.6	85	40	15	5	27.39	27.36	0.028
32	8.6	85	40	15	5	27.34	27.36	-0.022

Source: Olajide *et al.*, (2014)

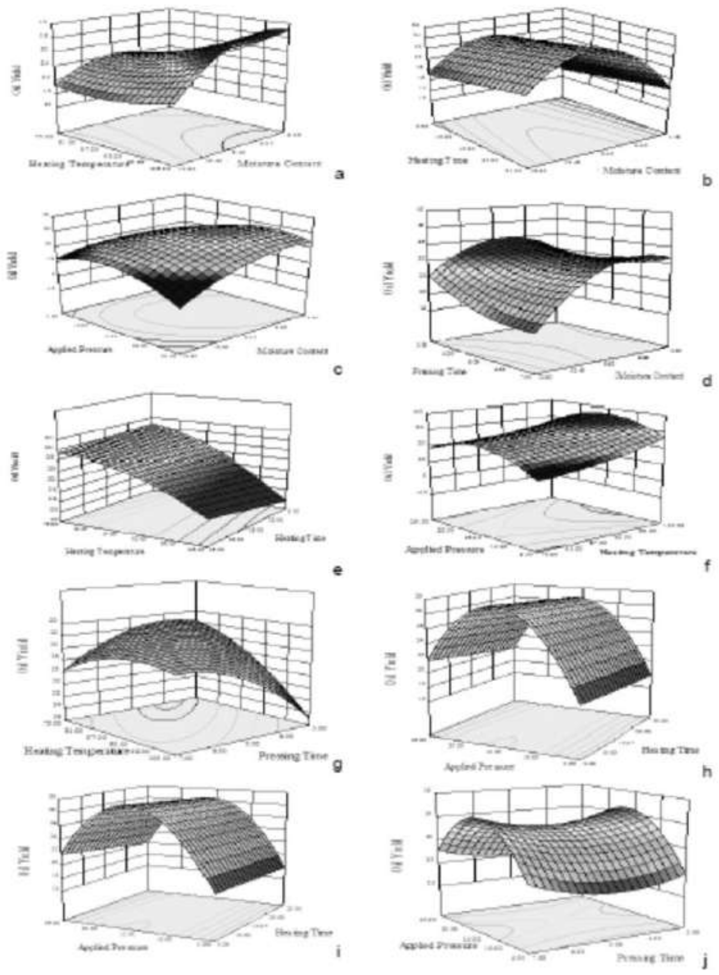


Figure 23a-j: Response Surface plots for the effects of input variables on oil yield

Source: Olajide et al 2014

Optimization of Oil Yield from Shea Kernel using Response Surface Methodology and Adaptive Neuro Fuzzy Inference System (ANFIS)

Optimization of oil yield from oil seed using RSM has been a subject of research in recent years. (Rezzoug *et al.*, 2005; **Olajide *et al.*, 2007**; **Olajide *et al.*, 2014**; Rostami *et al.*, 2014). Another useful optimization tool is Adaptive Neuro-Fuzzy Inference System (ANFIS) which has been applied to various processes in laboratories and industries (Aremu *et al.*, 2007; Karaagac *et al.*, 2012).ANFIS is an adaptive network that permits the application of neural network topology and fuzzy logic to predict the behaviour of variables and reduce optimization search space. It includes the characteristics of both methods and eliminates some disadvantages of separate application. ANFIS uses the learning ability of Artificial Neural Network (ANN) to define the input–output relationship and construct the fuzzy rules by determining the inputs structure. The system results were obtained by thinking and reasoning capability of the fuzzy logic (Jaliliantabar *et al.*, 2007).

A typical ANFIS architecture consisting of five layers is represented in Figure 24. This includes the input layer (Layer 0), the fuzzification layer (Layer 1) in which each node represents a membership function, the strength of the rule by means of multiplication operator in each node (Layer 2), the normalization layer which normalizes the firing strength of the rules (Layer 3), adaptive nodes (layer 4) and single node (Layer 5) which is fixed the summation of the inputs of the nodes in layer 4(Jaliliantabar *et al.*, 2007; Naresh *et al.*, 2008; MANFIST, 2009).

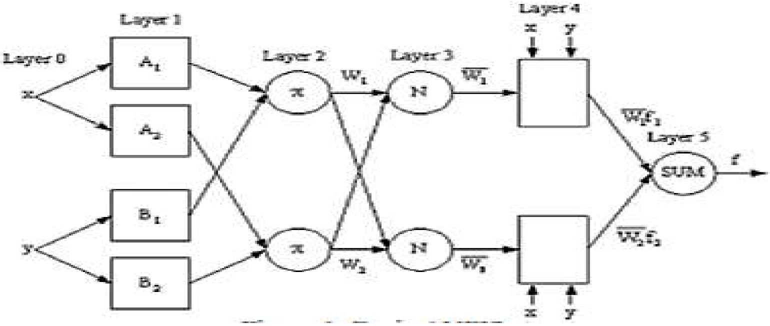


Figure 24: ANFIS Architecture of five layers

Source: Olajide *et al.*, (2014)

Subtractive clustering method involves the division of the training data according to their respective class labels and then the subtractive clustering algorithm is applied on each group of data individually to extract the rules for identifying each class of data. A group of data points was specified for a particular class in the feature space. Subtractive clustering was done to normalize the data in the feature space in the range [0,1]. Each data point in the class was considered a potential cluster center while the data points outside this radius had little influence on the potential of the data points within this radius. Thus, the measure of the potential of a data point became a function of its distances to all other data points. After the potential of every data point had been computed, the data point with the highest potential as the first cluster center was selected as suggested by MANFIST (2009).Subtractive clustering is a very fast and efficient clustering method designed for a moderate number of input patterns, because its computation grows linearly with the data dimension and as the square of the number of data points. The subtractive clustering method is available in the fuzzy logic toolbox for MATLAB.

Olajide *et al.,* (2014), suggested that comparison of both methods could give insight into the selection of influential input variables and their levels that will give an appreciable product yield. RSM and ANFIS were employed in our study to optimize the recovery of oil from shea kernel in a hydraulic press in order to obtain the optimum process conditions that would give insights into the input variable combinations that would favour the extraction of oil from shea kernel. The five factors considered were moisture content, heating temperature, heating time, applied pressure and pressing time on oil yield. In this work, subtractive clustering method was used in generating the Fuzzy Inference System (FIS). The experimental data were divided into training and checking data. Cluster centers were evaluated for the training data by competitive learning. Antecedents and consequents were calculated using the initial fuzzy model and input parameter features were attained with the neural fuzzy model. The training features were selected by applying subtractive clustering to obtain cluster centers. These cluster centers were then used to develop the fuzzy rule base and the membership function of the fuzzy rule was optimized using the back propagation algorithm. The model was developed, trained and evaluated.

A Central Composite Design (CCD), under the RSM was adopted to study the interaction effects of five factors (moisture content, heating temperature, heating time, applied pressure and pressing time) which are denoted as $\mathrm{X_i}(\mathrm{i} = 1, 2, 3, 4, 5)$, respectively. The quality of the fit of the model was evaluated using analysis of variance (ANOVA). The fitted quadratic response model is as described in Equation 3

$$Y = \sum_{i=1}^{k} b_i X_i + \sum_{i=1}^{k} b_{ij} {X_i}^2 + \sum_{i}^{k}{}_{1<j} \sum_{j}^{k} b_i X_i \, X_j + \ e \qquad 3$$

where Y is response factor (% Oil yield), and i and j denote linear and quadratic coefficients, respectively. b_0 is the intercept, b_i is the first order model coefficient, k is the number of factors, and e is a random number.

The performance of ANFIS model in training an d testing sets is validated in terms of the common statistical measures R (coefficient of determination) which presents the degree of association between predicted and true values and RMSE (Root Mean Square Error) which are preferred in many iterative prediction and optimization schemes.

$$R = \frac{\Sigma(Y_{obs}-Y'_{obs})(Y_{pre}-Y'_{pre})}{\sqrt{\Sigma(Y_{obs}-Y'_{obs})^2\,\Sigma(Y_{pre}-Y'_{pre})^2}} \quad (4)$$

$$RMSE = \sqrt{\frac{1}{N}\Sigma(Y_{obs} - Y_{pre})^2} \quad (5)$$

Where Y_{obs}= observed data, Y_{pre} = predicted data, Y_{iobs} = average value of observed data and Y_{ipre} = average value of predicted data.

In the RSM model developed, the analysis of the variance including the sequential F-test and lack of fit test were used in the assessment of the performance of the model. Also residual analysis and diagnostics case statistics were checked to ensure adequacy of the model. The quality of fit of the quadratic model was expressed by the coefficient of determination (R^2).

$$R^2 = 1 - \frac{SS_{residual}}{SS_{model} + SS_{residual}} \qquad (6)$$

Where SS = sum of square.

RSM and ANFIS are both data driven models used in predicting the outcome of an experiment. In this study, both models were used to predict the extraction of oil yield from sheabutter. RSM is powerful in identifying the insignificant main factors and interaction factors or insignificant quadratic terms in the model and thereby can reduce the complexity of the problem. On the other hand, ANFIS is a black box model approach which requires large and sufficient data for better performance. Thus, RSM gave a better prediction performance having R^2 of 0.9998 while ANFIS has R^2 of 0.9865. RSM is more statistical in analyzing and optimizing process variables. From the input parameters, RSM suggested the combination of Moisture content and Temperature has the most significant effect on the oil yield percentage with the highest F-value of 945.50 and R^2 of 0.9998. On the other hand, the best combination of two input parameters suggested by ANFIS is Temperature and Heating time having less RMSE of 0.1876 and R^2 of 0.9865 (Figure 25). Optimum oil yield of 47.13% was obtained when the moisture content, heating temperature, heating time, applied pressure and pressing time were 14.09%wb, 128.70 °C, 35.93 mins, 19.21 MPa and 6.69 mins, respectively. The two models proved effective at predicting the percentage oil yield at 99% accuracy (Figure 26). RSM gave a better prediction than ANFIS with reference to the obtained R^2 values for both models (Figure 26). The model we developed can be used for process behaviour prediction, performance measure, optimization and as training tools for operators.

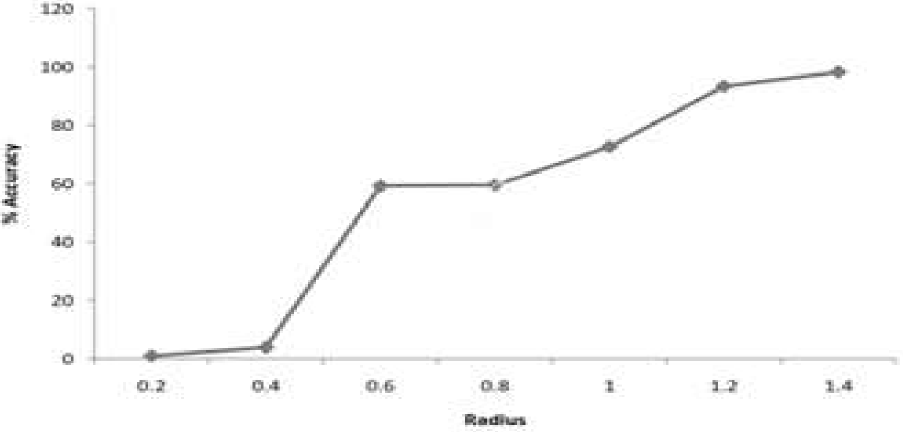


Figure 25: Percentage accuracy of the developed model for different radii values
Source: Olajide *et al.*, (2014)

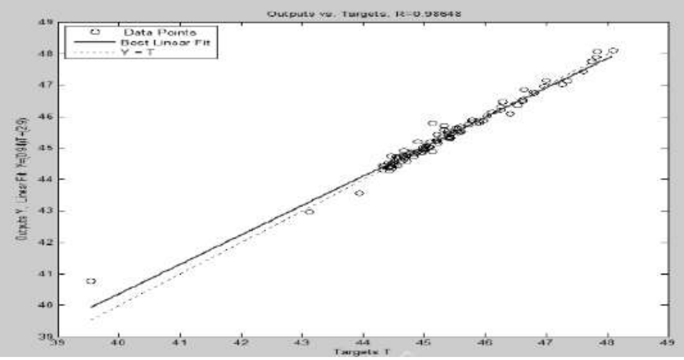


Figure 26: Experimental data value against the predicted value for the oil yield Source: Olajide *et al.*, (2014)

Development of Optimum Operating Conditions for Quality Attributes in Deep-Fat Frying of *Dodo* Produced from Plantain using Response Surface Methodology

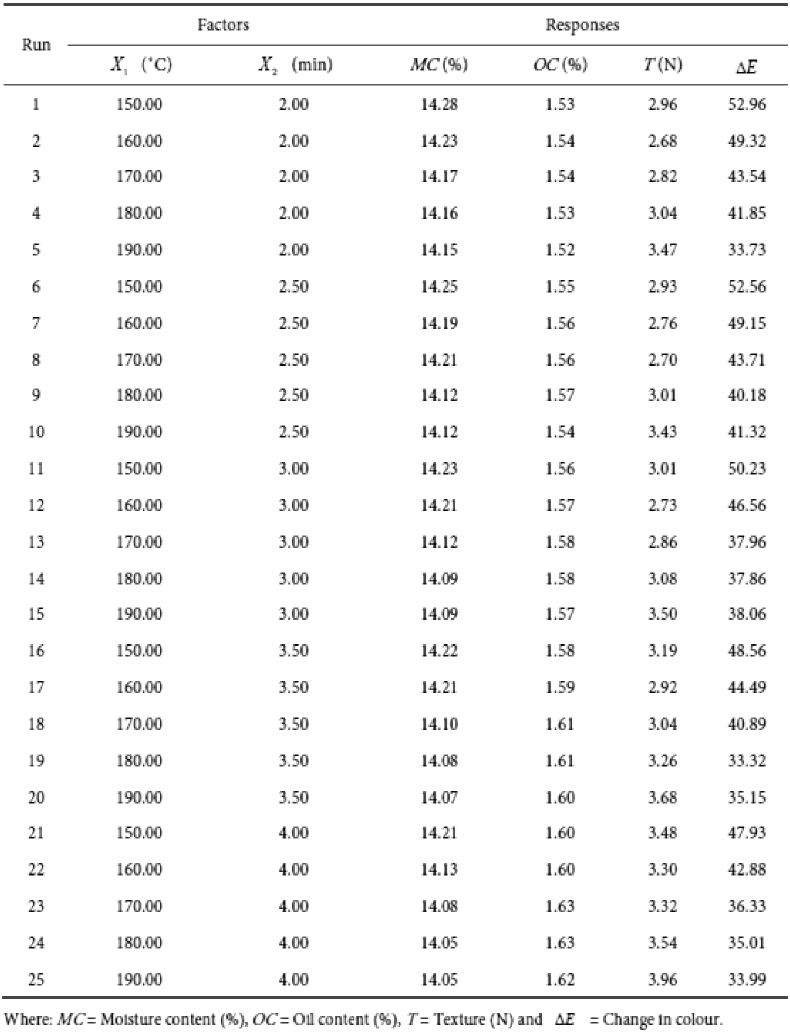
I and other researchers employed RSM which is an important technique in optimization process to generate optimum operating conditions for quality attributes in Deep-Fat Frying of dodo (DFF) (Adeyanju, *et al.,* 2016). We embarked on the study to assist the Food Engineers in optimizing process variables that will influence value addition to post-harvest products. In the present study, the frying oil temperature and time were considered as major variables controlling DFF operations (Suleiman *et al.*, 2001; Sobukola *et al.*, 2008) and were investigated as important processing condition for deep fried dodo with high quality attributes. The frying temperature and time were in the ranges 150-190 ˚C and 2.0-4.0 mins. The output parameters analyzed were moisture content, oil content, texture and change in colour.

Regression models were developed for the quality attributes of dodo as a function of the two process variables. The Design Expert software version 9.0.3.1 was used to analyze the frying data for developing response equations, undertake analysis of variance (ANOVA), and generate surface plots and determine optimum frying conditions using its optimization toolbox. The statistical significance of terms in the regression equations was tested for errors and test of significance considering probability at confidence limits $p < 0.05$ used for ANOVA.

The results obtained indicated that frying conditions had significant ($p < 0.05$) effects on the quality attributes. R^2 of the generated models ranged from 0.91 to 0.99. Optimum frying condition was 177.51 °°C for 2.10 min, at 14.16% moisture content, 1.54% oil content, 2.93 N texture and 40.89 change in colour were obtained (Table 10).The model graphs generated from this study are illustrated in Figures 13a-d. The effect of interaction of frying temperature and time on moisture content showed that the moisture content ranged between 14.05% and 14.28% and increase in temperature resulted in reduced moisture content in the dodo fried from plantain slices (Figures 27a). The effect of interaction of frying temperature and time on oil content (Figures 27b) showed that the oil content of the dodo was between the values of 1.52% and 1.63% and the frying temperature and time of the process increased the oil content of dodo.

The effect of interaction of frying temperature and time on texture of dodo and the texture varied between 2.96 to 3.96 N (Figure 27c), while the effect of interaction of temperature and time on change in colour (Figures 27d) gave a change in colour was between 33.33 and 52.96. The ΔE of dodo decreased progressively as the frying temperature and time increased. All these are in agreement with concepts and results obtained in various studies (Rice *et al.,* 1989; Hwang, 2001; Krokida *et al.,* 2001;; Nourian and Ramaswamy 2003; Tan, and Mittal, 2006; Avallone *et al.,* 2009; Shyu, and Moreira *et al.,* 2009)

Table 10: The experimental Design and Obtained values of the response



Run	Factors		Responses			
	X_1 (°C)	X_2 (min)	MC (%)	OC (%)	T (N)	ΔE
1	150.00	2.00	14.28	1.53	2.96	52.96
2	160.00	2.00	14.23	1.54	2.68	49.32
3	170.00	2.00	14.17	1.54	2.82	43.54
4	180.00	2.00	14.16	1.53	3.04	41.85
5	190.00	2.00	14.15	1.52	3.47	33.73
6	150.00	2.50	14.25	1.55	2.93	52.56
7	160.00	2.50	14.19	1.56	2.76	49.15
8	170.00	2.50	14.21	1.56	2.70	43.71
9	180.00	2.50	14.12	1.57	3.01	40.18
10	190.00	2.50	14.12	1.54	3.43	41.32
11	150.00	3.00	14.23	1.56	3.01	50.23
12	160.00	3.00	14.21	1.57	2.73	46.56
13	170.00	3.00	14.12	1.58	2.86	37.96
14	180.00	3.00	14.09	1.58	3.08	37.86
15	190.00	3.00	14.09	1.57	3.50	38.06
16	150.00	3.50	14.22	1.58	3.19	48.56
17	160.00	3.50	14.21	1.59	2.92	44.49
18	170.00	3.50	14.10	1.61	3.04	40.89
19	180.00	3.50	14.08	1.61	3.26	33.32
20	190.00	3.50	14.07	1.60	3.68	35.15
21	150.00	4.00	14.21	1.60	3.48	47.93
22	160.00	4.00	14.13	1.60	3.30	42.88
23	170.00	4.00	14.08	1.63	3.32	36.33
24	180.00	4.00	14.05	1.63	3.54	35.01
25	190.00	4.00	14.05	1.62	3.96	33.99

Where: MC = Moisture content (%), OC = Oil content (%), T = Texture (N) and ΔE = Change in colour.

Source: Adeyanju *et al.*, (2016)

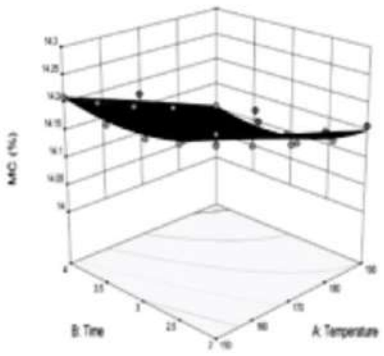


Figure 27a: The surface plot for moisture content of dodo as affected by frying temperature and time

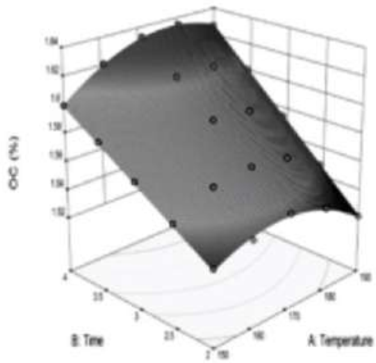


Figure 27b: The surface plot for oil content of dodo as affected by frying temperature and time

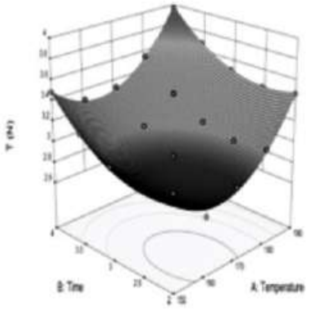


Figure 27c: The surface plot for texture of dodo as affected by frying temperature and time

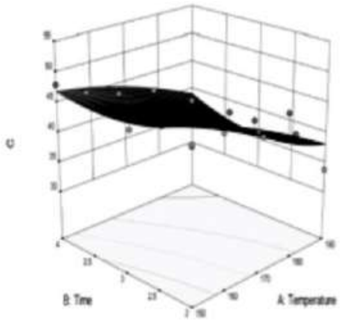


Figure 27d: The surface plot for colour of dodo as affected by frying temperature and time

Source: Adeyanju *et al.*, (2016)

Work in Progress

Mr. Vice-Chancellor Sir, distinguished ladies and gentlemen, I wish to bring to your attention that research activities are ongoing on the under listed projects in collaboration with researchers from this and other universities as well as the private sector.

1) Development of A Mobile Photovoltaic Forced Convection Solar Dryer for spices and cocoa beans (**Figure 28)**
2) Design, Fabrication and Evaluation of A Laboratory Scale Hot Air Dryer for Food Materials (Figure 29)
3) Development of A Bread Slicing Machine (Figure 30)
4) Development of A Laboratory Scale Baking Oven (Figure 31)
5) Development of A Meat Slicing Machine for Kilishi Processing (Figure 32)

Figure 28: Mobile photovoltaic forced air convection dryer

Figure 29: Laboratory scale hot air dryer

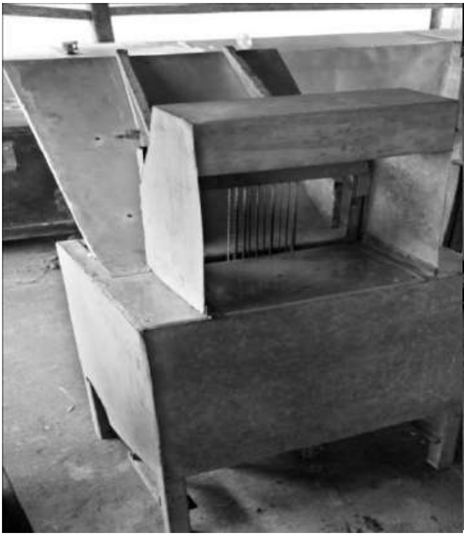
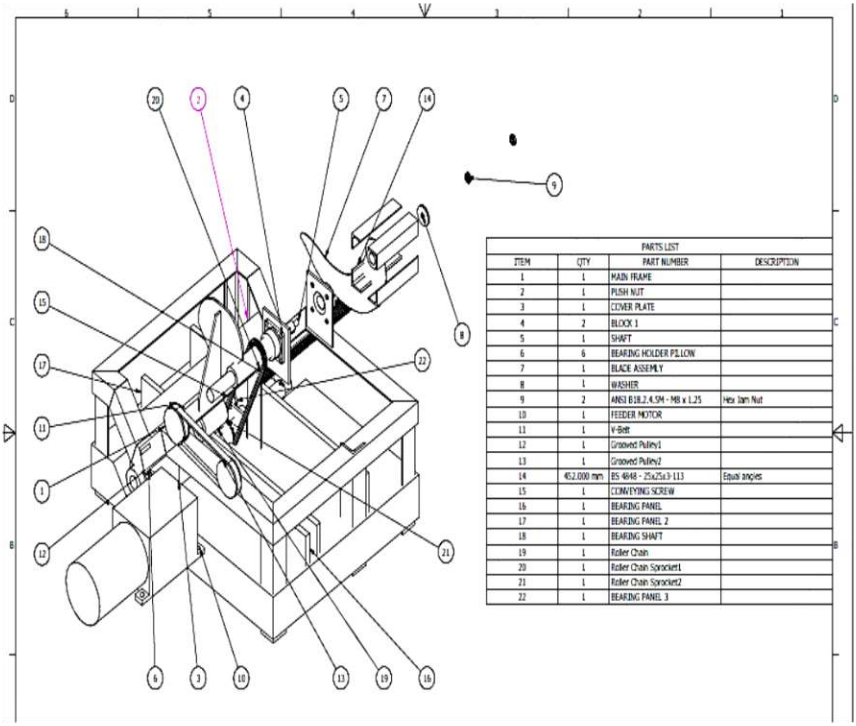


Figure 30: Bread slicing machine

Figure 31: Laboratory scale baking oven



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	MAIN FRAME	
2	1	PUSH NUT	
3	1	COVER PLATE	
4	2	BLOCK 1	
5	1	SHAFT	
6	6	BEARING HOLDER PILLOW	
7	1	BLADE ASSEMLY	
8	1	WASHER	
9	2	ANSI B18.2.4.5M - M8 x 1.25	Hex Jam Nut
10	1	FEEDER MOTOR	
11	1	V-Belt	
12	1	Grooved Pulley1	
13	1	Grooved Pulley2	
14	452.000 mm	BS 4848 - 25x25x3-113	Equal angles
15	1	CONVEYING SCREW	
16	1	BEARING PANEL	
17	1	BEARING PANEL 2	
18	1	BEARING SHAFT	
19	1	Roller Chain	
20	1	Roller Chain Sprocket1	
21	1	Roller Chain Sprocket2	
22	1	BEARING PANEL 3	

Figure 32: Meat slicing machine for Kilishi

CONCLUSIONS

Mr. Vice Chancellor Sir, in this presentation, I have tried to demonstrate the integral role of Food Engineers in value-addition as a proven means of reducing postharvest food losses in developing nations like Nigeria. This lecture contends that reducing post-harvest food losses is among the most sustainable alternatives to increasing agricultural food production and advancing food security. Food Engineers have made indispensable contributions to addressing the challenges of postharvest food losses through value- addition by designing and optimizing food processes and developing adaptable and cost effective food processing equipment for use at different levels. The following conclusions can be drawn from this presentation:

1. Exclusive emphasis should not be on increasing agricultural production, equal provisions and efforts are required to ensure that what is produced get consumed and utilized. In order to guarantee sustainable food security therefore, complementary efforts in reducing post-harvest food losses must be given due attention. This will not only add-value to raw food produce, but also enhance smallholder farmers' incomes and better accessibility to food.
2. The annual post –harvest food losses recorded in the Nigerian food supply chain as a result of inadequate storage facilities and food processing equipment constitute greater threat to food security and the development of the nation's economy.
3. Addressing the critical challenge of Food insecurity which is one of the most pressing challenges in Nigeria today is a task to be tackled with urgency. No country can truly be a sovereign nation if it is not capable of ensuring food security for its citizens.
4. Food Engineers have critical roles to play in the transformation of the agricultural potentials of the nation into reality and strengthening the food value chain so as to make Nigeria self-reliant in food production and generate income and wealth for Nigerian farmers and food processors.

RECOMMENDATIONS

The following recommendations are put forward from the presentation:

1. There is need for the Government of Nigeria to deploy more resources in the promotion of post-harvest handling and processing of food raw materials by providing enabling environments (including easy accessibility to funds being provided for food processors by the Bank of Industry (BOI)) for the establishment of food processing enterprises in large number at the small and medium scale levels. In this way, jobs and wealth will be created, while poverty will be substantially reduced and there will be promotion of industrialization and substantial value will be added to the food raw materials.
2. Government should facilitate the commercialization and adoption of the various indigenous post-harvest and preservation methods that can be used to ensure food security.
3. Development of the steel rolling mills and machine tools industries is crucial for the fabrication of food processing equipment. Therefore, government should intensify efforts in reviving the Ajaokuta Steel Rolling Mills, Osogbo Machine Tools Company and others. As these are needed for the production of steel products and machine parts for machinery and equipment fabrication locally so as to drastically reduce manufacturing costs, making them affordable.
4. Government should encourage the establishment of a very strong machine building industry that will translate functional equipment and machinery prototypes developed by Food Engineers in our tertiary institutions and research institutes all

over the nation into commercialise-able processing machinery that SMFPE can afford to buy. Designers of prototypes should be rewarded by patenting the prototypes. Thereafter, the patents can be licensed or out rightly sold to machine manufacturers.

5. There is the need to strengthen partnership between the industry and academia so that Nigerian can benefit from the research and development findings of Food Engineers and other researchers.
6. Considering the importance of energy in food production and processing, it is imperative for Government to partner with the private sector to boost power supply in the country so as to encourage production and food processing.
7. The strategic grain reserve programme of the Federal Government should be extended to all the Local Government Areas in the nation. Strategic storage of food raw materials on a large scale should be given priority.

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My parents of blessed memory Pa Joseph Ogunrinde Olajide and Madam Alice Olukunbi Olajide are remembered for their special love

for my siblings and I , nurturing us to maturity, providing and caring for us while they lived, and for instilling in us the virtues of discipline, honesty and love for mankind. May their souls rest in peace – Amen. My siblings, Mr. Julius Adisa Olajide (Daddy Agba) and Mrs. Bidemi Adigun and their spouses are highly appreciated for their constant love and support.

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I want to thank all the former Vice Chancellors of this University especially Prof. O.L. Oke who appointed me as an Assistant Lecturer in 1992, Late Prof. A.M. Salau under whom I became a Senior Lecturer and Acting Head of Department of Food Science and Engineering between 2004 and 2007, Prof. B.B. Adeleke during whose tenure I became a Reader and got a post-doctoral Commonwealth Fellowship to University of Leeds in the United Kingdom, Prof Nassar under whom my professorial promotion was announced, Prof. A.S. Gbadegesin during whose tenure I served as Dean of Faculty of Engineering and Technology between 2011 and 2015, and also nominated me to serve as a council member of COREN. I most sincerely thank the current Vice-Chancellor Professor Michael Olufisayo Ologunde for approving my request to deliver my inaugural lecture and making it possible for me to deliver the lecture today. Thank you, Sir for your encouragement and support over the years.

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I appreciate most sincerely the love, friendship and support I have enjoyed over the years from all my elders and colleagues; technical and administrative staff in the Food Science and Engineering Department that transformed recently into the Department of Food Engineering and Faculty of Food and Consumer Studies respectively .I am grateful to all the past and present HODs, and all that have contributed in one way or the other to my modest achievements especially Profs. I.A. Adeyemi, P.O. Ngoddy, E.T. Otunola, M.O. Ologunde, O.O. Fapojuwo, B.I.O Ade-Omowaye, T.Y. Tunde-Akintunde, O.J. Oyelade, B.A. Akinwande, E.A. Akande, Drs. H.A. Agbooola, O.E. Adelakun, V.F. Abioye, G.O. Babarinde, J.A. Adejuyitan, B.F. Olanipekun, S.A. Olaniyan, I.F. Bolarinwa and S.J. Olatunde; Engrs. Drs. A.O. Abioye, M.O. Oke, A.S. Ajala, G.O. Ogunlakin, J.A. Adeyanju.

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REFERENCES

Abioye, A.O., **Olajide, J.O.**, and Ngoddy, P.O. (2019). Single-Screw Extruder for Production of Expanded Products: Design, Construction and Performance Testing**,** *Journal of Agricultural Science and Technology*, B 9: 294-305.

Adekola, K.A. (2014). Analytical Engineering Designs for Twin-Screw Food Extruder Dies, *International Journal of Engineering Innovation and Research*, 3(5):713-717.

Ademosun O.C. (2002). The challenges of Development of Agricultural Engineering Practice within a Democratic System in Nigeria, *Proceedings of COREN 11th Engineering Assembly held at the International Conference Center*, Abuja, Nigeria. pp. 36-50.

Ademosun, O.C., Adewumi, B.A., Olukunle O.J. and Adesina, A.A. (2003). Development of Indigenous Machines for Weeding and Grain Harvesting, *FUTA Journal of Engineering and Engineering Technology*, 3(2): 77-84.

Adetola, O.A., **Olajide, J.O.** and Olalusi, A.P. (2014). Development of a Screw Press for Palm Oil Extraction *International Journal of Scientific & Engineering Research*, 5(7):1416-1422.

Adetola. O.A., **Olajide, J.O.**, and Olalusi, A.P. (2014).Effect of Processing Conditions on Yield of Screw Press expressed Palm oil, Journal *of Emerging Trends in Engineering and Applied Sciences and Reports*, 5(4):243-247.

Adeyanju, J.A., **Olajide J.O**., Oke O.E. and Adedeji A.A. (2019). Numerical modeling and mass transfer simulation of deep-fat frying of plantain (*Musa paradisiacal* AAB) chips (*ipekere*). *Journal of Food Science and Human Wellness*, (In-press)

Adeyanju, J.A., **Olajide, J.O.** and Adedeji, A.A. (2016). Development of Optimum Operating Conditions for Quality Attributes in Deep-Fat Frying of Dodo Produced from Plantain Using Response Surface Methodology, *Food and Nutrition Sciences*, 7:1423-1433.

Adeyanju, J.A., **Olajide, J.O**., and Adedeji, A.A. (2016). Optimization of deep-fat frying of plantain chips (*Ipekere*) using response surface methodology, *Journal of Food Processing and Technology*, 7(5):1-6.

Adeyanju, J.A., **Olajide, J.O.**, Oke, O.E. and Adedeji A.A. (2018). Numerical simulation of mass transfer during deep-fat frying of plantain (Musa paradisiacal AAB) chips (ipekere), *International Journal of Food Studies* (In-press).

Agbetoye, L.A.S. (2004). The Unsolved Problem of Cassava Harvesting and Mechanization: Why and How? An Invited Paper Presented at the technical session of the Bi–Monthly Meeting of the Ondo State Branch of the Nigerian Institution of Agricultural Engineers, held at the Rufus Giwa Polytechnic, Owo, Ondo State, 11th January, 2004.

Ajala, A.S., and **Olajide, J.O.** (2009). Development of an hydraulic oil press for vegetable oil Expression, *Science Focus*, 14(3): 323 – 329.

Ajala, A.S., and Ajala, F.A. (2014). A study on drying kinetics of shrimps, *International Journal of Innovation and Applied Studies*, 9: 1778-1785.

Ajala, A.S., Ngoddy, P.O., and **Olajide, J.O.** (2014). Statistical Modeling and Simulation of Drying Cassava Chips in Tunnel Dryer, *International Journal of Emerging trends in Engineering and Development*. 2(7):

Ajala, A.S., Ngoddy, P.O., and **Olajide, J.O.** (2018*).* Design and construction of a Tunnel dryer for food crops drying, *International Multidisciplinary Research Journal*, 8: 1-7.

Akinwande, B.A**.**, Ngoddy, P.O., **Olajide J.O.,** and Fakolujo, A.D. (2013) Production and Storage of Cassava Chips for Reconversion to Gari. *Innovative Systems Design and Engineering* 4(9):68-72.

Aremu, M.O., Araromi, D.O., Adeniran, J.A., and Alamu, O.S. (2014). Optimization of Process Variables for C-massecuite Exhaustion in a Nigerian Sugar Refinery, *British Journal of Applied Science & Technology*, 4(21): 3039-3052.

Asogwa, I.S., Okoye, J.I, and Oni, K, (2017) Promotion of Indigenous Food Preservation and Processing Knowledge and the Challenge of Food Security in Africa. *Journal of Food Security*, 5(3): 75-87.

Avallone, S., Rojas-Gonzalez, J.A., Trystram, G., and Bohuon, P. (2009). Thermal Sensitivity of Some Plantain Micronutrients during Deep-Fat Frying, *Journal of Food Science*, 74: 339-347

Aworh, O.C. (1990). Upgrading traditional techniques of food processing and preservation: Cheese-making, *W. Afr. J. Archaeology*, 20: 232 – 238.

Aworh, O.C. (2008).The role of Traditional Food Processing Technologies in National Development: The West African experience. *Chapter 3 in Using Food Science to Improve Nutrition and Promote National Development. Roberts*, C.L.; Lupien J.R. (Eds). IUFOST.

Bruinsma, D. (1991). Review of food processing practices and opportunities in Africa, *Margareth Haswell and Diana Hunt* (ED).

Chee, P.L. (1986). Small Industry in Malaysia, *Berita Publishing Sendirian Berhad*, Kuala Lumpur, Malaysia.

FAO, (2013). Food wastage footprint: Impacts on natural resources.

FAO–World Bank (2010). Reducing post-harvest losses in grain supply chains in Africa, *Report of FAO–World Bank workshop held from 18–19th March, 2010 in Rome, Italy*: 120.

FAO. (2019). The State of Food and Agriculture 2019 *Moving forward on food loss and waste reduction.* Rome. CC BY-NC-SA 3.0 IGO.

FAOSTAT (2018) Food and Agriculture Organisation of United Nations.www.fao.org/ faostat.

Fellows, P. (2009).Food Processing Technology Principles and Practice, Woodhead Publishing, 3rd Edn. Boca Raton, FL.

Garayo, J. and Moreira, R. (2002). Vacuum Frying of Potato Chips. *Journal of Food Engineering*, 55: 181-191.

GIZ (2013). Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH. The Ecological footprint of cassava and maize postharvest losses in Nigeria, *A Life Cycle Assessment. Eschborn*, GIZ: 48.

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., and Meybeck, A. (2011). Global food losses and food waste. Rome: *FAO*, Available at: http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

Harper, J.M. (1986). Extrusion Texturization of Foods, *Food Technology*, 6 (3): 70-76.

Harper, J.M. (1979). Food extrusion, *Critical Reviews in Food Science and Nutrition,* 11: 155–215

Heldman, D.R. (2003). Encyclopedia of Agricultural, Food and Biological Engineering. *CRC Press Publisher*, 1st edition New York

Heldman, D. R., and Hartel, R. W. (1998).Principles of Food Processing, *Springer*, New York.

Hodges, R.J., Buzby, J.C., and Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use, *Journal of Agricultural Science*, 149: 37–45.

Jaliliantabar, F., Rabbani, H., Lorestani, A., Javadikia, P., and Gholami, R. (2013). Noise evaluation of mf285 and u650 tractors by using adaptive neuro-fuzzy inference systems (ANFIS) method, *International Journal of Agriculture and Crop Sciences,*

Karaagac, B., Inal, M., and Deniz, B. (2012). Predicting optimum cure time of rubber compounds by means of ANFIS, *Materials and Design*, 35: 833 – 838.

Kiranoudis, C.T., Maroulis, Z.B., Tsami, E, and Marinos-Kouris, D. (1993). Equilibrium moisture content and heat of desorption of some vegetables, *Journal of Food Engineering*, 20: 55-74.

Kitinoja, L. (2016). Innovative Approaches to Food Loss and Waste Issues, *Frontier Issues Brief submitted to the Brookings Institution's Ending Rural Hunger project.* https://www. endingruralhunger. org.

Kolani, J.L. (1993). The Effect of Processing History on Chemical Changes in Single-Screw and Twin-Screw Extruders, *Trends in Food Science and Technology*, 4(10): 324-9.

Krokida, M. K. and Orepoulou, V. (2000). Water Loss and Oil Uptake as a Function of Frying Time, *Journal of Food Engineering*, 44, 39-46.

Krokida, M.K., Oreopoulou, V., Maroulis, Z. B., and Kouris, D.M. (2001). Effect of Pre-Drying on the Quality of French Fries, *Journal of Food Engineering*, 49: 347-354

Majee, SW., Avlani, D., Gosh, P., and Biswas, G.R. (2018). Therapeutic and pharmaceutical benefits of native and modified plant pectin .*Journal of Plant Medicinal Plant Research* 12(1): 1-6.

MATHWORKS, (2009). Adaptive Neuro Fuzzy Inference System Toolbox.

Ministry of International Trade and Industry (MITI). (1993). Policy and Status of SMIs in Malaysia: Small and Medium Scale Industries Division, *Ministry of International Trade and Industry (MITI)*, Malaysia.

Moreira, R.G., Da Silva, P.F. and Gomes, C. (2009). The Effect of a De-Oiling Mechanism on the Production of High-Quality Vacuum Fried Potato Chips, *Journal of Food Engineering*, 92: 297-304

Naresh, R, Veena, S., and Manisha, V. (2009). An Integrated Neural Fuzzy Approach for Fault Diagnosis of Transformers, *IEEE transactions on power delivery*, 23(4): 2017 – 2024.

Naresh, R., Veena S., and Manisha, V. (2008).An Integrated Neural Fuzzy Approach for Fault Diagnosis of Transformers, *IEEE transactions on power delivery*, 23(4): 2017 – 2024.

Ngoddy, P.O. (2004-2018). Undergraduate and Postgraduate Lecture-series (unpublished).

Nourian, F. and Ramaswamy, H. S. (2003). Kinetics of Quality Changes during Cooking and Frying of Potatoes: Part 1. Texture, *Journal of Food Process Engineering*, 26: 377-394.

Ojediran, J.O., Jekayinfa S.O., **Olajide, J.O.** and Adebiyi, K.A. (2004). The Status of Agro-Processing Equipment Fabrication Industry In South-western *Nigeria, Zuma Journal of Pure and Applied Sciences,* 6(1):210-218

Olabinjo, O.O. **Olajide, J.O.,** and Olalusi A.P. (2017). Mathematical Modeling of Sun and Solar Drying Kinetics of Fermented Cocoa Beans, *International Journal of Environment, Agriculture and Biotechnology (IJEAB)*,5(2): 2419- 2426.

Olajide, J.O. (2012).Design and Production of Food Processing Equipment for SME'S prospects and Challenges, A paper presented at the Nigerian Institute of Food Science and Technology (NIFST) Day Symposium held at Adekunle Ajasin Auditorium Rufus Giwa Polytechnic, Owo.

Olajide, J.O., Igbeka, J.C., Afolabi, T.J., and Emiola, O.A. (2007). Prediction of oil yield from sheakernels in an hydraulic press using artificial neural network (ANN), *Lautech Journal of Engineering and Technology*, 4(1): 27 – 32.

Olajide, J.O., Sunny-Roberts E.O., Otunola E.T. and Ogundele O.A. (2003).Some Physical and Chemical Properties of three varieties of Eggplant (*Solanum Melongena*), *Science Focus,* 5:64-67.

Olajide, J.O. and Ade-Omowaye, B.I.O. (1999). Some Physical Properties of Locust Bean Seed, *Journal of Agricultural Engineering Research*, 74(2): 213-215

Olajide, J.O. and Khokhar, S. (2009). The potential of resistant starch in enhancing the nutritional and health status of people in developing countries, *Science Focus*, 14(2):217-222

Olajide, J.O., Ade-Omowaye, B.I.O., and Otunola, E.T. (2000). Some Physical Properties of Shea – kernel, *Journal of Agricultural Engineering Research*, 76(2): 419-421.

Olajide, J.O., Afolabi T.J., and Adeniran J.A. (2014). Optimization of oil yield from Shea Kernels using Response Surface Methodology and Adaptive Neuro Fuzzy Interference System (ANFIS), *International Journal of Engineering Research and Technology*, 3(8): 1611-1620

Olajide, J.O., Afolabi, T.J., and Adeniran, J.A. (2014). Optimization of Oil Yield from Groundnut Kernel (*Arachis hypogeae*) in a Hydraulic Press Using Response Surface Methodology, *Journal of Scientific Research and Reports*, 3(14): 1916-1926.

Olajide, J.O., and Igbeka, J. C. (2003).Some Physical Properties of Groundnut Kernels, *Journal of Food Engineering*, 58:201-204

Olajide, J.O., and Oyelade O.J. (2002). Performance Evaluation of the Strategic Grain Reserve Programme in Nigeria. *Technovation*, 22: 463-468

Olajide, J.O., Igbeka, J.C., Afolabi, T.J. and Emiola, O.A. (2007). Prediction of Oil yield from groundnut kernels in an hydraulic press using Artificial Neural Network (ANN), *Journal of Food Engineering*, 81(4):643 – 647.

Olajide, J.O., Jekayinfa, S.O. and Adeola, S.A. (2002).Development and Testing of an Extractor for Small and medium scale fruit juice processors, *Journal of Science and Technology*, 10(1): 4768-4772.

Olajide, J.O., Ogunlakin, G.O., and Ekaeteh, C.T. (2008). Moisture dependent physical properties of pumpkin seeds, *Journal of Science and Technology Research*, 3(4):63-69.

Olajide, J.O., Tunde-Akintunde T.Y. and Omolola, A.O. (2009). Development of a tray dryer using a zig–zag air flow configuration. *Lautech Journal of Engineering and Technology*, 5(1):32–35

Ologun, D.O. (2006). Small and Medium Scale Industries Nigeria: Problems, Prospects and Management Techniques, *JBS Printing and Publishing*, 2nd Ed., Akure, Nigeria.

Olukunle, O.J. (2002). Development of an Indigenous Combine Harvester, Ph.D. Thesis, *Federal University of Technology*, Akure, Nigeria.

Omobuwajo, T.O., Sanni, L.A. and **Olajide, J.O.** (2000).Physical Properties of Ackee Apple (*Blighia sapida*) seeds, *Journal of Food Engineering*, 45(1): 43-48.

Onwumere, J. (2000). The nature and relevance of SMEs in economic development, *The Nigerian Banker-Journal of the Chartered Institute of Bankers of Nigeria*:

Pant, S., and Chinwan, D. (2014) Value addition of Food products *International Journal of Engineering and Science Research* 4 (12): 946-949

Parfitt, J., Barthel, M., and McNaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050, *Philosophical Transactions of the Royal Society B*, 365(1554): 3065–3081.

Prusky, D. (2011). Reduction of the incidence of postharvest quality losses, and future prospects, *Food Security*, 3(4), 463–474.

Rezzoug, S.A., Boutekedjiret, C., and Allaf, K. (2005). Optimization of operating conditions of rosemary essential oil extraction by a fast controlled pressure drop process using response surface methodology, Journal of Food *Engineering*, 71: 9–17.

Rice, P. and Gamble, M.H. (1989). Technical Note: Modelling Moisture Loss during Potato Slice Frying, *International Journal of Food Science and Technology*, 24: 183-187.

Rostami, M., Farzaneh, V., Boujmehrani, A., Mohammadi, M., and Bakhshabadi. H. (2014). Optimizing the extraction process of sesame seed's oil using response surface method on the industrial scale, *Industrial Crops and Products*, 58: 160–165

Senanayake, S.A., and Clarke, B. (1999). A Simplified Twin Screw Co-rotating Food Extruder: Design, Fabrication and Testing, *Journal of Food Engineering*, 40: 129-37

Shyu, S. and Hwang, L. (2001). Effects of Processing Conditions on the Quality of Vacuum Fried Apple Chips, *Food Research International*, 34: 133-142

Sobukola, O.P., Awonorin, S.O., Sanni, L.O. and Bamiro, F.O. (2008). Deep Fat Frying of Yam Slices: Optimization of Processing Conditions Using Response Surface Methodology. *Journal of Food Processing and Preservation*, 32:343-360.

Sulaeman, A., Keeler, L., Giraud, D.W., Taylor, S.L. and Driskell, J.A. (2001). Carotenoid Content and Physicochemical and Sensory Characteristics of Carrot Chips Deep-Fried in Different Oils at Several Temperatures, *Journal of Food Science*, 66: 1257-1264.

Sule, E. (1986). Small scale industries in Nigeria-concepts appraisals of Government policies and suggested solutions to identified problems, *Central Bank of Nigeria Economic and Financial Review:* 24.

Tadmor, Z., and Klein, I. (1970). Engineering Principles of Plasticating Extrusion, *Polymer Engineering and Science,* 10 (1): 55-67.

Tan, K.J. and Mittal, G.S. (2006). Physicochemical Properties Changes of Doughnuts during Vacuum Frying. *International Journal of Food Properties*, 9: 85-98.

UNEP/GRID**, (**2010). Rapid Response Assessments: The Environmental Food Crisis (World food supply-food from Animal Feed Voices. Newsletter, (2006). Increasing post-harvest success for smallholder farmers, 79.

Wheatly, C., Gregory, J., Scott, J., Best, R., and Siert, W. (1995). A manual on product development. Adding value to root and tuber crops, IITA, Ibadan: 4

Wiedman, W., and Strobel, E. (1987). Processing and Economic Advantages of Extrusion Cooking in Comparism with Conventional Processes in Food Industry, *Extrusion Technology for the Food Industry*,

Wiedman, W., and Strobel, E. (1987). Processing and Economic Advantages of Extrusion Cooking in Comparism with Conventional Processes in Food Industry, *Extrusion Technology for the Food Industry*, Elsevier Science 132-69.

Wikipedia (2019). Engineering. https://en.wikipedia.org/wiki/Engineering. Accessed on November 2019.

Yadollahinia, A. R., Omid, M. and Rafiee, S. (2008). Design and fabrication of experimental dryer for studying agricultural products, *International Journal of Agriculture and Biology*, 10: 61-65