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THE FOX AND THE PIGLET:
A PARADOX FOR UNTAPPED RESOURCE IN NIGERIA

By

AKINYELE O. K. ADESEHINWA
Professor of Animal Science and Production Systems

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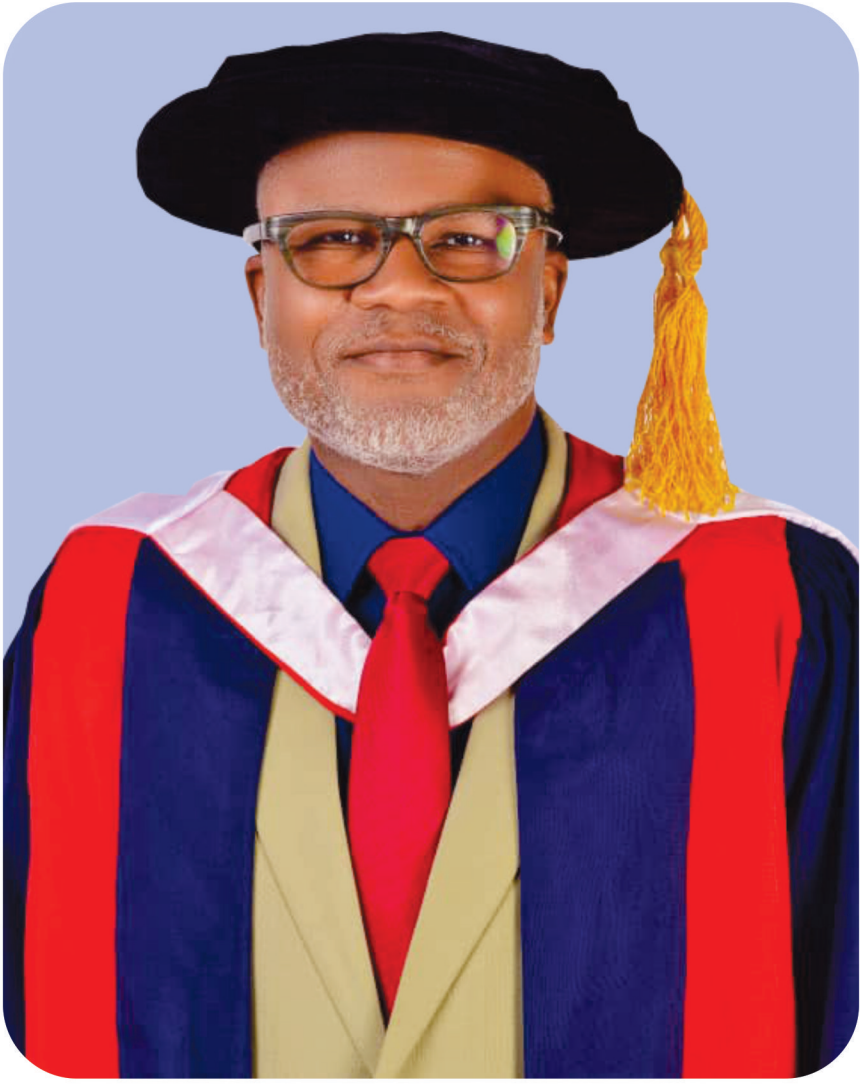

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THE FOX AND THE PIGLET: A PARADOX OF UNTAPPED RESOURCE IN NIGERIA

An Inaugural Lecture Delivered at Oduduwa Hall,
Obafemi Awolowo University, Ile-Ife, Nigeria
On Tuesday, 11th April, 2023

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1. PREAMBLE

Vice Chancellor Sir, Principal Officers of the University, Distinguished Colleagues, Guests, Ladies, and Gentlemen, I am humbled and delighted to stand before this great audience to deliver the 370th Inaugural Lecture at this prestigious citadel of Learning and Culture, Obafemi Awolowo University. It is the First Inaugural Lecture from the Livestock Improvement Programme and the 8th from the Institute of Agricultural Research and Training (IAR&T) of the University. I give all the glory to my Maker and the Creator of Heaven and the Earth, who has made it possible for me to attain this height and to stand before you this day!

I started my academic and research career at Ahmadu Bello University (ABU), Zaria, National Agricultural Extension and Research Liaison Services (NAERLS) in 1993 as an Extension Specialist in the Livestock and Fisheries Technology Transfer Programme, where I was involved in several National and International studies and surveys, across the length and breadth of Nigeria, before transferring my services to Obafemi Awolowo University, Ile Ife in 2003.

I appreciate God for granting me the privilege of climbing on the shoulders of academic giants in an attempt to make me one. My sojourn at becoming an Animal Scientist, which I may lay claim to today, cannot be said to be mine, hence I could be tagged an "Accidental Animal Scientist", having become one, by the shear grace of God through His use of notable men, whom I will refer to as 'Academic Giants', to direct my path. My attempt at fulfilling my father's wish of 'becoming a Medical Doctor' got me in contact with, then Dr Ajayi Borofice of the Department of Zoology, University of Ibadan (a senior alumnus of Victory College, Ikare Akoko - my alma mater), who later rose to the rank of Professor and a Distinguished Senator of the Federal Republic of Nigeria. He was the one who requested that I consider choosing a career in Agronomy, Animal Science, or Agricultural Economics. After a short period of investigation and interaction with people and considering my interest in Biological Science, I

opted to study Animal Science. I was then referred to Prof. J.A. Oluyemi, who was then, the Head of Department of Animal Science at the University of Ibadan, hence, my application and subsequent admission into the Department.

In the course of my study, despite several challenges, I was later privileged to come across Prof. Gabriel Nwachukwu Egbunike, another giant, in the field of Animal Physiology, who later supervised my Bachelor's degree project. He was responsible for initiating and mentoring me in the Animal Science profession. However, upon my return for postgraduate studies, in Agricultural Biochemistry and Nutrition, Prof. Bankole Kayode Ogunmodede, another academic giant, took me in to build on the foundation laid by my previous mentors. While under his supervision, I grew in stature and relationship with him to be nicknamed "Omo Baba", such that at the completion of my Master's degree, he personally requested me to continue my PhD with him. My earlier plan to return to my previous supervisor to specialize in Nutritional Physiology was redirected, and I settled for Animal Production, with special emphasis on pigs - an underexploited livestock specie in Nigeria.

However, it was a known fact in those days at the Department of Animal Science, University of Ibadan, that any student willing to use pigs as experimental animals would have to relate closely with Professors G. N. Egbunike and late Prof Olumide Odeleye Tewe. So, having interacted and worked closely with both, it was a smooth sail, though not without its challenges and rough times with some "powers that be" in the Department.

"*Behind every strong person is a story that gave them no choice*" – Anonymous.

I was able to overcome by the help of God and the wisdom of elders (the human academic giants). The regular and timely advice and counsel from my late mother and father, who were retired Headmistress and retired Principal respectively, were not scarce in those days.

Even though I was already an academic staff with Ahmadu Bello University, Zaria, the late Prof. B. K. Ogunmodede paid my tuition fee when I was requested to pay for a new session before my defense due to the delay caused by ASUU strikes. I thank God for the impactful life he lived and the good legacies he left behind and that of the Living Legend, Prof. G. N. Egbunike, who had positively influenced my academic career to date. He is surely watching and listening to this lecture in Asaba, where he now resides. They are both "Fathers and Giants" indeed!

My journey thus far can be said to be in tandem with one of the rare quotes of Thomas Edison:
"*Great people don't cry, they try to rebuild their dreams*
Great people don't give up, but live up to the challenges that life throws at them
Great people don't go through; they grow through the difficulties that come on their path
They start all over again with great hope, great determination, great grit
and that is why they reach the highest peaks of success that most people only aspire for."

Vice Chancellor Sir, Nigeria is blessed with several unexploited, untapped, unexplored, and underexploited resources. Of a critical note is that which has to do with mitigating food insecurity (MDG 1), WHO's call to action for zero hunger (SDG 2) and for good health and well-being (SDG 3) for world transformation. The pig industry in Nigeria can be a huge contributor toward Nigeria's attainment of the UN Sustainable Development Goal on Zero Hunger and Poverty Eradication as a:

- Means of job creation, sustainable source of income, source of poverty reduction businesses
- Source of nutrition and food security arising from pork and its consumable by-products
- Source of organic manure for crop production.

Nigeria has the required resources to meet her needs but is not taking advantage of them. Therefore, it could be said that Nigeria has all it takes for self-sustenance in animal protein. It is, however, yet to take advantage of these opportunities to increase Pigs' contribution to the GDP of the livestock subsector. Hence, my lecture, titled **"The Fox and the Piglet: a paradox of untapped resource in Nigeria"**, will attempt to look at the pig's untapped resource in four cardinal areas, which have informed my contributions to increased pig production in Nigeria to date:

- Animal Protein from pig as an untapped resource in terms of potential for an increased number of pigs and pig meat yield per animal
- Harnessing and enhanced utilization of locally available feed resources for pig feeding, as an untapped resource in terms of opportunities for deploying available technologies for enhanced utilization of agro-industrial by-products for pig feeding
- Deployment of improved pig management, Production systems and marketing practices as untapped resource for increased revenue generation, job creation and the overall well-being of the Nigerian populace
- Aggregation and engagement of trained human resource base for enhanced pig production, as an untapped resource, such that professionals with skills will be more engaged in the commercial production of pigs for which Nigeria has a comparative advantage

2. Nigeria's Agricultural Policies, Strategies and Plans

Agriculture is the single most important economic activity and source of livelihood for millions of people in Africa. It provides employment for about two-thirds of the continent's working population and contributes up to 60% of GDP. In spite of its key role in Africa's economy, the untapped potential of the agricultural sector continues to contribute to persistent poverty and deteriorating food and nutritional security. This is further aggravated by a steady rise in human population, climate change, and urbanization. Transforming agriculture by making the sector

more productive, resilient, efficient, and inclusive is key to achieving lasting and inclusive economic growth in Africa (NARES, 2022).

In Nigeria, agricultural policies, programmes, and strategies have undergone changes focusing on more equitable growth in agriculture for the local market as well as for export-led growth. While there has been some growth on both fronts, these have been modest relative to what is possible and what is desirable. Structural changes have tended to reflect the political interests of governments or administrations in power, with the instruments varying only in nomenclature and structure but limited in sustainable outcomes and impacts. Examples include transitions from the National Accelerated Food Production Programme (NAFPP), Green Revolution, Better Life Programme (BLP) for Rural Women, National Economic Empowerment and Development Strategy (NEEDS), and the Agricultural Transformation Agenda (ATA). There has also been a general lack of participation by critical stakeholders (especially farmers and farmer organizations) in policy formulation processes, as well as a lack of cross-sectoral coherence, programme continuity and integration, that are needed for agricultural transformation. These shortcomings reflect the fact that many of these "policies, strategies, and initiatives" have tended to reflect the priorities of funders and/or passions of reigning administrations. Some have also been quite short and with no continuity by subsequent administrations to get them to tipping points. The NARES (2022) report opined the need to ensure broad-based stakeholder participation in demand-driven policy, strategy, and plan formulation.

3. Population Growth and the need for Increased Supply of Animal Protein in Nigeria

Vice Chancellor Sir, the population growth rate of Nigeria is estimated at 2.4% per annum, with a projected increase from about 220 million in 2023 to 377 million people in 2050. (WDI, 2022) This growing population is expected to be more affluent, become increasingly urbanized, and therefore will demand more and more

high quality and healthy animal source foods in the coming decades. The economic indices in Nigeria indicate that the domestic supply of food is growing at 1.8% per annum while the overall demand is estimated to be rising by 5.1% annually (FAOSTAT, 2018). This requires an urgent modernization of key elements of the economy to generate jobs, household income and promote social stability. The impacts on food and nutrition security as well as public safety and national security are significant and far-reaching. The purpose of the National Livestock Transformation Plan (NLTP) Strategy was to lay a focused effort in the agricultural subsector that will serve as a catalyst for building national prosperity (NLTP, 2019), of which pig production is no exception. The NLTP, which was designed to deliver for Nigeria a livestock sector transformation, using classic value-chain building tools, which countries like Paraguay, Brazil, Zambia and Ethiopia have gone through, is yet to achieve the set objective of bringing together private investors, catalytic government services, capital investments and targeted donor support.

Fig. 1: Ten most important things Nigerians spend money on.
Source: Channels-tv

To meet this increasing demand for food, being the most important thing Nigerians spend their money on, as rated by Channels

Television (Fig. 1), the livestock sector will have to significantly transform because the demand for livestock products will surge, with consumption of all types of animal source foods more than tripling the current demand. The annual meat consumption per person is expected to more than double in sub-Saharan Africa from 2000 to 2050 (IFPRI, 2022). Available projections (FAOSTAT, 2018) suggest that the Nigeria livestock sector will go through enormous changes in the coming decades. Hence, the growing demand for high-quality meat products presents an opportunity for livestock producers to take advantage of emerging markets for value-added meat products.

The problem of providing the much-needed animal protein has become pronounced in the face of the ever-increasing human population (Adesehinwa, 2007). Besides the failure of meat production capacity to match the human population growth, the distribution of meat animals in Nigeria is apparently lopsided (Adesehinwa *et al*., 2003a). It has become imperative that this lopsided production and distribution of meat be mitigated to allow for better nutrition and health of the Nigerian populace. If Nigeria is to meet its demand for meat and improve the nutrition of the populace while increasing people's income generating potential, integrated modern livestock production using highly prolific and fast-growing animals that are amenable to large-scale production has to be developed.

4. Untapped Resource expected to transform the livestock subsector of Nigeria

Current statistics show that livestock products account for about 30 percent of the global value of agriculture and 19 percent of the value of food production. It provides 34 percent of protein and 16 percent of the energy consumed in human diets (FAO, 2021). The World Bank survey of 2021 indicated that agriculture contributed 24.14% of the GDP, with livestock accounting for only 4.11%. Robust economic growth in Africa has been and is anticipated to translate into a growing demand for animal-source foods. Meat and dairy products are high-valued food products for which

consumption is well correlated with income level (Jokthan *et al*., 2022).

For this transformation to happen, livestock needs to improve sustainably, and be seen as a business investment. This will improve productivity and product quality. Aside from providing the best environment for livestock, in view of the challenging climate, it also makes sense to find the best animal suitable for a given environment and management skill. We must, therefore, never be afraid to replace what we have with better seedstock and embrace commercial farming.

4.1. Relative Importance of Pigs in the Meat Industry

Vice Chancellor Sir, the global trend in world meat production (2016−2020) shows that pig meat (pork) is a very important source of animal protein in human diets. Estimates from FAO data by Ritchie *et al.* (2019) show pork as the world's most widely eaten meat accounting for 36% of the total meat production, surpassing poultry (29%), beef and buffalo (27%) and, goat and sheep (5%). The world's pork industry has been on the rise since the 1970s and by 2022, global production surpassed 110 million Metric tonnes per year (Knoema, 2019; Statistica, 2023).

The pork industry includes all forms of pig meat, including flesh and processed meats. The value of trade in pig products around the world runs into billions of dollars every year, however, Africa enjoys less than 5 percent of this. China, with a fifth of the world's population, is both the largest producer and net importer of pig products globally (Statistica, 2023). Also, recent global data (Fig. 2) show that there has been greater output of meat from pigs (63.9 million Metric tonnes/year) than the combined output of meat from cattle, buffalo, sheep, and goats (58.9 million Metric tonnes/year) (FAOSTAT 2021).

Investment in pork production has proven to be one of the most profitable livestock businesses because of its relatively low cost of production compared to other major livestock farming businesses

(FAOSTAT, 2021). Hence, pig farming is a buoyant sector with strong potential to generate billions of Naira for the Nigerian economy, if given the required attention and investment. Nigeria is the largest producer and consumer of pork in Africa, accounting for 18.52% of the total pork produced in the last ten years, despite the disruption caused by African Swine Fever (ASF) and the COVID-19 pandemic. The FAOSTAT (2021) report projects that the production of pork in Nigeria will grow by 22.6% in the next ten years (Table 2), from 278,000 Metric tonnes in 2020 to 341,000 Metric tonnes in 2029. Previous trends, not only pointed to the leading vantage position occupied by Nigeria in accounting for as much as 65% and 19% (Table 1) of the production for West Africa and Africa (Fig. 2), respectively, the recorded growth rate in production was also higher than the average annual growth rate for Africa, West Africa, and the world (Table 2).

Table 1: Nigeria Pig Production Relative to Regional and Global Production

Region	**2020 Production Figure (MT)**	**Nigeria's Percentage of Regions Production**
Nigeria	302,976	-
South Africa	301,990	-
West Africa	464,985	65.15
Africa	1,597,492	18.96
World	85,088,181	0.27

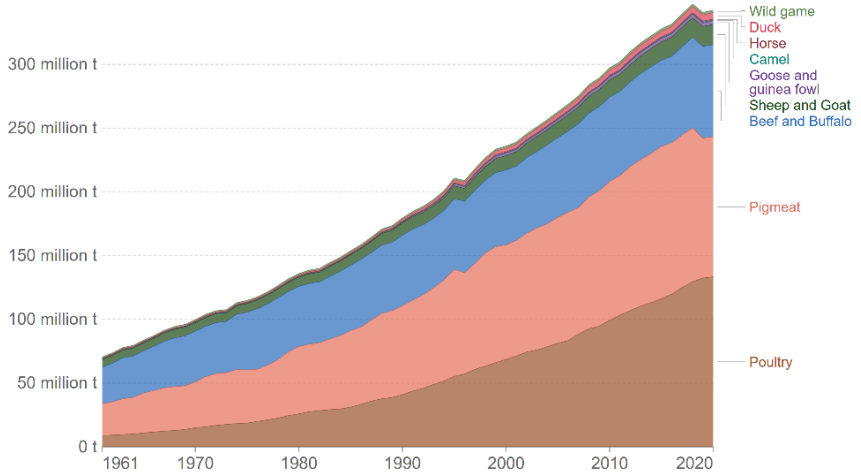

Fig. 2: Global Meat Production by Livestock Species (1961–2020).
Source: FAO

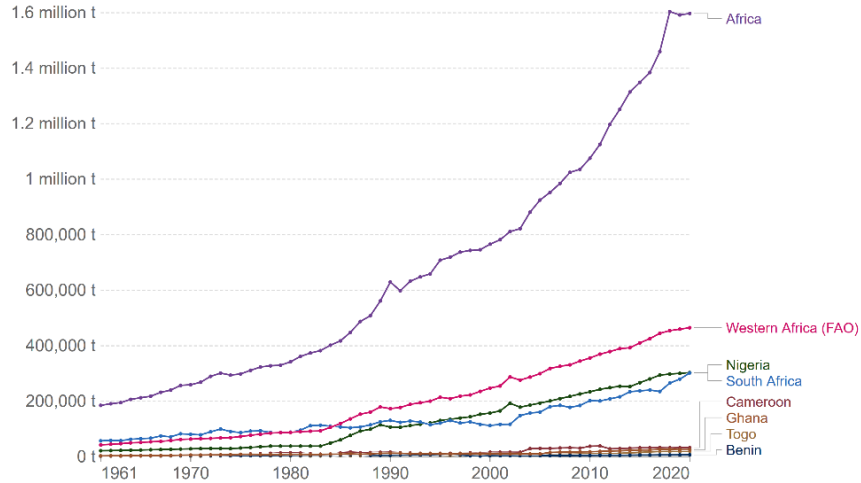

Fig. 3. Pig Meat Production in some selected African Countries (1961–2020)
Source: FAO.

Table 2: Average Annual Growth Rate of Pig Meat Production

Region	Average Annual Growth Rate (%)
Africa	12.73
Nigeria	21.71
West Africa	16.43
World	5.73

Vice Chancellor Sir, in Nigeria, pork has been one of the most widely consumed meats over the years, with consumption per capita (measured in kg per person per year) reaching 1.47 kg in 2020 (Fig. 4). Out of a total of 1.25 million Metric tonnes of various types of meat consumed by Nigerians in the last ten years, pork accounted for 22.42%. With a total of 280,000 Metric tonnes of pork consumed in the last ten years, valued at N252.39 billion at the international price of $2003.1 per ton, Nigeria's pork production is projected to reach N265.35 billion in 2029. This potential is largely enhanced by the huge market with a widening gap between demand and supply for pork.

The gap between the demand and supply of pork has been the industry's challenge in the past years. Though Nigeria is ranked as the leading producer in Africa, domestic production still falls short of demand with dependence on importation to meet the demand for pork and other products. The market size for pork is projected to expand by 23.6% in the next ten years (FAOSTAT, 2021).

The value of trade in pig products runs into billions of dollars annually, with Africa enjoying less than 5% of the "economic fat" generated in the pig-farming sector. Pig production is so valuable that it is described as an "asset for wealth" or "safety net in times of crises".

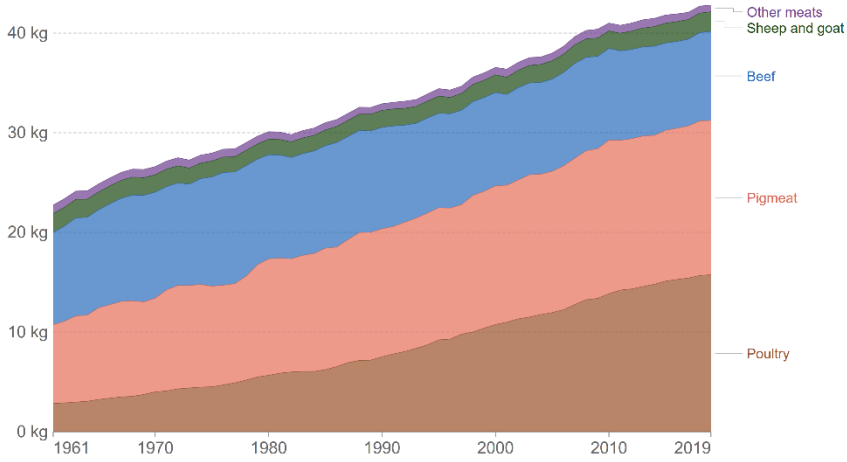

Fig. 4: Global Per Capital Meat Consumption by Livestock Species (1960–2019). Source: FAO.

However, the growth rate in pig meat production can mainly be attributed to growth in the stock of animals as productivity in terms of meat yield per animal has relatively stagnated at around 45 kg per animal over the years (Table 3) compared to productivity increases recorded in South Africa within the same period. The meat yield per animal is considerably low compared to the World average, United States, Europe and China, pointing to huge deficiencies in the productivity of pig breeds and production systems operating in the country over the years.

This should actually be of great concern to Animal Breeders, in particular, and Animal Scientists, in general. One of the questions to ask is, "What technology or type of breed do we use in Nigeria that has kept giving us these same results over the years? Are there better technologies in terms of breeds, feeds and feeding, housing and/or management system that are yet to be adopted to increase the pig meat yield?" Available statistics also reveal that the United States, Europe and South Africa have had a steady increase in their pig meat production over the years (Table 3).

Table 3: Global Pig Meat Yield (kilograms) Per Animal

Country/Region	1961	2020	Change in Pig Yield (%)
Africa (FAO)	48.20	43.00	-11%
Cameroon	30.00	30.30	+1%
Ghana	28.00	42.50	+52%
Nigeria	45.00	45.00	+0%
Benin	28.00	30.00	+7%
Togo	28.00	30.00	+7%
South Africa	57.10	86.00	+51%
West Africa (FAO)	38.00	41.90	+10%
United States	63.10	97.60	+55%
Europe (FAO)	74.90	92.40	+23%
China	41.50	58.30	+40%
World	65.80	72.70	+10%

Source: FAO

4.2. Pig Production in Nigeria

Vice Chancellor Sir, in 1943, Nigeria had the largest pig farm in the world (McKay, 1963) located in Kano, established by the United African Company (UAC). The farm grew into a very large-scale farm in the '50s and '60s during which time the pig meat was transported by rail to Lagos, at that time, the commercial city and political capital of Nigeria. It is unfortunate that the pig farm eventually folded up in the late '70s due to religious prejudice. If this farm had been allowed to continue, Nigeria would probably have become one of the leading pig-producing countries in the world. The religious discrimination against pig production and consumption has restricted pig production to the central and southern parts of Nigeria (Dafwang *et al.,* 2010). Even with the high potential to increase pig productivity due to its fast growth rate, shorter generational interval, good feed conversion efficiency, and large litter sizes, pig production in Nigeria is not rising fast enough due to the strong religious and traditional taboos forbidding its production and consumption (Ikeobi, 1990) in certain areas.

Nigeria is the largest consumer of pork in sub-Saharan Africa, with pork contributing 4.5% of its meat consumption (Oluwafemi,

2021). The sow is the most prolific among domestic livestock, with the ability to produce at least twice a year, producing a minimum of 10 piglets/litter. If well managed, 80−85% of the piglets may reach a slaughter weight of about 90 kg in 6 months, with a dressing percentage of up to 75% (Ogundipe, 2010), yielding 1,440 kg total live weight and 1,080 kg of meat (pork)/female/year. This is in comparison to the Fulani cattle, which at 1 calf/year, will yield 250 kg live weight in 2.5 years and 158 kg meat (beef) at 63% dressing percentage. The higher feed efficiency and carcass yield of the pig will make pork cheaper than beef and other meats.

The pig is compared to the palm tree, where every part is useful to man. So, apart from the pig's muscle, which is for pork and bacon, the skin is for soft leather, the hair for brush, the fat (lard) is used for cooking and for cosmetics, the blood and bones for animal feed, the intestine for surgical suture material and for sausage casing, the heart as organ transplant for humans, the manure for maggot production for fish feeding, cooking gas production and soil enrichment and, the live pig for medical research.

Nigeria is ranked number 21 for pig production worldwide (Statistica, 2023), with about seven to eight million pigs (FAO, 2022). Pig rearing is popular in many parts of Nigeria, with commercial production under semi-intensive conditions becoming more popular because of the favourable rate of return on investments. The distribution of this farm animal is not found in equal proportion across Nigeria. This is due to climatic conditions, customs and religious beliefs of the inhabitants of each particular region, the type of vegetation and the topography of the area. Pigs are more widely distributed in the southern parts of the humid zone in Nigeria and in the middle belt between the humid and subhumid zones (FAO, 2021). The religious bias against pork has hindered the production and distribution of pork in some major states, especially, in the Northern part of Nigeria. This is why the bulk of pigs produced in the country are consumed mainly in the South-South region of the country, comprising of Edo, Delta, Rivers, Cross Rivers, and Akwa Ibom states, where there is little or no

religious injunction against pork consumption, as well as, Southern Kaduna, Plateau, Benue, Adamawa, Taraba, Lagos, Ogun, Ekiti and the Southeastern States (Fig. 5).

The popular system of pig rearing in Nigeria, as stated earlier, is the semi-intensive production system, especially in the rural communities of the southern and the middle belt of Nigeria, and it is commonly practiced by smallholder farmers as an alternative livelihood activity. Commercial production under an intensive system is increasing because of the favourable rate of return on investments and due to the demand for quality food by the urban dwellers in the southern part of the country (Adesehinwa *et al*., 2003a).

However, because of the abundance of feed resources, especially farm residues and agro-industrial by-products, the whole country can be said to have a comparative advantage for pig production. It is worthy of note that it was the abundant supply of groundnut haulms and groundnut cake during the days of the groundnut pyramids of Kano, apart from the rapid fecundity of the pig that made the pig the livestock of choice and the farm sited in Kano, for accelerated meat production by the then United African Company (Dafwang *et al.*, 2010).

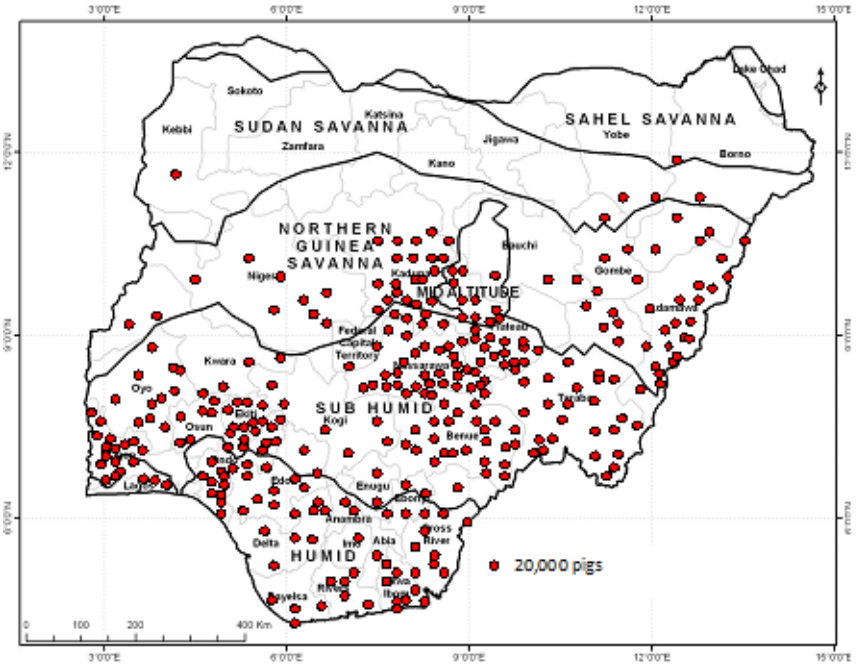

Fig. 5: Pig population distribution in Nigeria

No wonder Fr. Kelvin Ugwu once said, and I quote, "Some places consider it taboo to eat pork. Where I come from, nobody can even dare to rear pigs. When I got admission into the seminary, I was scandalized the day I saw some seminarians and priests eating pork. I couldn't believe my eyes. But surprisingly, the first day I summoned the courage to eat it, my life never remained the same. I hated that it took me so long to realize what I was missing" (Ugwu, 2022). He also said, "People eat dogs, others don't. Some eat snakes, others won't dare. There are places where it is taboo to eat beef. We can go on and on. If you check yourself, there are so many things you do and believe that have no basis except that you grew up seeing people believing and doing same.

Of all the domestic livestock, pig has been unfairly treated in certain parts of the world, including Nigeria. The pig is regarded in some religious circles as dirty and unclean with resultant efforts to discourage its multiplication. Federal government policy towards

the pig can best be described as unfriendly. We can therefore state that the greatest obstacle to widespread pig production in the tropics is the religious prejudice against it (Fig. 5).

4.3. Pig Transformation Agenda in Nigeria

Vice Chancellor Sir, it may interest you to note that having identified the huge potential of this species of livestock, The Honourable Minister of Agriculture, by then, Dr Akinwunmi Adesina under the Pig Transformation Agenda proposed, amongst others, as regards pig production, as follows:

- To make pig production in the country a dynamic and rapid growth subsector of the livestock industry.
- To create a rising demand for pork and its value-added products.
- To increase per capita consumption of pork and its products through poverty eradication and wealth creation that will be generated.
- To boost domestic pig production to meet most of the new demands that may arise.
- To increase then current, heads of pigs in the country from 7,000,000 to about 11,238,000 heads by 2015.
- To increase the amount of pork supplied into the national market from 218,000 MT to about 350,000 MT by 2015, which is about 60% increase.
- To raise the national average slaughter weight of pigs from 45 kg to 105 kg.
- To create opportunities to meet future market demands in pork and pork products through the expansion of pig farms and
- To create opportunities for more research and development in this subsector.

The set objectives were to be achieved through:

- Changing the side-line approach of pig production to grain-based diet for more efficient and profitable production.

- Upgrading the genetic make-up of the local pig breeds with reputable exotic breeds through cross breeding or back crossing and artificial insemination.
- Ensuring an efficient input/service delivery chain through the private sector and product quality consistency using research-based techniques.
- Increasing the number of commercial farms through the participation of states and the private sector
- Training farmers on basic pig production and breeding techniques using livestock extension agents.
- Development of proper marketing trends that will enable the sales of pork and its value-added products (chilled pork, sausage, lard, bacon) to such places as supermarkets, eateries, and hotels.
- Advocacy for value addition to increase pork converted to sausage, bacon and prime cuts.
- Linking value chain actors with finance institutions for credit facilities to expand operations.
- Policy implementation on the provision of incentives and subsidies to value chain actors.
- Effective feed quality control and use of balanced rations for the pigs to meet their various physiological needs, i.e., growth, gestation and lactation, and
- Empowering the crop sector for more available plant protein and energy concentrates to make feed formulation easier and cheaper and make pig feed more readily available, such that, grain farming will be stabilized.

Vice Chancellor Sir, you and this august audience are in the best position to judge if these set objectives have been addressed to bring about the expected outcomes that will transform this livestock subsector.

The triple helix model has postulated the synchronization of academia, government and industry as the key drivers to the economic growth of any nation. As such, the continuous disconnect of these three sectors in the production of pigs and the

available resources in Nigeria has contributed in no small measure to the untapped resource in this subsector. Hence, to continue the production of pigs in Nigeria in a sustainable manner, in line with the global best practices and directives, a number of alternative strategies, as against the general practices of the farmers, have formed the basis of my research. This has not been limited to the use of nutraceutical products or pro-nutrients, carefully tailored nutrition regime, better husbandry, housing management, marketing and biosecurity, in specific terms but also ensuring that the animals on the farm are healthy, viz-a-viz the health of the man (either as manager of the animal or its consumer), in a healthy environment (where both the man and the animal co-exist), thereby embracing the 'One Health concept' (Fig. 6)

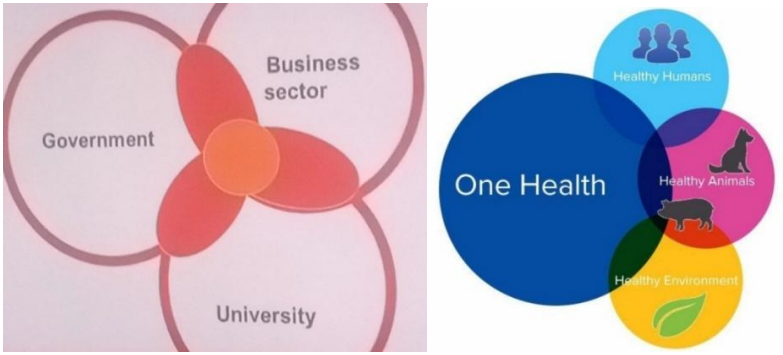

Fig. 6: Triple Helix Model of key drivers to economic growth and the One Health Concept

5. Earlier Research Efforts at Developing a Nigerian Hybrid Pig

The outstanding breeding work by then, Dr. Adebambo and her team at the Institute of Agricultural Research & Training (IAR&T), Obafemi Awolowo University in the '80s, which led to the development of a Nigerian hybrid pig (Adebambo,1986) could not be sustained due to lack of government intervention for continuity and sustainability of production to generate the needed seed stock for farmers. The hybrids found in virtually all smallholder farms several years back were mainly crosses of Large White and the indigenous pig. However, traits of other exotic

breeds, such as Hampshire, Landrace and Duroc could also be seen in the phenotypic features of most of the hybrids. The hybrids had evolved through selective controlled breeding as practiced in developed commercial breeding farms, where specific breeds are reared, while controlled cross-breeding was also a common practice (Dafwang *et al*., 2010). The hybrid pigs had comparable growth performance, economy of feed conversion, serum and haematological results with the exotic breed of pigs. The return on investment showed that even when exotic breeds of pigs were more cost-effective than the hybrid, it was still an option to be considered for investment over the Nigeria Indigenous Pig (NIP) commonly reared by pig farmers, under extensive system of management (Adesehinwa *et al*., 2010a).

5.1 Introduction of Production Traits of Economic Importance into the Nigerian Swineherd

Vice Chancellor Sir, pursuant to the aforementioned and on behalf of the Nigerian Institute of Animal Science (NIAS), as the Council Representative for Swine Production Science Discipline and Head, Livestock Improvement Programme of the Institute of Agricultural Research and Training (IAR&T), in 2010, I initiated the organization of the 1st International Pig Summit, jointly sponsored by NIAS and IAR&T, which was held in Ibadan. It was attended by over 500 participants and resource persons from different parts of the world (Photos 1, 2 &3).

In 2011, as a follow-up to the Pig Summit and my continued interest in developing this area of research, I made a request to the then management of the Institute, under the leadership of Professor Benjamin Adefemi Ogunbodede, though a Plant Breeder and Geneticist. He acceded to the passionate plea and request, which was one of the decisions of the over 500 participants in attendance at the Summit, by funding the importation of Great Grand Parent Stock (GGPS) of four breeds of Exotic pigs from the United Kingdom to improve the genetic base of pigs at the Institute in particular and in Nigeria, as a nation.


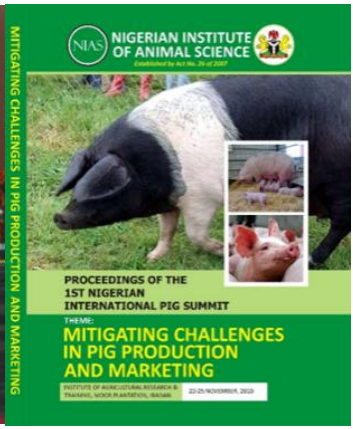

Photo 1: Prof Sandra Edwards receiving an award from Dr. G.O. Oyediji (NIAS Registrar) and Cover page of Book of Proceedings


Photo 2: Standing - Prof Placid Njoku (former NIAS President), Prof Benjamin A. Ogunbodede (former Director of IAR&T); while sitting (l-r) late Prof I. Adu (former 1st NIAS VP), Prof Boye Okai of KNUST, Kumasi Ghana


Photo 3: Chief Folorunso Ogunnaike (Private Investor), Mrs. Mope Omotoso (then Livestock Feed Quality Assurance Manager) & Prof. Babafunso Sonaiya (OAU, Nigeria); Mrs. Pat Aboe (Ghana Ministry of Food & Agriculture) & Prof. Augustine Nazie (University of Ghana)

The importation was preceded by the construction and establishment of the Boar Stud (Photo 4), with required Electric power generating set and water storage facilities (Photo 5a & b) and Semen Processing Laboratories (Photo 4) with well-equipped training facilities (Photos 9a & b) and relevant state of the art semen processing and preservation equipment (Photo 10a-f). A Pig Multiplication Center, was also built in another location, away from the Boar Stud, at the Ikenne outstation of the Institute.

Photo 4: Artificial Insemination centre and the External & Internal view of the Boar Stud at Ikenne Sutstation

Photo 5a: Generator powering the facilities at the AI centre

Photo 5b: Water storage facilities at the AI centre

The Boar Stud was stocked with four imported pure breeds, comprising GGPS of Landrace, Large white, Gene Converter 500 (Duroc), and Gene Converter 750 (a Terminal Sire Line exotic breed) boars (Photo 6a-d), for the production of semen for research and commercial sales to willing pig farmers. The Pig Multiplication Centre was stocked with GGPS of only two of the imported pure breeds, comprising Landrace and Large white gilts

(young female pigs), for the production of exotic purebred foundation stock of the two breeds, sold as "seed stock" to prospective farmers, for commercial rearing or breeding. Aside from research activities, using either the semen or seed stock of the exotic breeds of pigs, farmers were also able to buy quality semen obtained from the imported GGPS of pure exotic breeds of Landrace, Large white, Gene Converter 500 (Duroc), and Gene Converter 750 (a Terminal Sire Line) boars (Photos 6a-d).

Photo 6a: Landrace Boar

6b: Gene Converter 750 Boar

6c: Large White Boar

6d: Duroc Boar

Photos 7a&b: Dummy & Training of boar for dummy mounting and semen collection

Vice Chancellor Sir, it is worthy of note that, as part of the outcomes of the 1st International Pig Summit held in Ibadan in 2010, the National Animal Production Research Institute (NAPRI), Shika - saddled with the national mandate for livestock research (stocked in Otukpo), Benue State Government (stocked in Yandev) and two private investors in the Southwestern part of Nigeria (Jo-Daniel and Imo Hill Farms), were also involved in the importation of improved breeds of pigs. However, apart from the four breeds, Pietrain was an additional breed imported to one of the two private farms.

The four imported exotic breeds by IAR&T management had different economically important production traits to be introduced to rapidly improve the genetic quality of the existing pigs in the Nigerian swineherds. After the introduction of the exotic pure breeds, the next step for the genetic improvement was the effective breeding methods to be used to maximize the expression of the production traits desired. Relative to artificial insemination (AI), both pen-mating and hand-mating are natural mating methods, which were already generally in use in Nigeria. Pen-mating is simply turning one or a few boars into a pen of many females to be bred, while hand-mating is serving a single female on heat by bringing the boar to it (Photo 8). Hand-mating has advantages over pen-mating in that there is an assurance that each female is bred and that the exact mating time can be recorded. However, hand-

mating requires more labor than pen-mating (Holden and Ensminger, 2005).

Photo 8: Natural Mating Procedure

5.2 Improvement of Swine Production Practices using Artificial Insemination (AI)

AI is an advanced animal breeding method that involves semen collection from a sexually matured male either using a dummy (Photo 7a) or a sow on heat and, inseminating one or more sows on heat with fresh diluted or processed semen. In swine production practice, this method or technique can offer numerous advantages over natural mating methods (Sokunbi *et al*., 2010). The AI operation allows more extensive use of genetically superior boars, increasing the rate of genetic improvement within a herd. Fewer boars are necessary on farms that employ AI techniques and as a consequence, feed, housing and veterinary costs are reduced. With AI, new genes can be easily introduced into a herd with minimal health risks. Use of AI saves time and labour in the breeding barn and young gilts are not subject to injury even though they can be mated artificially to very large boars.


Photos 9a&b: Training of staff on semen collection and processing

Photo 10a: Light microscope with stage heater

10b: Sealing machine

10c: Autoclave

10d: Water bath

10e: Semen mobile climate box

10f: Temperature-regulated semen storage cabinet

Vice Chancellor Sir, my earlier research work with Prof. G.N. Egbunike, on the effects of artificial hemi-cryptorchidism on daily sperm production and extragonadal sperm reserve potentials in adult rabbits, aroused my interest in the area of animal reproductive physiology. The result of our studies demonstrated that hemi-cryptorchidism depressed sperm production through its degenerative effect on the cryptorchid testis by a complete testicular shrinkage and disorganization of the kinetics of spermatogenesis (Egbunike *et al*., 2001). The effects are also extended to the epididymides by depressing sperm reserves therein. The results suggested that hemi-cryptorchidism will result in reduced fertility of the affected animals. The findings re-awakened my consciousness to the importance of semen in animal production and the need to provide quality semen for the livestock farmers in Nigeria if they are to be encouraged to embrace the use of Artificial Insemination (AI) as a production technology. Hence, when I was more established in the profession, I sought to contribute my quota in this area of research. The establishment of the Boar Stud and Semen processing facility at Ikenne informed my involvement in further works with colleagues (Ewuola *et al*., 2014 & 2015; Omodewu *et al*., 2021) when I had the opportunity, even though, now with pigs.

The comparative study of the physiological response of the four imported exotic breeds of boar (Gene Converter 500 (Duroc), Gene Converter 750 (a terminal sire line hybrid), Large white (LW), and

Landrace (LR)) from the temperate environment of the United Kingdom to the humid tropical environment of Nigeria was studied. Daily ambient temperature and relative humidity of the pen house were 27.98±1.66^{o}C and 84.48±5.99% respectively, the thermoregulatory responses showed the daily rectal temperature recorded for LW (37.14±0.45^{o}C) was significantly (P<0.05) lower when compared to other breeds, while the respiratory rate of the boars ranged between 26.16±3.26 (LW) and 27.07±3.96 bpm (GC 750). Hence, the physiological response of the boars to the humid tropical environment was found to be different between the breeds. The Large white showed the best capacity to tolerate heat among the four breeds, indicating that ambient temperature elicited different levels of physiological responses according to breed (Ewuola *et al*., 2014). This led us to recommend LW as a breed of choice for Nigeria when compared to the other breeds studied.

In another study on the comparative assessment of semen quality and antioxidant activities of the exotic breeds of pigs in a humid tropical environment, revealed no significant difference in the semen temperature, mass activity, semen volume, progressive motility, and sperm concentration among the breeds. However, in terms of percentage livability, the least significant (P<0.05) value was obtained in LR (87.66±8.58%) and the highest in Duroc (96.45±2.70%). The glucose level in the GC 750 (0.13±0.04 mmol/L) was significantly (P<0.05) higher than that of LW (0.055±0.05 mmol/l) but not significantly different from that of Duroc (0.07±0.03 mmol/L) and LR (0.11±0.02 mmol/L). This is an indication of the differences in the ability of each of the breeds to respond to tropical humid conditions but none fell below the normal spermiogram for successful AI. However, the anti-oxidant profile of the boar seminal plasma did not show any significant difference among the breeds (Ewuola *et al*., 2015).

In a further study, the effects of including *Moringa oleifera* leaf extract (MLE) on breed and storage time of the semen quality of imported boars extended with Beltsville thawing solution (BTS) were examined. Semen samples were collected weekly from

twelve boars (Four Duroc, four Large White, and four Landrace). Samples were extended with 0, 0.25, 0.50, 0.75, and 1.00 g MLE inclusions. The ejaculate volume and spermatozoa concentration of the samples were determined immediately after collection, while pH, mass activity (%MA), progressive motility (%PM), liveability (%LA), and abnormality (%ABN) were taken at 0, 24, 48, and 72 hours. The results revealed that as storage time increased, all sperm viability parameters declined. The values of the parameters dropped below normal limits between 48 and 72 hours. The breed effect was significant ($P<0.05$) for MA, Volume, and Concentration. This study concluded that the inclusion of 0.75−1.00 g methanolinated Moringa Leaf Extract in the Beltsville Thawing Solution as a replacement for synthetic antibiotics compared well at 0−24 hours (Omodewu *et al*., 2021), thus confirming the phytobiotic properties of *Moringa oleifera* leaf extract.

Vice Chancellor Sir, it is gratifying to note that two academic staff of the Institute have earned a Masters and, another, a Ph.D. degree using the facilities at Ikenne. This is aside from students of other Institutions who have taken advantage of the facilities for their postgraduate studies. In fact, another Ph.D. award is being awaited for another staff of the Institute, who used the facility at Ikenne for his research work. Documented below is the procedure for insemination in pigs (Photo 11a-f).

Photo 11a: Stimulating sow by parading boar before sow.

Photo 11b: Wipe Vulva

Photo 11c: Insert Catheter

Photo 11d: Attach Semen bottle

Photo 11e: Stimulate sow by rubbing flanks and Photo

11f: Remove catheter slowly & record service applying back pressure

5.3 Impact of Improved Pig Semen or Seed/Foundation Stock Supplied to Farmers

Taking advantage of the improved breeds of pigs and artificial insemination, there was an increased number of piglets littered (Photos 12a & b). At 7−8 months, depending on the feeding regime employed, the pigs farrowed reached a market weight of about 90 kg and above.

Photos 12a&b: Sows that farrowed 18 and 14 piglets, respectively, after artificial insemination

With the use of CT scanning and proper interpretation of the results, as shown below (Photo 13a-c):

- Producers are able to identify the most suitable breeds/lines to rear
- Processors are able to determine the yields of specific cuts and
- Retailers are able to appraise/assess the meat quality through muscle compactness score by the image density.

However, to increase customer profitability, there must be a balance between the costs of maximizing sow output and optimizing growth and feed efficiency and the resultant values in terms of optimized back fat, maximized meat yield and improved meat quality (Photo 14).

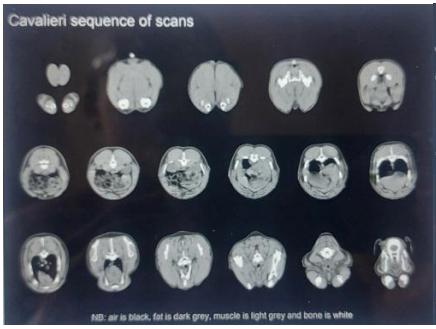

Photo 13a: Cavalieri sequence of scans

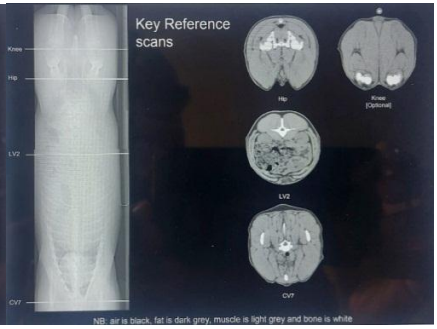

Photo 13b: Key reference scans

Photo 13c: Dorso-ventral and lateral positioning scans

Photo 14: Cross-sectional cut

6. Pig Housing Designs and Supervision of Construction

In 2003, I transferred my service to the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, to assist in resuscitating the Swine Research Unit of the Livestock Improvement Programme after the exit of my senior professional colleague, Emerita Prof. (Mrs) Olufunmilayo Ayoka Adebambo to the University of Agriculture (now the Federal University of Agriculture), Abeokuta. She left the Institute after anthrax wiped off the entire pig stock for her research at the Southern Farm Pig Research Facility of the Institute. In 2004 the Institute management, under the leadership of Prof. Ebenezer Adebisi Adebowale as Director, also a senior professional colleague, provided funds for the construction of another swine production facility to commence my research activities in another location (Bora Research Farm) which I designed and supervised its construction. By 2006, an additional pig house had to be constructed (Photo 15a) when the 2004-constructed facility could no longer accommodate the pig population, even with the weekly slaughter of 5−10 pigs (Photos 16-18) for sale to staff and students in the Institute and the Colleges, after the expiration of studies.

Later, as the Institute Representative on the Ibadan Forum for the Urban and Peri-Urban Agriculture Project, I was made to design and supervise the construction of a prototype 5-pen and 1-store Pig House (Tewe and Adesehinwa, 1995b), with an effective built-in waste management system at Bodija Iso-Pako area of Ibadan North LGA.

Photos 15a&b: Prof. E.A. Adebowale on an inspection visit and Photo of award received in 2019

Photos 16a&b: Processing of slaughtered pigs for sale

Photo 17a&b: Slaughtered pig cut into two halves for further processing into smaller portions (note leaness)

Photos 18a&b: Weighing of pig meat (pork) for packaging and sales by Programme staff

While on sabbatical leave at the Department of Animal Science, University of Ibadan in 2014, apart from my teaching and research activities, I was tasked by Prof. I. F. Adewole, the then Vice Chancellor of the University, to redesign the Breeding and Nutrition Units of the University Teaching and Research Farm, from the old structure I was trained with as a student. This, I did and I also supervised the construction of the new structure to completion, even after the expiration of my leave. The new structure which now houses 44 farrowing and 40 growing pens, is shown below (Photos 19a-d), while under construction. It was later completed and commissioned for use in 2020 by Prof. Kayode Adebowale, the current Vice Chancellor of the University of Ibadan. Aside from these Institution based structures, I have also been involved with several others through my activities in PFAN, ASAN, and NIAS for government nationwide (Photo 20) and in the ECOWAS States.

Photos 19a-d: Newly Reconstructed Pig Houses at the T&R Farm, University of Ibadan

Photo 20: Completed NIAS/PFAN Assisted Privately-owned Pig House Design and Construction Supervision

7. Global Feed Production

Vice Chancellor Sir, the global feed production remained steady in 2022 despite significant macroeconomic challenges that affected the entire supply chain. Europe bore the brunt of the impact, including significant disease challenges, severe weather, and the impacts of the invasion of Ukraine by Russia (AllTech, 2023). Feed production in Europe decreased by 4.67% and was down by 3.86% in Africa. Production in the Asia-Pacific region also dropped 0.51% (Table 4). Globally, increases in feed tonnage were reported in the aquaculture, broiler, layer, and pet food sectors, while decreases were reported in the beef, dairy, and pig sectors (AllTech, 2023).

The use of enzymes to improve the digestibility of nutrients, decrease the cost of production, and reduce the environmental

impact of agriculture had a significant positive impact. Thirty-two percent (32%) of respondents interviewed noted the use of enzymes as being the most significant nutritional solution to their market. Inflation and the overall state of the economy, particularly the increased prices of raw materials, feed and food have been the biggest challenges affecting the agrifood sector in 2022. Animal diseases have also been reported to have disrupted feed production in more than 80% of countries in the world.

Table 4: Global feed Tonnage by Region

Region	Sum of 2021 total feed production (MMT*)	Sum of 2022 total feed production (MMT)	Growth (MMT)	Growth (%)
Africa	44.506	42.788	–1.718	–3.86%
Asia-Pacific	467.922	465.540	–2.382	–0.51%
Europe	276.114	263.232	–12.882	–4.67%
Latin America	187.904	190.910	3.006	1.6%
Middle East	25.484	31.785	6.301	24.73%
North America	259.367	261.639	2.272	0.88%
Oceania	10.433	10.466	0.033	0.32%
Grand Total	1,271.731	1,266.350	(5.381)	–0.42%

*Million metric tons

**Latin America includes all Central American countries, including Mexico

***North America includes Canada and the US

Global Pig Feed Production

Globally, the pig sector experienced decreased feed tonnage. The feed production was down in 2022 (319.383 MMT) by almost 3% from 329.185 MMT in 2021 (a difference of 9.802 MMT). African swine fever (ASF) and high feed prices were said to have depressed pig production in many countries. However, in Vietnam, China, South Africa, Brazil, and Mexico, better pork prices and

other market conditions led to growth in the sector (AllTech, 2023).

Even though better pork prices in South Africa led to an increase of 0.175 MMT in pig feed production, still, the overall pig feed production in Africa was down slightly, due in part to ASF and high feed costs, from 3.319 in 2021 to 3.317MMT in 2022, representing −0.05% growth (0.002). The survey respondents observed that the top three technologies making the most impact on animal feed are Nutritional solutions (33%), Biosecurity (13%), and Automation of labour (use of robots, 13%) (AllTech, 2023), none of these technologies is yet to be taken seriously in Nigeria.

8. Evaluation of Pig Feeds and Feeding Systems in Nigeria

The type of feed and the method of feeding greatly influence feed efficiency, growth rate, breeding efficiency, carcass quality, and the general health of pigs (Adesehinwa and Ogunmodede, 1995). The choice of feeding periods for pigs is based entirely on nutritional and economic considerations (English *et al*., 1988). In Nigeria, most farmers feed their pigs once daily, while others allow the animals free access to agro-by-products throughout the day. In conventional pig feeding management, however, more variable feeding systems are applied. The question of how often the pig should be fed for efficient feed utilization, which remained unanswered, led to our study on the effect of once, twice, or thrice daily feeding on the performance and nutrient digestibility parameters of growing pigs. The performance of the pigs fed twice daily was better than those fed once per day. Twice-daily feeding also increased the digestibility of dry matter, crude protein, and crude fibre resulting in better growth and feed utilization, compared to once-daily feeding of the same daily allowance. However, there was no apparent advantage realised by increasing the feeding frequency to thrice daily (Fanimo *et al*., 2003).

Iron (Fe) is the only additional nutrient required by baby pigs because it is deficient in the sow's milk, its only source of nutrients during the first 2−3 weeks of life. It requires 6−8 mg of Fe/day for

haemoglobin synthesis, as against 1 mg/day in the sow's milk. Supplemental Fe was therefore required for the prevention of iron deficiency anaemia in piglets. Hence, a study conducted to compare oral iron to an injectable iron source showed that the latter was more effective in preventing iron deficiency anaemia in piglets, thereby preventing production losses (Adesehinwa *et al*., 1999c). Simple, well-managed creep feed served to the piglets in the farrowing house made a significant improvement of 42.2 and 21.6%, respectively, on survival rates of the piglets, in two trials, by reducing pre-weaning mortality from 18.5 to 14.5% (1st trial) and 19.9 to 11.5% (2nd trial), without creep training and with creep training, respectively (Adesehinwa, 2016).

8.1 Evaluation of Commercially available Customised Feed for Pigs in Southwest Nigeria

The escalation of pig farming activity has led to the development of commercial pig feeds. Feeds given to livestock should meet their nutrient requirements as well as health assurances for their supply and marketing (Gabbi *et al*., 2011). The form of delivery to the animals must be suitable for the use to which it is intended, and this can be justified by, but not limited to, the chemical and biological evaluation (Condé *et al*., 2017). Increased pig growth and better feed efficiency, as a result of improved nutrient digestibility, reduced feed wastage, and increased flow-ability is reported to be associated with feed pelleting, which may also be of better microbiological quality than the meal (Burns *et al*., 2015).

Three commercially available feed samples (tagged CAF1, CAF2, and CAF3) in pellet form and a fourth feed sample in mash form (CAF4) were compared based on the performance of weaner pigs fed the sampled diets. The study which was supported by Grand Cereals (Nigeria) Limited, Jos and AK Research Farms, Ibadan (in terms of materials and facilities), concluded that feeds for weaner pigs could be formulated to contain 2992 Kcal/kg digestible energy, 18.55% crude protein, and 7.07% crude fibre, as stated on the label and ideal energy to protein ratio (E:P), for optimum performance of weaner pigs was proposed to be 161:1 or, at most,

166:1. Therefore, for optimum performance of weaner pigs, commercially available CAF3 and CAF4 feeds were recommended (Table 4). However, pelletizing weaner pig feed may not be necessary considering the cost implication (Table 5a&b), since performance was the same irrespective of feed forms (Adesehinwa *et al*., 2020b).

Table 5a: Performance of weaner pigs fed commercially available starter feeds (0−8 weeks)

Parameters	CAF1	CAF2	CAF3	CAF4	SEM	P-value
Initial body weight (kg)	14.1	14.0	14.1	14.3	0.408	0.997
Final body weight (kg)	30.2^{b}	21.9^{c}	37.3^{a}	37.6^{a}	1.61	0.0002
Body weight gain (kg)	16.1^{b}	7.83^{c}	23.2^{a}	23.3^{a}	1.42	<.0001
Daily weight gain (kg)	0.29^{b}	0.14^{c}	0.41^{a}	0.42^{a}	0.0254	<.0001
Daily feed intake (kg)	0.94^{a}	0.68^{b}	1.15^{a}	1.09^{a}	0.0479	0.0005
Feed conversion ratio	3.61^{b}	5.04^{a}	3.25^{b}	2.75^{b}	0.270	0.0127

^{abc} Means with different superscripts across the rows are significantly different (p<0.05), SEM; standard error of mean (Adesehinwa *et al*., 2020b)

Table 5b: Economic analysis of the pigs fed commercially available starter feeds (0−8 weeks)

Parameters	CAF1	CAF2	CAF3	CAF4	SEM	P-value
Cost of feed/Kg diet (₦)	112^{a}	89.9^{c}	108^{b}	108^{b}	1.49	<.0001
Total feed intake (Kg)	53.5^{b}	38.7^{c}	64.4^{a}	61.3^{a}	1.83	<.0001
Total cost of feeding (₦)	6011^{b}	3477^{c}	7012^{a}	6675^{a}	244	<.0001
Cost of feeding per day (₦)	105^{a}	60.7^{b}	125^{a}	119^{a}	5.78	<.0001

Feed cost/Kg weight gain (₦/Kg)	405[a]	453[a]	353[b]	299[c]	12.7	<.0001

[abc] Means with different superscripts across the row are significantly different (P<0.05), SEM; standard error of mean (Adesehinwa *et al*., 2020b)

In another study (Adesehinwa *et al*., 2020c), comparing three sets of commercially available pig feeds, in the same form, the findings revealed that there were marginal variations in the nutritional composition of the three starter feeds compared to what was displayed on the label attached to the feed bag. Two of these feeds met the nutritional requirements of this class of pigs, while the fibre content in the other was beyond what the young pigs could tolerate, which affected the gut health negatively, hence resulting in poor performance of the animals (Table 6). It was noted that chemical and biological evaluations should be done for emerging pig starter feeds before getting to the end users.

Table 6: Economic analysis of weaner pigs fed three commercially available Pig Feeds

Parameters	**CAF1**	**CAF2**	**CAF3**	**SEM**	**P-value**
Cost of feed/kg diet (₦)	112.39[a]	89.94[c]	108.96[b]	1.6635	<0.0001
Total cost of feeding (₦)	1483.65[a]	756.20[c]	1088.98[b]	62.4444	<0.0001
Average cost of feed/ day (₦)	427.90[a]	305.55[b]	316.34[b]	21.9018	0.0334
Feed cost/Kg weight gain (₦/Kg)	328.52[b]	368.84[a]	318.32[b]	7.8324	0.0210

[abc] Means with different superscripts across rows are significantly different (p<0.05), SEM; standard error of mean (Adesehinwa *et al*., 2020c).

8.2 Comparative Evaluation of Different Feed Troughs

One of the challenges faced by pig farmers is the lack of uniformity in the body weight of the animals, even though the animals are subjected to the same dietary conditions. The search for strategies to address the issue of body weight variability among

pigs of the same age has gained attention recently in the pig industry. The use of strategies that are commercially relevant, easy to implement, and acceptable, such as feeder space and feeding management, are among those strategies (López-Vergé *et al.*, 2018). Feeder space and design have been considered to be one of the possible ways to reduce body weight variability experienced in pig production. The feeder has been described as a tool used to enable pigs correctly access their diets (Gonyou and Lou, 2000) and acts as the interface used for pigs to potentially meet their maximum growth.

Quite a number of types of feeders for pigs have been identified in the market, and all of them were designed for similar goals; to maximize feed intake and minimize feed wastage to optimize pig performance. The feeder, then, may affect the performance, growth, and homogeneity of pigs (López-Vergé *et al*., 2018). Therefore, using different feeders may lead to differences in growth rate and body weight variability in growing pigs. Thus, the performance of growing pigs fed from concrete feeding troughs, semi-automatic feeders, and their combination was studied. The overall performance showed that the combination of the feeders improved the daily weight gain (448.74 g) and average daily feed intake (1666.56 g). The pigs fed from both feeders had the highest ($P<0.05$) total cost of feeding (₦9293.40), while the lowest cost of feeding (₦8691.50) was observed in pigs fed from semi-automatic feeders (Plate 1). In conclusion, the combination of concrete feeding troughs and semi-automatic feeders (Plate 2) improved the average daily weight gain and average daily feed intake of growing pigs when compared with the pigs fed from concrete feeding troughs (Adesehinwa *et al*., 2019a).

Table 7: Economic analysis of growing pigs fed from different feeders

Parameters	T1	T2	T3	P(ANOVA)	SEM
Period 1 (1−4weeks)					
Cost of feed (₦/Kg)	99.58	99.58	99.58	-	-
Total cost of feeding (₦)	3666.99	3704.73	3748.01	0.68	38.38
Average cost of feed per day (₦)	130.96	132.31	133.86	0.68	1.37
Feed Cost/kg live weight gain (₦/Kg)	349.78	381.72	377.55	0.70	17.37
Period 2 (5−8 weeks)					
Total cost of feeding (₦)	5138.36^{b}	5588.69^{a}	4943.45^{c}	<.001	44.55
Average cost of feed per day (₦)	183.51^{b}	199.60^{a}	176.55^{c}	<.001	1.59
Feed Cost/kg live weight gain (₦/Kg)	421.02	451.08	441.47	0.53	11.30
Period 3 (1-8 weeks)					
Total cost of feeding (₦)	8805.40^{b}	9293.40^{a}	8691.50^{b}	0.01	78.31
Average cost of feed per day (₦)	157.24^{b}	165.95^{a}	155.21^{b}	0.01	1.40
Feed Cost/kg live weight gain (₦/Kg)	380.89	407.34	401.71	0.68	13.17

SEM- Standard error of mean

^{a,b,c} Means along the same row with different superscripts are significantly ($P < 0.05$) different (Adesehinwa *et al*., 2019a)

Low feed intake in the post-weaning period and consequent low growth have been reported to impair performance and negatively affect metabolism and health status in pigs (Dong and Pluske,

2007). Therefore, correct access to feed is crucial to allow pigs to meet their nutrient requirements or at least not to limit them (Gonyou and Lou, 2000). Therefore, exploring different feeders may lead to improvements in growth rate and reduce variability. Thus, the objective of a further study was to observe the effect of the different feeders on the growth performance of weaned pigs. The overall performance showed that the combination of the feeders (T2) improved the daily weight gain (369.71 g) and average daily feed intake (1021.14 g) with the best feed conversion ratio (2.99). It was concluded that a combination of concrete feeding troughs and semi-automatic feeders improved the growth performance of weaned pigs (Adesehinwa *et al*., 2019b). However, the feed cost/kg live weight of the pigs in this study was lower when compared to the earlier findings reported by Adesehinwa *et al*. (2019a) where the cost of producing a kilogramme live weight (₦/kg) of growing pigs fed from different feeding troughs ranged from ₦380.09 to ₦407.34 compared to the results in Table 7.

Photo 21: Piglets crowding in Concrete Feed Trough

Plate 1: Semi-Automatic Feeder

Plate 2: Showing Concrete Feed Trough, Combination of concrete feed trough, and Semi-Automatic Feeder.

Photo 22: Growing piglets feeding from Concrete Feed Trough and Semi-Automatic Feeder separately

9. Utilization of Agro-industrial By-Products (AIBPs) as Feed Resources for Pigs

Maize has frequently been used as the primary energy source in conventional feeds for non-ruminants. The different uses to which maize and other cereals are being put, particularly brewing, confectionery, and other related uses, have worsened its use as a feed ingredient for livestock (Adesehinwa *et al*., 1998). The high cost of conventional feeds and feed ingredients coupled with the demand for the same ingredients by man, prompted my continuous and active research into the use of non-conventional feedstuffs as alternative feed resources for pigs. Since pigs represent one of the fastest means of correcting the shortage of animal protein in the Nigerian diet, and also capable of converting AIBPs into wholesome animal protein, I therefore evaluated several agro-industrial by-products to establish their nutritional value in pig rations.

One of such studies, for which I enjoyed the funding support of the Bassir-Thomas Biomedical Research grant, was the utilization of maize offal as a replacement for maize in the diets of pigs (Adesehinwa *et al*., 1999a; Adesehinwa *et al*., 2000; Adesehinwa and Ogunmodede, 2002; Adesehinwa, 2004a & b). We, later comparatively evaluated MO enriched with chicken offal or blood meal as protein sources in diets of weaned and growing pigs (Adesehinwa *et al*., 1999a). The results showed that newly weaned pigs could utilize 25% maize offal (MO) as replacement for maize

in a ration without animal protein supplementation, this increased to 45% when the diet was enriched with chicken offal meal (Adesehinwa *et al*., 2001). Chicken offal meal protein was discovered to be superior to blood meal as feed supplement for pigs. The growing pigs on the other hand, which utilized 50% MO without animal protein supplementation (Adesehinwa *et al*., 1999b; Adesehinwa and Ogunmodede, 2002), were able to utilize total replacement of the maize content of the diet with MO when chicken offal was added (Adesehinwa, 2004b). This resulted in a drastic reduction in the cost required for the production of a kilogramme live-weight gain. The overall result of the study was an indication that maize offal and chicken offal had tremendous potential as alternative feed resources to alleviate the problems of feeding newly weaned and growing pigs in the face of scarcity and high prices of the conventional feedstuffs (Adesehinwa *et al*., 1999b; 2001).

I further investigated the utilization of a mixture of "dusa" (a by-product of local alcohol production from sorghum) and cashew nut testa (a by-product of cashew nut processing) as ingredients in diets of growing pigs. The result showed that the mixture of the two ingredients as a replacement for soybean meal, had a tremendous potential to alleviate the shortage of protein components of livestock feeds, without an adverse effect on the performance and health status of pigs (Adesehinwa and Ogunmodede, 2004). Taking into consideration the fibrous nature of dusa, a feature of most locally available agro-industrial by-products and wastes, and a major determinant that has limited their use in monogastric animals, hence, several other products were evaluated for their nutritive value, as feed resources for growing pigs (Adesehinwa, 2008b).

The increase in the number of cottage oil palm processing industries in Nigeria, with a resultant abundant availability of palm kernel cake (PKC), as a by-product, necessitated the investigation of PKC as a potential energy source and a cost-effective ingredient in the formulation of compound feed for growing pigs. The

increased use of this local feedstuff with improved efficiency of utilization represented a potential means of cutting down on the cost of feeding growing pigs (Adesehinwa, 2007). In another study, the utilization of 20% palm kernel cake supplemented with two levels (10 and 20%) of cassava flour waste as a replacement for maize in a 40 kg maize-based diet for growing crossbred pigs was also investigated (Adesehinwa, 2009). The inclusion of the PKC supplemented with cassava flour waste (CFW) showed beneficial effect. The cost-effectiveness of the diets was an indication that the combination of these two agro-industrial by-products (AIBP) could be explored to increase the profit margin of a growing pig enterprise, in an area with an abundance of the AIBPs, without depressing the performance of the animals (Adesehinwa, 2009).

The increasing cost and unpredictable availability of Fish meal (FM) have necessitated the unending search for its replacement with cheaper and abundantly available plant protein sources (Robinson and Menghe, 2007). Even though soybean and other common legume grains play a key role as a protein source for human beings and animals alike, their production is not sufficient to meet the protein requirements of the increasing and expanding livestock industries (Vijayakumari *et al*., 2007). The use of raw soybean is limited due to the presence of endogenous and heat-labile antinutritional factors (ANFs), i.e., lectin, phyto-haemoglutinin, antivitamins, and protease (trypsin) inhibitors (Liener, 1980). Hence, the development of processing technologies for the removal of the ANFs has brought about a number of by-products, which are of little or no nutritional value to man. This has therefore resulted in its increased consideration as a protein source in animal feeds (Garg *et al*., 2002).

I therefore sort to evaluate the nutritional value of expeller-extruded soybean meal and on-farm processed soybean in diets of growing-finishing pigs. The result showed the feed efficiency to be 18 to 24% significantly ($P<0.05$) poorer for pigs fed the expelled soybean meal diets compared to the improvement observed in the

feed conversion of pigs when fed the on-farm processed soybean (Adesehinwa, 2008a). The gains, as well as the efficiency of feed utilization obtained with the on-farm processed soybean, were significantly ($P<0.05$) superior to the expeller-extruded soybean. However, the serum metabolites of the pigs were observed to be unaffected by the different processing methods.

Poultry litter includes excreta, bedding (mainly wood shavings in Nigeria), wasted feed, and feathers (Fontenot and Hancock, 2001). Hence it represents a vast reservoir of cheap nutrients. Good management, including the exclusion of dead birds/other extraneous materials from the litter and appropriate processing prior to feeding, such as sun-drying has been reported to prevent the growth of microorganisms (Fontenot and Hancock, 2001). On-farm generated poultry litter in farms with no reported disease cases, could be a potential cheap source of feedstuff for growing-finishing pigs. I, therefore, evaluated the feeding value of sun-dried on-farm generated poultry litter (SOPL). The SOPL was included at 0, 33.33, and 66.67% as replacement for 30% maize in diets of growing-finishing pigs, on a weight for weight basis. The effect of SOPL inclusion on the chemical composition of the feed, growth performance, and blood chemistry of the pigs was evaluated.

Table 8: Performance, carcass, and cost of feed conversion of growing-finishing pigs fed SOPL-based diets

Parameters	**0%SOPL**	**33%SOPL**	**66%SOPL**	**SEM**
Daily feed intake (kg)	1.39	1.44	1.37	0.07
Daily weight gain (kg)	0.42	0.46	0.44	0.02
Feed: Gain	3.32	3.12	3.11	0.13
Cost of feed consumed/day (N)	40.07[a]	39.13[a]	33.27[b]	0.82
% Reduction in cost of feed consumed	-	2.35	16.97	-
Cost of Feed/Weight Gain (N/kg)	105.35[a]	90.09[b]	78.94[b]	4.23
% Reduction in				

cost of feed/Gain	-	14.48	25.06	-
Dressing percentage (%)	67.71	67.25	65.80	0.78
Back fat Thickness (cm)	2.35	2.28	2.38	0.11

[a,b,] Means along the same row with different superscripts are significantly (P< 0.05) different

Source: Adesehinwa *et al*. (2010c)

The result showed that growing-finishing pigs could tolerate the replacement of up to 66% (Table 8) of the 30 kg maize fraction of the diet (that is, 20 kg) with SOPL, without adverse effect on performance, cost of feed conversion and overall health status of the pigs (Adesehinwa *et al*., 2010c). With these results, it was obvious that with good management, feeding SOPL had no adverse effect on the health status of pigs. Rather, it was beneficial for the poultry industry by helping to reduce the overapplication of poultry litter to the soil. This had been reported to possibly result in high levels of nitrogen and phosphorus in soil water (Dilger *et al*., 2004), especially where the integrated farming system is practiced. FAO sponsored the presentation of the outcome of this study at an IAEA organized meeting in Austria.

Nigeria is the world's largest producer of cassava (*Manihot esculenta*), cultivated in two-thirds of its states, mainly in the southern part of the country. About 90% of the total production is used for human consumption and the processing of cassava generates about 14 million metric tonnes of by-products, comprising peels, stumps, woody, and undersized tubers, currently disposed of as waste (Okike *et al*., 2015). Several researchers have confirmed the suitability of cassava and its by-products for feeding livestock and the potential of cassava peels as a good substitute for maize for all classes of pigs (Akinfala and Tewe, 2001; Fatufe *et al*., 2007; Adesehinwa *et al*., 2008; Akinola *et al*., 2013).

FAO (2001) estimated that about 250-300 kg of cassava peel was produced per ton of fresh cassava root, and with the current increase in production of cassava in Nigeria, a substantial amount of processing waste would be generated around cassava processing

sites leading to pollution and the problem of waste management. The recent technology of innovative processing of cassava peels by grating, pressing, sieving, and drying of cassava peels developed by the International Livestock Research Institute (ILRI, 2015) to produce High Quality Cassava Peel (HQCP) fine mash has reduced the drying time drastically from 3 to 5 days to about 6 hours, resulting in improvement of the product, in terms of quality and quantity (Okike *et al*., 2015). The final product with 10–12% moisture content, when bagged and stored safely, could stay for 4-6 months without spoilage (Adesehinwa *et al*., 2019d).

The new innovative processing method of fresh cassava peels by ILRI has transformed fresh cassava peels into high-quality, safe, and hygienic livestock feed and has been demonstrated as technically feasible and economically competitive against existing equivalents. It has also dramatically improved the nutritive value of cassava peel and resulted in an end product known as High Quality Cassava Peel (HQCP®) which can either be fine or coarse. In the light of the forgoing, we conducted a study to evaluate the effect of graded levels of HQCP fine mash as a replacement for maize on growth performance, cost of production, haematological and serum biochemical indices of growing pigs. Our research results showed that HQCP fine mash could effectively replace 75% of the maize in the diet of growing pigs with approximately 4% reduction in cost per kg weight gain, with no adverse effect on growth performance, serum biochemical, and haematological indices. Implications of the findings were that processed HQCP fine mash can replace 75% of the maize in growing pigs' diet and thus spare maize—a high-value commodity with potential use in food, industrial, and feed for the poultry sector (Adesehinwa *et al*., 2016b).

A series of other trials conducted have proved HQCP to be a good substitute for a significant portion of maize in the diet of growing and weaned pigs without adverse effects on performance and blood parameters determined in the studies (Fatufe *et al*., 2017; Adesehinwa *et al*., 2018b; Adesehinwa *et al*., 2019c; Adesehinwa

et al., 2020a). The findings also demonstrated the potential for replacement of up to 15% of the 40% maize inclusion in the diet of weaned pigs and 30% in the diet of growing pigs with or without direct fed microbial (DFM) supplementation (Adesehinwa *et al*., 2018b). A compilation of the results of the various studies on the utilization of HQCP by pigs has formed part of an outstanding contribution to the chapter on 'Cassava peel waste as a source of environmental and economic value' written by Okike *et al*. (2022), in a recently Springer published Book on 'Root, Tuber and Banana Food System Innovations: Value Creation for Inclusive Outcomes' (edited by Graham Thiele *et al*., 2022).

10. Utilization of Additive-enhanced AIBPs as Feed Resource for Pigs

The presence of non-starch polysaccharides (NSP) and anti-nutrients in many feedstuffs, such as the numerous Agro-Industrial By-Products available in Nigeria, has limited their utilization in the diet of pigs. Hence, a study aimed at assessing the effect of different enzyme combinations in a multi-enzyme complex on the growth response of weaned pigs was conducted. The results showed improved feed utilisation and growth characteristics, resulting in increased daily and final weight gains in an economically beneficial manner (Figs 7.1 and 7.2), in terms of feed cost per kg weight gain (Boladuro *et al*., 2020).

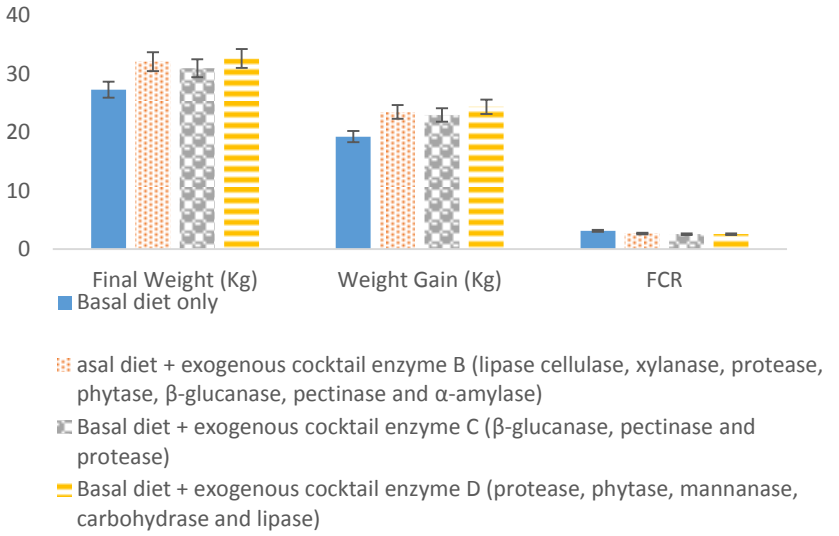

Fig. 7.1: Growth response of weaner pigs fed different combinations of enzymes in a multi-enzyme complex (Boladuro *et al*., 2020)

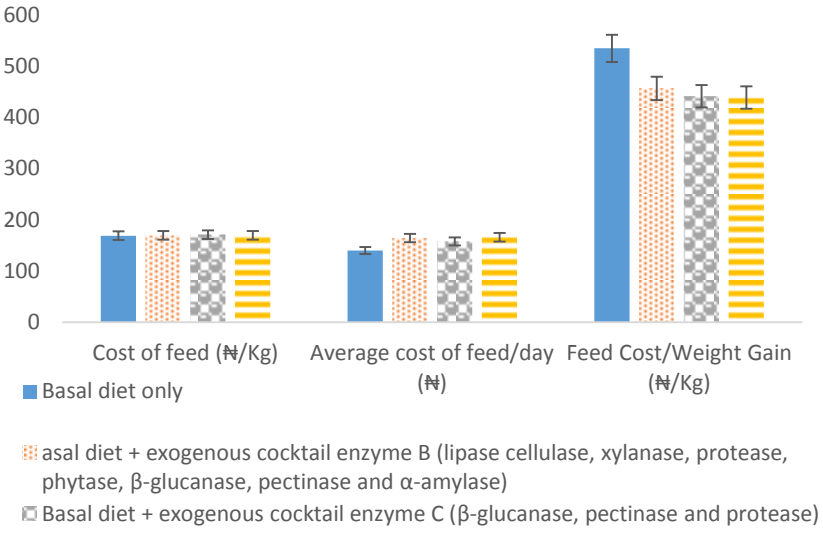

Fig. 7.2: Cost-benefit analysis of supplementation of multi-enzyme complex in the diet of weaner pigs (Boladuro *et al*., 2020)

Consumption of a high-fibre diet with non-starch polysaccharides (NSP) has the potential to adversely affect energy and nutrient utilisation with a consequent reduction in pig performance (Sorunke *et al*., 2021). Another study was initiated to investigate the efficacy of three different enzyme cocktails on the growth performance of growing pigs fed high-fibre diets. The enzyme cocktails included 0.3 g (combination of Xylanase, Cellulase, Protease, Alpha-amylase, Beta-glucanase, Phytase, and Pectinase)/kg basal diet, 0.5 g (combination of Carbohydrases, Beta-glucanase, Pectinase, Protease)/kg basal diet and 0.25 g (combination of Xylanase, Phytase, Alpha-amylase, Protease, Bacillolysin)/kg basal diet. There were no significant differences ($P>0.05$) in the performance indices of the pigs, though those fed enzyme cocktails had improved daily weight. The lowest feed cost per kg weight gain (₦345.38/kg) was observed in pigs fed a diet supplemented with an enzyme cocktail at 0.25 g/kg (Table 10). From the findings of the study, it was concluded that a cocktail of enzymes improved the daily weight gain of growing pigs fed diets containing non-starch polysaccharides and that an enzyme cocktail of 0.25 g/kg reduced feed cost per kg weight gain of the pigs (Table 9).

Table 9: Performance of growing pigs fed diets supplemented with different multi-enzyme complexes

Parameters	T1	T2	T3	T4	SEM	P-value
Initial body weight (Kg)	27.214	25.967	26.107	24.967	0.7826	0.8018
Final body weight (Kg)	46.571	47.367	48.143	46.367	1.2558	0.9607
Body weight gain (Kg)	19.357	21.400	22.036	21.400	0.8838	0.7470
Daily weight gain (Kg)	0.307	0.340	0.350	0.340	0.0140	0.7470
Daily feed intake (Kg)	1.339	1.432	1.507	1.403	0.0288	0.4106
Feed conversion ratio	4.362	4.212	4.306	4.126	0.2328	0.8413

SEM; standard error of means (Sorunke *et al*., 2021).

T1 – No added enzyme (Control experiment)
T2 – Xylanase, Cellulase, Protease, Alpha-amylase, Beta-glucanase, Phytase and Pectinase (300g/tonne)
T3 – Carbohydrases (Beat-glucanase), Pectinase, Protease (500g/tonne)
T4 – Xylanase, Phytase, Alpha – amylase, Protease, Bacillolysin (250g/tonne)

Table 10: Economic analysis of growing pigs fed diets supplemented with different multi-enzyme complexes

Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**	**P-value**
Cost of feed (₦/kg)	82.62	83.33	84.77	83.42	-	-
Total cost of feeding (₦)	6973	7516	8047	7376	345.25	0.8115
Average cost of feeding/day (₦)	110.69	119.29	127.73	117.08	5.623	0.8115
Feed cost/kg weight gain (₦/kg)	361.40	350.06	366.52	345.38	8.624	0.8542

SEM; standard error of means. Source: (Sorunke *et al*., 2021).

The replacement of maize with cassava peel had no adverse effect on the dressing percentage and other parameters in some instances. However, the inclusion of Farmazyme_ 3000 proenx® further enhanced the utilization of the cassava peel-based diet, resulting in better performance, comparable to pigs fed maize-based control diet (Table 11). This indicated that the economically cheaper cassava peel meal, hitherto regarded as waste in some areas of Nigeria, can be used successfully to replace maize in conventional pig feed without any depression or adverse effect on the growth performance, health status, and carcass characteristics (Adesehinwa *et al*., 2011).

Table 11: Performance characteristics and economy of gain of growing pigs fed diets with or without Farmazyme® 3000 proenx inclusion

Parameters	Maize-based	Cassava peel-based		SEM
		Without enzyme	With enzyme	
Average initial weight (kg)	22.50	22.78	22.94	0.88
Average final weight (kg)	39.28	37.17	39.44	1.13
Average total weight gain (kg)	16.78[a]	14.39[b]	16.50[ab]	0.36
Average daily dry matter intake (kg)	1.63[a]	1.42[b]	1.49[b]	0.02
Average daily weight gain (kg)	0.40[a]	0.35[b]	0.39[ab]	0.36
Feed conversion (Feed: Gain)	4.51	4.65	4.20	0.13
Av cost of feed consumed/day (₦)	46.16[a]	30.81[b]	34.03[b]	0.02
Av cost of feed per gain (₦)	115.40[a]	88.03[b]	87.26[b]	0.05

[a,b,] Means along the same row with different superscripts are significantly ($P < 0.05$) different from each other. (Adesehinwa *et al*., 2011).

We also evaluated the response of growing pigs to a high cassava peel-based diets supplemented with Avizyme® 1300. Avizyme is a product containing a mixture of xylanase, protease, and amylase. Thirty-six growing pigs (Large white x Landrace x Duroc) weighing 27.56±0.51 kg, were allocated to three groups of Avizyme® 1300 inclusion (no enzyme inclusion control, 100 g/100 kg diet, and 200 g/100kg diet) in a 45% Cassava peel meal (CPM)-based diet (Table 12). The 0.1% Avizyme® 1300 (100 g/100 kg diet) in the 45% cassava peel-based diet for growing pigs resulted in enhanced growth, as indicated by improved protein efficiency and feed conversion (Adesehinwa *et al*., 2008).

Table 12: Performance characteristics of growing pigs fed cassava peel-based diet supplemented with Avizyme® 1300

Parameters	No Enzyme	0.1% Avizyme	0.2% Avizyme	SEM
Daily weight gain (kg)	0.30 [c]	0.57 [a]	0.41 [b]	0.04
Daily dry matter intake (kg)	1.78	1.84	1.84	0.01
Feed conversion ratio	5.97 [a]	3.23 [c]	4.65 [b]	0.17
Protein Efficiency ratio	0.88 [c]	1.50 [a]	1.14 [b]	0.03

[a,b,c] Means along the same row having different superscripts differ significantly (p<0.05) Source: Adesehinwa *et al*. (2008)

In a study to evaluate the response of growing-finishing pigs to rice mill by-product (RMBP) supplemented with or without Allzyme® SSF as a substitute for wheat bran. It was found that the addition of Allzyme SSF enhanced the digestibility and utilization of the RMBP-based diet (Adesehinwa *et al*., 2010b). The gains of the pigs on the wheat bran-based control diet were comparable to those of pigs on the RMBP-based diet with Allzyme SSF supplementation, while both were superior (P<0.05) to those of pigs on the RMBP-based diet without Allzyme SSF supplementation. Hence, the 30% rice mill by-product-based diet with Allzyme SSF supplementation replaced the wheat bran and reduced the cost of fattening pigs to market weight (Adesehinwa *et al*., 2010b). We further conducted a study to evaluate the effect of multi-strain direct-fed microbials, mycotoxin binder and yeast culture on the growth performance and blood parameters of crossbred (Landrace × Large White) weaned pigs. The result revealed that direct-fed microbials promoted growth over and above the mycotoxin binder and yeast culture, with the highest final body weight observed in pigs fed a diet containing multi-strain direct-fed microbials. Additionally, the result showed that none of the feed additives had any deleterious effect on the health status of the weaned pigs (Adesehinwa *et al*., 2018a).

Another study was conducted to investigate the effects of probiotics on the comparative utilisation of Brewers' dried grain (BDG), Wheat Offal (WO) and Palm Kernel Cake (PKC) by

weaner pigs, in terms of growth, apparent nutrient digestibility and economics of production. Though the growth performance of the pigs on PKC and BDG supplementation with probiotics increased ($P<0.05$) in terms of the final weight and average daily gain, but the feed conversion ratio was best with the WO-based diet, even without probiotics (2.14). However, the apparent nutrient digestibility results showed that probiotics had a significant ($P<0.05$) positive effect on the dry matter, crude protein, crude fibre, ash content and ether extract digestibility. We therefore, concluded that the inclusion of probiotics had significant positive effects on the utilization of the PKC and BDG-based diets for growth, apparent nutrient digestibility and the feed cost/kg gain (Akinfala *et al*., 2015). Effect of *Macleaya cordata* preparation, as a phytobiotic feed additive was investigated on the performance and blood profiles of weaned pigs. With sanguinarine as the active ingredient, it has been reported to possess various biological activities that stimulate the secretion of enzymes in the intestine (Franz *et al*., 2005). The result of the study revealed that the two inclusion levels of the *Macleaya cordata* preparation (sanguinarine) in the study had no effect on the performance of the weaned pigs (Table 13). This was an indication to farmers to desist from indiscriminate use of additives, which ultimately adds to the cost of feed (Table 14), vis-à-vis cost of production, without producing any positive effect or impact (Adesehinwa *et al*., 2019).

Table 13: Performance of weaned pigs fed *Macleaya cordata* preparation as phytobiotic feed additive.

Parameters	0	0.2g	0.3g	P (ANOVA)	SEM
Initial weight (kg)	8.93	8.54	8.98	0.644	0.210
Final weight (kg)	27.17	26.86	27.25	0.966	0.640
Daily weight gain	0.32	0.32	0.33	0.998	8.170
Average daily feed	0.855	0.897	0.895	0.271	11.90
Feed conversion	2.73	2.91	2.88	0.538	0.071

SEM - Standard error of mean.
T1 - Unsupplemented basal diet
T2 - 0.2 g of the phytobiotic (*Macleaya cordata*) per kilogram diet
T3 - 0.30 g of the phytobiotic (*Macleaya cordata*) per kilogram diet

Table 14: Economics of production of weaned pigs fed *Macleaya cordata* preparation as phytobiotic feed additive.

Parameters	T1(0)	T2(0.2g)	T3(0.3g)	P (ANOVA)	SEM
Cost of feed (₦/Kg)	111.40[c]	111.80[b]	112.00[a]	<.0001	0.03
Total cost of feeding (₦)	6001.70	6314.50	6315.20	0.2094	83.96
Average cost of feed per day (₦)	107.17	112.76	112.77	0.2094	1.50
Feed Cost/kg Weight Gain (₦/Kg)	303.73	324.84	322.80	0.4919	7.98

SEM - Standard error of mean.

The paucity of information on the supplementation of wet or dry feed with *Saccaromyces cereviseae* probiotics led to a study, to assess the growth pattern, behavioural responses and faecal microbial load of growing pigs fed wet or dry feed supplemented with or without *Saccaromyces cerevisiae* (Adebiyi *et al*., 2016). The results showed that wetting pig feed had no significant effect on feed efficiency (Table 15). However, the addition of *Saccaromyces cereviseae* to the dry diet in this study elicited positive growth performance and reduced the faecal colliform load. Unlike the pigs fed diets in wet form, the pigs fed dry diets had increased ($P<0.05$) water intake, which was an indication of the dryness of the feed, leading to frequent visit of the pigs in this group to the drinking trough and had more hours of resting showing satisfaction, in terms of lower physical pen interaction (Fig. 8). Pigs fed dry feed, supplemented with *Saccaromyces cereviseae* probiotics had better overall performance, least faecal microbial load than pigs fed wet feed, either supplemented or not supplemented with *Saccaromyces cerevisiae* (Adebiyi *et al*., 2016).

Table 15: Effects of feed forms (Dry or Wet) supplemented with *Saccaromyces cereviseae* probiotics on growth performance of pigs

Treatments	ADFI (kg)	ADG (kg)	FCR
T1	1.10[a]	0.31	3.54
T2	1.02[b]	0.21	4.85
T3	0.95[b]	0.51	1.86
T4	0.95[b]	0.31	3.06

SEM	0.10	0.02	2.06

[a,b] Means along the column with same superscripts are not significantly (P<0.05) different
ADFI - Average daily feed intake (kg)
FCR - Feed conversion ratio
SEM - Standard error of mean
T1 - Dry feed without *Saccromyces cereviseae* probiotics (Positive control)
T2 - Wet feed without *Saccromyces cereviseae* probiotics (Negative control)
T3 - Dry + *Saccromyces cereviseae* probiotics
T4 - Wet feed + *Saccromyces cereviseae* probiotics

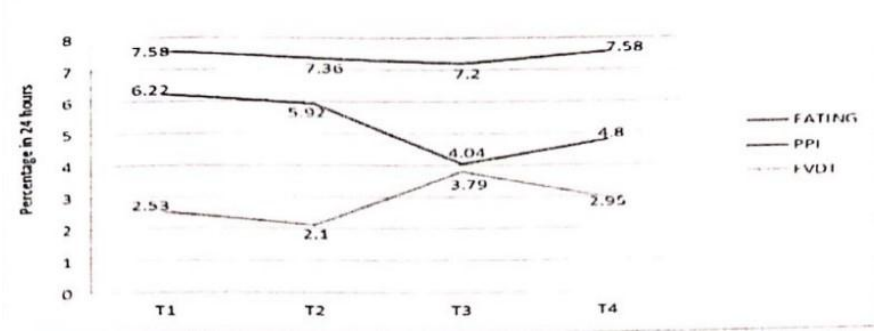

Fig. 8: Effects of feed forms supplemented with *Saccaromyces cereviseae* probiotics on behavioural pattern of growing pigs.
FVDT = Frequency of visiting drinking troughs
PPI = Physical pen interaction
T1 - Dry feed without *Saccaromyces cereviseae* probiotics (Positive control)
T2 - Wet feed without *Saccaromyces cereviseae* probiotics (Negative control)
T3 - Dry + *Saccaromyces cereviseae* probiotics
T4 - Wet feed + *Saccaromyces cereviseae* probiotics

11. Survey of some Pig Production and Marketing Systems in Nigeria

The pig industry can be a very reliable one due to certain attributes of pigs and the Nigerian production system. Pigs have a high survival rate and the ability to utilize a host of agro-industrial by-products and crop residues with little or no processing and at minimal cost (Tewe and Adesehinwa, 1995a). Pigs are known to be prolific producers, realizing 20 to 30 piglets from 2 or 2½ litters per year. Its ability, under efficient management and balanced nutrition to reach a slaughter weight of about 80 to 90 kg in about 7 to 8 months makes it one of the most efficient feed converters.

The production of pigs in an economically viable livestock system, therefore calls for the provision of nutritionally balanced rations. However, feed represents between 50 to 83% of the cost of production in a commercial pig enterprise (Tewe and Adesehinwa, 1995a). Dwindling profit in a pig enterprise has been reported to be a function of poor-quality feeds resulting from unbalanced rations (Adesehinwa and Ogunmodede, 1995). This was as a result of insufficient knowledge about the nutritional requirements of the animals, the nutrient composition of the feed ingredients, seasonal variations in their availability, and the prohibitive cost of some of the basal ingredients.

Thus, a diagnostic survey of pig production systems conducted in Ogun State revealed that there are prospects for successful swine production in the state if the farmers are provided with financial assistance. The lack of credit facilities was the most limiting constraint (Fanimo *et al*., 1999). Demographic and socio-economic characteristics of animal producers go a long way in influencing their adoption of improved production technologies (Adesehinwa *et al*., 2003b). The implication is that producers' characteristics such as gender, family size, main occupation, religion, type of farming, farming experience, and herd size should be considered before technologies are developed and disseminated (Ajala *et al*., 2007).

Our study to identify production strategies employed by pig producers in some peri-urban areas of Southwestern Nigeria (Lagos and Ogun) (Adesehinwa *et al*., 2003a) revealed that as much as pig production integrates well into farming activities in the peri-urban area, it is highly sensitive to demand and supply variables. As such, breeding and general management of feeds and feeding, cost, and profitability aspects of pig production enterprise are targets for strategic manipulations to meet desirable production and marketing objectives to remain in business. While the current production strategies adopted have apparently impacted positively on the quantity and quality of pork put on the table of consumers, they tend to paint a bleak future for the commercial pig feed

market; unless a more attractive commercial pig feed product is developed. The result also showed that non-conventional feedstuffs obtained from the farm, household, and agro-industrial wastes are indispensable for many farmers to keep operational costs low, particularly average daily feeding costs. The sale or slaughter of pigs at a predetermined live weight (50 to 70 kg) formed part of the overall strategy to reduce economic waste and enhance profitability to stay in business.

Another study which appraised pig production and management practices amongst 300 households, randomly selected from five village areas around Zango Kataf local government area of Southern Kaduna revealed that, to boost the indigenous pig performance, a lot needs to be done in the area of management, especially, to curtail disease incidence and mortality rates, as well as improved housing and feeding. This was an attempt to overcome the major production constraints, which included disease incidence, high cost of feed, drugs, and poor housing (Ajala *et al*., 2005). The socioeconomic factors influencing swine management practices were level of education, household size, investment, herd size, income earned from pigs, number of pigs started with, and contact with a veterinary officer, which were found to be correlated to the management score (Ajala *et al*., 2006; Ajala *et al*., 2007). The determinant of the herd size of pigs reared was the amount invested, contributing about 40.8% of the variance as the best predictor (Adesehinwa *et al*., 2007). A well-defined and properly planned extension service was therefore recommended.

A commissioned study by the National Animal Production Research Institute (NAPRI) on the analysis of pig marketing in Northern Nigeria revealed its efficiency and profitability, with many buyers and sellers, to be such that entry into the market as a participant was very easy but the operating capital required was high. Other problems associated with pig marketing in the study area and policy implications were highlighted in the findings by Ajala and Adesehinwa (2007), were lack of capital, high cost of transportation, lack of standardization, lack of functional abattoirs,

and lack of storage facilities (Photo 21). All these had to do with the need to provide adequate market infrastructural facilities. Fig. 7 showed an ariel view of the pig market in Kafanchan. The roles and efficiency of the participants in pig marketing in this part of the country have been reported (Ajala and Adesehinwa, 2007).

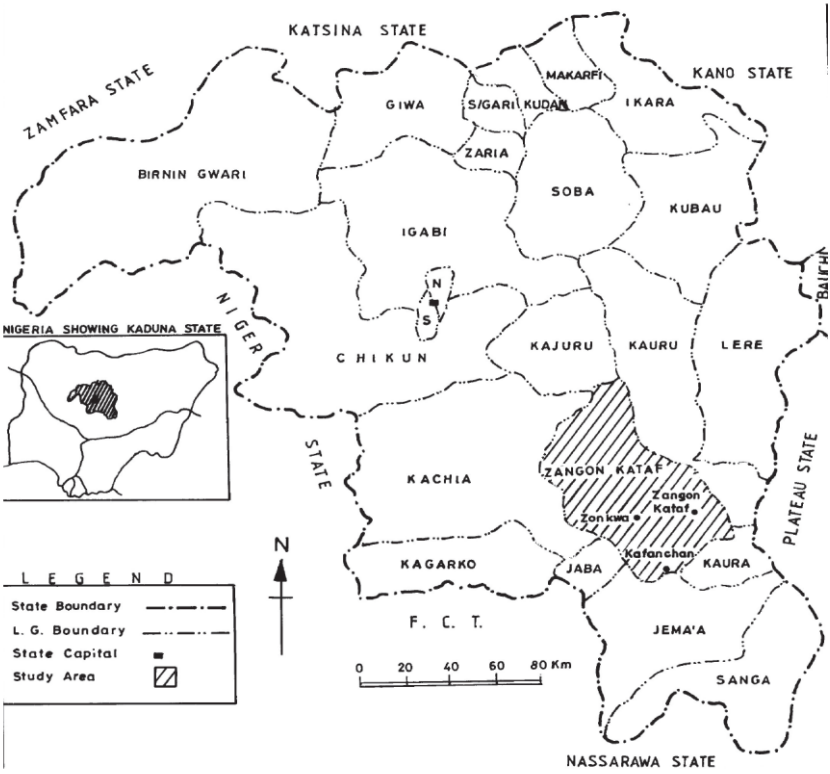

Fig. 9: Zango Kataf Local Government Area of Kaduna State

Fig. 10: Aerial view of Kafachan pig market

Photo 23: Kafanchan pig Market in 2007, without proper market infrastructure

Although pig marketing channels were found to be simple, there were a number of constraints to the efficient functioning of the market arising from lack of market information, limited own capital, lack of access to formal credit sources, lack of good roads, and exorbitant transport fees. These constraints increased actual market and transaction costs. The provision of credit facilities to enable aspiring traders to overcome market entry limitations posed by the lack of own capital will increase the number and volume of trade (Ajala and Adesehinwa, 2007; 2008). With appropriate price

incentives, most of the services provided by the market could be improved for the benefit of consumers and producers; the overall volume of the market could be higher, the quality of meat could be more uniform, and some marketing costs could be decreased. Also, the on-shelf durability of meat could be improved upon through the installation of processing plants. It is expected that if these suggestions are considered, they will help to improve the performance of the pig/pork marketing system; consequently, consumers will have more value for their money.

The ability to market pigs at the right time is a major determining factor in the success of commercial pig production (Ajala and Adesehinwa, 2007; 2008), as there is a ready market for pork in many parts of the country. There is a well-defined marketing channel and structure in the Kafanchan area. Fig. 11a&b shows that the pig marketing channel is made up of the producer, rural assembler, commissioned agents, urban wholesalers, retailers, and finally, the rural/urban consumers. The minor channel constitutes the flow of products from the producer directly to the rural/urban consumers. The bulk of pigs in Nigeria is sold live. There is a year-round market; however, the demand increases before occasions like Christmas and other ceremonies like dowry payment, funerals, etc. On these occasions, well-fed animals are sold at a premium price, higher than the usual weight-based price.

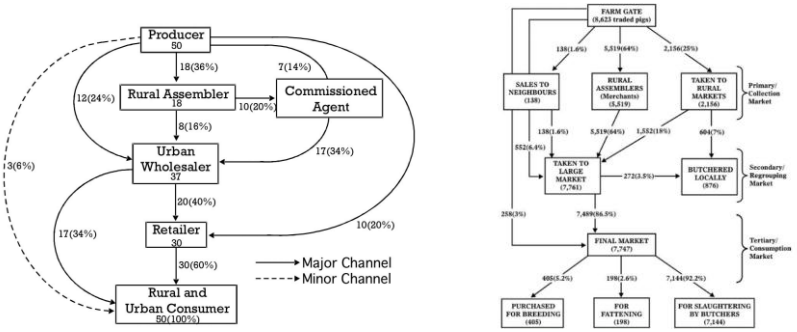

Fig. 11a&b: Marketing Channel, Structure, and Volume of flow of pigs in some parts of Northern Nigeria

The survey by Ajala and Adesehinwa (2008) showed that 1.6% of market pigs were sold directly to neighbours for slaughter (fatteners) or rearing (piglets), 25% of pigs were taken to rural markets, and 64% of the pigs were sold to Rural Assemblers who take them to larger markets. The pig producer's share of the price paid by the final consumer was high (61%), giving a marketing margin of 39% shared between the Rural Assembler and Final Retailer, showing pig marketing as a profitable venture. The major constraints of pig marketing in Nigeria include; (a) the Perception of pigs (and therefore pork) as a dirty animal and, more especially, its association with cases of trichinosis (*Trichinella spiralis* infestation), as well as (b) Religious and cultural taboos banning its consumption by certain segments of the population in Nigeria (Ajala *et al*., 2005; 2007) and in other countries like Ghana (Okai, 2010). Major problems associated with the provision of adequate market infrastructural facilities for pigs are lack of capital, high cost of transportation, lack of standardization, lack of functional abattoirs, and lack of storage facilities (Ajala and Adesehinwa, 2008; Dafwang and Adesehinwa, 2010).

Vice Chancellor Sir, live animal sales constitute the primary marketing channel for the disposal of pigs by producers (Fig. 11a&b). The conditions for transportation, handling and selling of pigs are subject to many problems, which constitute animal welfare and public health concerns. The mind-boggling problems associated with the inter-state transportation of pigs and other live animals are larger than life and would require the cooperation of relevant agencies of Government at all levels to solve. This subsector of the livestock agriculture in Nigeria cannot be made sustainable to yield its desired potential in the Nigerian economy if its production practices are unregulated and its products are not value-added. Hence, there is a need to harness the untapped resource in its production practices and marketing structure. Therefore, developing the pig/pork industry in Nigeria would require standardization/grading of animals/carcass, without which there may be no encouragement or incentive to improve.

Photo 24: Pig transportation

Swine is the major host for lungworms (*Metastrongylus* sp.). Hence, we also studied the seasonal variation (harmattan versus rainy season) and the prevalence of lungworm infection in the local, crosses, and exotic breeds of pigs slaughtered in the Bodija Municipal Government Abattoir. The result showed that higher infection rates were observed during periods of heavy rains, and the local pigs were the most susceptible. Adequate preventive measures, as described by Nssien *et al*. (1999), to prevent human infection must be followed by the pig farmers, as well as the need for the farmers to embrace the rearing of exotic breeds and their crosses, which were less susceptible. Hence, there was therefore the need for continuity in this line of research, thus introducing superior production traits of economic importance from the exotic breeds into the Nigerian swineherd to rapidly improve its genetic quality.

12. African swine fever (ASF) disease and its implications on pig production in Nigeria

Vice Chancellor Sir, African swine fever (ASF) is a highly contagious viral disease of pigs. It is caused by a deoxyribonucleic

acid (DNA) virus belonging to the Asfarviridae family. ASF is a highly contagious viral disease of domesticated pigs for which there is no known treatment or vaccine (Adeoye and Adebambo, 2010). It is characterized by widespread hemorrhages and very high mortality (Murphy *et al*., 1999), with any recovered pig potentially acting as a carrier of infection for life. Although the disease tends to run a subacute or chronic course in areas where it has become enzootic, mortality rates close to 100% have often been observed during epizootics in previously free areas (Plowright *et al*., 1969). Following the first report of the disease in Kenya (Montgomery, 1921), it was subsequently reported in South Africa (Dekock *et al*., 1940) and Angola (Velho, 1956). With the exception of Lesotho and Swaziland, ASF has been reported in all countries of Southern, Eastern, and Central Africa (Penrith, 1998; Wilkinson, 1984). In West Africa, ASF outbreaks have been recorded in Cameroon, Cape Verde islands, Guinea Bissau, Senegal, and Côte d'Ivoire, occurring in Togo, Benin, and Nigeria between 1997 and 1998 (Penrith, 1998).

Nigeria was free until the first outbreak occurred in September 1997 (Ayoade and Adeyemi, 2003) and was associated with a spread of the epizootic from the Benin Republic, as shown in Fig. 12. An unprecedented high rate of mortality among pigs was reported from four local government areas of Ogun State, namely, Ipokia, Yewa-South, Yewa-North, and Imeko-Afon, bordering the Benin Republic. The ASF outbreak was also reported in the contiguous Lagos State from the end of 1997 to early 1998 (Odemuyiwa *et al*., 2000), with Oke-Aro as a major site of concentration upon entry and spread (Fig. 12 &13; Photos 25-27). A second wave of the outbreak started in August 1998, spreading across six states, namely Kaduna and Benue states in the North, and Enugu, Akwa Ibom, Rivers, and Delta states in the South. Since the first report in Nigeria in 1997, the disease has spread rapidly to all the pig-producing states., The disease now poses a considerable threat to pig production in Southwestern Nigeria (Adeitan *et al.*, 2003; Babalobi *et al.*, 2003; Esuruoso *et al.*, 2005; Olugasa, 2006). While pigs are affected by many diseases, ASF

stands out as the most devastating in Nigeria (Saka *et al*., 2010), as observed in Oke-Aro (Photos 25 & 26).

The results of a survey of 247 farmers in Lagos State by Saka *et al*. (2010) showed the prevalence of ASF among 88% of pig farms visited, and this resulted in the loss of about 79% of the stock population of animals with an estimated average revenue loss of ₦485, 000 per farm. The contributing factors were predominantly hygiene-related, as the majority of the farmers either shared implements, labourers, or transport products and inputs in the same vehicle, especially in the absence of adequate access to warning information about the incidence and/or spread of the disease. Also, a situation whereby foundation stocks, were predominantly sourced from neighbouring farms made control of the spread of the disease difficult, and there was also evidence of a dearth of certified sources for foundation stock. There is thus the need for intensive sensitization on an integrated approach for preventing the occurrence/reoccurrence and spread of the disease between the pig farms. Such, should include adequate surveillance and a warning mechanism to alert farmers of the threat of infectious diseases, before the spread gets out of hand. Lack of adequate compensation for infected farms has been a major limiting factor in disease reporting among farmers. Creating an avenue for such would no doubt go a long way to effectively involve the farmers in the surveillance program, especially when they are assured of getting adequate compensation for animals lost when incidences are reported.

Oke Aro Pig farm settlement is located in Ifo Local Government Area of Ogun State. It is located between Latitude $6^0$4'55" N and Longitude $3^0$19'05" E and Latitude $6^0$41'28" N and Longitude $3^0$19'42" N. It is about 18km from Murtala Mohammed Airport, Ikeja, while it is about 113km to Seme, a border town between Nigeria and Benin Republic. The pig farm estate (Photo 27) has a total coverage area of about 35 hectares, with over 2075 pig farmers. Administratively, it operates on two sites, namely the new and old sites. The new site currently has 650 farmers, rearing a

total of about 19,500 pigs, while the old site has 1,425 pig farmers rearing a total of about 38,025 pigs (February, 2023). Oke Aro could be said to be the epicentre of African Swine Fever (ASF) in Southwestern Nigeria, taking into consideration the cyclical occurrence of ASF annually, as well as the number of farmers clustered in the location and the different unwholesome management practices operated by them. The current low number of farmers and the current stock of about 30 pigs per farmer, is an indication of the last ASF attack suffered between December 2022 and January 2023. This is also evident in the high number of abandoned pig houses on the Pig Farm settlement (Photo 25) arising from total loss of stocked pigs in most cases, and their eventual improper burial in shallow graves by inappropriately dressed farm staff, as shown in Photo 26.

Legend	➡	Initial entry point		→	Pig trade movement	✸	Outbreak locations

Fig. 12: Probable spread of ASF within Nigeria 1997−1998 and 1999−date

Photo 25 & 26: Abandoned Pig House at Oke Aro Farm Settlement and improper burial of ASF infected pigs in shallow grave by inappropriately dressed farm staff.

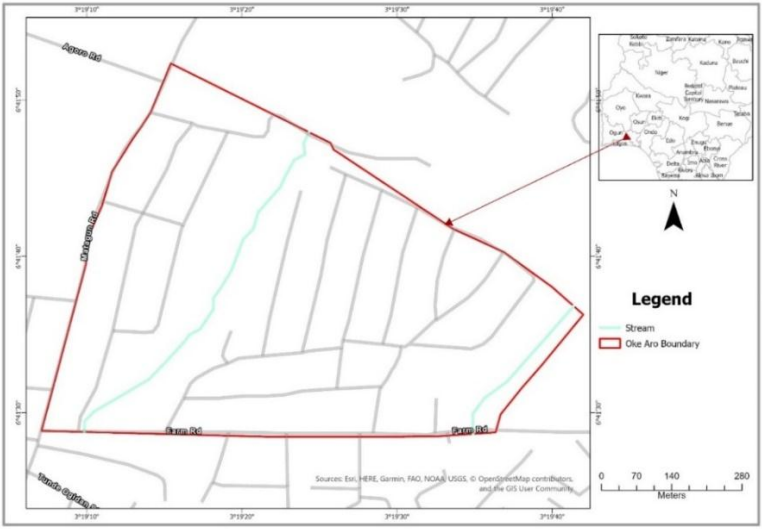

Fig. 13: Map of Oke-Aro Pig Farm Settlement Layout

Photo 27: Aerial photograph of Oke Aro Pig Farm Settlement. Source: Google Earth

13. OTHER CONTRIBUTIONS TO LIVESTOCK AGRICULTURE AND PARTICIPATION IN EXTERNALLY FUNDED PROJECT INTERVENTIONS

13.1 My Involvement in the Professionalization of Animal Science Practice in Nigeria

Vice Chancellor Sir, as a way of identifying and recruiting the professionals to drive the animal husbandry subsector, I was part of the formation of the Animal Science Association of Nigeria (ASAN), which was inaugurated in 1996 at the Airport Hotel in Lagos, and incorporated in 1997 with the Corporate Affairs Commission. ASAN is industry and private-sector-based, welfare-oriented and ensures the maximal utilization of its hitherto untapped and underutilized abundant professional resource base. Hence, in harnessing the untapped resource in aggregating and productive engagement of the knowledgeable human resource base, in livestock production/husbandry and pig production/husbandry in particular, my professional involvement in the formative days of ASAN, as one of the pioneer members, later Publicity Secretary, 2nd General Secretary, a Life Member and one of the Foundation Fellows, is worthy of mention.

Photo 28: Late Professor V. A. Oyenuga (1st Registered Animal Scientist in Nigeria – RAS 0001), Dr G. O. Oyediji (2nd ASAN President & later 1st Registrar of NIAS) and then Dr A. O. K. Adesehinwa (2nd ASAN General Secretary)

I was also a member of the team (comprising Prof. O. A. Osinowo, Dr G. O. Oyediji, and then, Dr A. O. K. Adesehinwa) involved in the initial consultations with potential members and other professional associations/bodies, with an attempt that produced the initial draft and eventually submitted the draft bill for the establishment of the Nigerian Institute of Animal Science (NIAS) at the National Assembly in Abuja. We also followed up till the passage at the House of Representatives on 14 September 2004 and subsequent concurrence by Senate on 23 May 2007, before being assented to by the then President of the Federal Republic of Nigeria, to become law on 28 May 2007, as NIAS Act No. 26 of 2007, as amended in 2015. Its major role has been to regulate Animal Science practice in Nigeria and register its professional. The functions of the Institute, are as contained in the Official Gazette of the Federal Republic of Nigeria, volume 94, issue 95 of 2007 (FRN Official Gazette, 2007).

Apart from being a pioneer member and Registered Animal Scientist (RAS), I have served as Member of Council, representing the Swine Production Science Discipline on the 1st Council after my election at the inaugural meeting, here in Obafemi Awolowo University in September 2007 (Photo 28). I have also been a pioneer member of the Membership Committee of the Institute and later Member of Council representing the Animal Biotechnology Science Discipline. I am currently the 2nd Vice-President and a Foundation Fellow (FNIAS) of the Institute (2012). I have also committed similar efforts to the Nigerian Society for Animal Production (NSAP), where I am also a Life Member and was invested as a Fellow (FNSAP) in 2019.

In addition, beyond the shores of Nigeria, my efforts at recruiting trained men and women into the practice of the profession has no borders nor boundaries. Hence, I have also been honoured with a Fellowship of the Ghana Society of Animal Production (FGSAP), apart from being the current Continental General Secretary of the All Africa Society of Animal Production (AASAP) and the National President of Pig Farmers Association of Nigeria (PFAN) since 2018. My role in PFAN has been that of bringing together and coordinating all those engaged and involved in the art of rearing pigs (at small, medium and large/commercial scale), as well as, those engaged in any other activity related to pig production, processing/value addition and or marketing, registered with the Association, which has been incorporated since 1999. To date, my actual involvement and participation as a practitioner in the industry earned me the 2019 Best Pig Farmer of the Year, as well as, being the focal person for pig production and research, both nationally and intercontinentally.

13.2 Fish−Rice−Poultry and Fish−Rice−Pig Farming Projects

I was a member of two CORAF/WECARD Projects on Fish–Rice–Poultry and Fish–Rice–Pig research teams led by Professor E. K. Ajani of the Department of Aquaculture and Fisheries Management, Faculty of Renewable Natural Resources of the University of Ibadan, as the Lead Livestock Expert. The two

projects were supported to the tune of One Million US Dollars ($1,000,000:00) involving three universities in three countries of West and Central Africa, namely the University of Ibadan in Nigeria; Njala University in Sierra Leone, and Buea University in Cameroun. The University of Ibadan was the Lead Institution for the two projects.

The overall objective of the two projects was aimed at developing a viable and sustainable integrated aquaculture system with agricultural production for rural farmers. This was to ensure diversification of livelihoods in rural areas, improved nutritional status, increased income-generating capacity as well as provision of additional off-season activities through enhanced land and water resources utilisation (Ajani, 2019). The project was expected to transform the production of the products of the integration (fish, rice, pig, and poultry) towards commercial production and import substitution in West and Central Africa.

In order to secure the food security of the growing human population, it is imperative that a suitable agricultural production system that will meet the increasing demand for food be embraced. An important way of increasing agricultural production is through Integrated Aquaculture (IA). IA is known to diversify production, thereby ensuring increased productivity and profitability in an eco-friendly manner. A project to assess the productivity of IA as a method of increasing food production was conducted. The two integrated combinations (Photos a-f) of Fish–Rice–Poultry (FRPo) and Fish–Rice–Pig (FRPi) were studied for the production performance for a period of one year. Comparison of the productivity of FRPo, FRPi, and a single system of production of fish, rice, poultry, and pig were investigated.

The results showed that integrated fish farming was more productive and profitable than a unitary system of farming, as it ensured a spread of financial risk because of its varied and diversified nature in the rearing of fish, animals and crops. The research study also showed that IA offered a cost-saving strategy

of operation in a manner that conserved the ecosystem by converting wastes to resources. IA, therefore, was a more productive system than the unitary system of production (Ajani *et al*., 2020). The study has also showed that integrated fish, rice, and poultry/pig production was practicable, environmentally friendly, and more productive, as measured by the yield of fish and rice. Poultry manure was discovered to be an excellent source of nourishment for increasing nutrients available to the plankton communities and fish in ponds, as well as, a rich source of nutrients for rice production. Integrated production of fish, rice, and poultry/pig helped to conserve water, as it was recycled between rice and fish. Hence, the recommendation that, integrated aquaculture should be embraced, developed, and applied in Nigeria, as a means of practising integrated farming activities in an eco-friendly manner (Jenyo-Oni *et al*., 2014).

Photos 29a&b: Visiting CORAF M&E personnel on inspection to participating farmer's farm


Photos 29c&d: Growing rice field in an integrated Fish-Rice-Poultry farm


Photos 29e&f: Piggery and Poultry sheds in Fish–Rice–Pig and Fish–Rice–Poultry Farming systems

13.3 CARGS project for the Development of Feed Standards and Feed Solution Software

I was also part of an ARCN Competitive Agricultural Research Grant Scheme (CARGS) project for the Development of Feed Standards and Feed Solution Software, led by Prof. Samson O. Ogundipe of the Department of Animal Science, ABU Zaria (the Lead Institution), Coordinator for Southwest Nigeria. The other participating Institutions were National Animal Production Research Institute (NAPRI); National Agricultural Extension Research Liaison Services (NAERLS); Institute of Agricultural Research and Training, Ibadan; University of Agriculture, Umudike and Raw Materials Research Development Agency. Abuja. The funding agency of the project at inception was the Agricultural Research Council of Nigeria (ARCN) and the Tertiary Education Trust Fund (TETFUND) later facilitated its completion by giving additional funds.

A compendium of data obtained from the analysis of feed ingredients used in feed formulations obtained from different parts of Nigeria, was used to develop feed ingredient tables consisting of values of 82 feed ingredients, of both plant and animal origins, in addition to several mineral sources categorised and sorted into nutrient composition, essential amino acids, micro- and macro-minerals, vitamins, energy, ether extract and linoleic acid. Both conventional and a couple of non-conventional feed ingredients were also included.

Photo 30a,b&c: Feed Ingredients Composition booklet, Feed Solution software Manual and CD

Apart from the book publication (ISBN 978-978-790-302-5) containing feed ingredients composition and nutrient requirement tables for poultry, swine and fish (Photo 30a), the team of researchers and a Nigerian private software developer also designed and developed a feed formulation software (Photo 30c), called "Feed Solution Software" to formulate balanced animal rations, using the least cost formulation concept. An operating manual (Photo 30b), with all screen snapshots and explanations of how the software operates, was also developed and published (ISBN 978-978-790-303-2). All major Nigerian feedstuffs were accommodated and their nutritional compositions were put in the database. The Feed Solution software runs on Windows with a nice graphical interface. It accommodates an unlimited number of nutrients and feed ingredients. It can equally analyze pre-formulated rations, listing their nutrient compositions. The project, which commenced in 2010, has since been completed in 2022, and the Software is officially released for use by willing commercial feed millers and professionals. The Software possesses unique features such as:

- A good inventory management system designed to track the movement of feed materials (feed ingredients) in and out of the feed-mill warehouse
- Production planning and active inventory management system are both fully integrated into the database of the software for effective planning and cost savings

- Production simulation system for predicting portable inventory levels and material consumption patterns in the feed mill warehouse
- Ability to be used for both non-ruminant and ruminant livestock feed formulations depending on the type and nature of feed materials inputted into the database, amongst others (Ogundipe *et al*., 2022).

13.4 KAFACI Project on Capacity Building and Empowerment of farmers in SW Nigeria for improved chicken egg production management techniques

With research grant received, as Principal Investigator from the Korea-Africa Food & Agriculture Cooperation Initiative (KAFACI), South Korea and support of the Institute of Agricultural Research and Training, my team, comprising some staff of the Institute, the six SW State Agricultural Development Projects (ADPs) and some Local Government Agric Officers, executed a multidisciplinary and multistakeholder participatory project targeted at the development and application of improved management techniques for chicken egg production in SW Nigeria. The approach provided a well-linked innovation system that tracked the prevailing production environment of the farmers through a baseline survey, developed a training manual (Photo 31a), based on findings from the baseline survey, and deployed same to the training and empowerment of the selected farmers. Farmers selected from the six states in southwest Nigeria were trained on improved management systems to address the gaps identified during the baseline survey. They were then empowered with a stock of birds, feed and drugs (Photo 31g) as motivation for the adoption of the technologies and practices disseminated through the training. The participatory approach also provided for periodic technical advisory services, as well as monitoring and evaluation through a multistakeholder team of researchers, extension workers, farmers (Photos 31c, d, f & h), and in some instances, the funding agency.

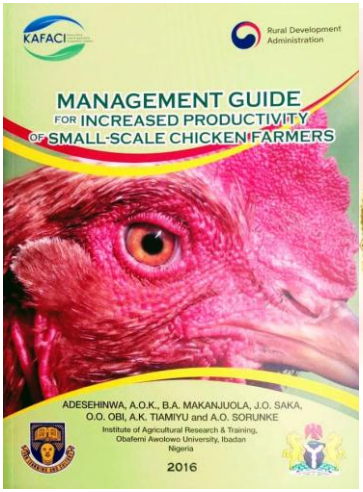

Photo 31a&b: Poultry Training Manual and Most Outstanding Principal Investigator Award for KAFACI Project


Photo 31c&d: Training/Field Visit with KAFACI Monitoring and Evaluation Team to Lagos and Ekiti

The intervention was designed to address the identified challenges of the high cost of feed, shortage of capital, periodic glut arising from poor access to markets, and high mortality rate arising from the incidence of diseases (Adesehinwa *et al*., 2016a; Saka *et al*., 2017). The effectiveness of the intervention in providing incentive for growth was empirically evident in the reduction of the mortality rate from the baseline figure of 37.8% in 2016 (Saka *et al*., 2017), 42.74% in 2017 to 7.76% in 2018 (Adesehinwa *et al*., 2019e). In addition, egg production per bird increased from 37 (2017) to 212 eggs per production cycle (i.e., 427.9% increase) in

2018. Total Factor Productivity (TFP) increased from 0.01in 2017 to 0.05 in 2018, representing a 400% increase in productivity for farmers in the project. Consequently, the Rate of Return on Investment increased from −38.62% to 75.90% in 2017 and 2018, respectively (Adesehinwa *et al.*, 2019e). The consistent improvement in the farm-level performance, not only enhanced the profitability of the enterprise for greater income to the farmers, it also improved the re-investment capabilities of the farmers for a post-intervention growth in stock size. The execution of the project revealed the enormity of the challenges constituted by the high mortality rate and high cost of feed on the quest for sustainable growth through improved farm-level productivity, among smallholder chicken egg producers.


Photo 31e&f: Ibadan project site poultry house before and during M&E Visit with KAFACI Team


Photo 31g&h: Input supply to Ibadan project site and Succes story visit to Ikole project site

The project showed the impact of incentives in promoting good agricultural practices for enhanced adoption. The response of the farmers (chicken egg producers) in Southwest Nigeria to the recommended intervention, promoting change in production practices, which resulted in productivity increase, was attributable to the reduction in mortality rate and increase in egg production throughout the three years of the intervention. Consequently, the project enhanced the managerial capabilities of the farmers and enlisted their interest in additional investment, as indicated by tremendous growth in average stock size per farm after the project. It, therefore, demonstrated enhancement of managerial capabilities through constant training, monitoring of biosecurity compliance among farms, and facilitation of improved access to quality feed, veterinary and technical support services as incentives for sustainable growth (Adesehinwa *et al*., 2016a&c; Saka *et al*., 2017 and Adesehinwa *et al*., 2019e). The successful implementation of the project resulted in the emergence of Prof A. O. K. Adesehinwa as the recipient of the award of the Most Outstanding Principal Investigator, at the close of the project in 2019 (Photo 31b).

13.5 Participation in Exploratory studies on Urban Agriculture in Ibadan Metropolis

Urban Agriculture (UA) is reported to contribute significantly to the socio-economic and nutritional well-being of urban dwellers, especially the poor and unemployed in several countries in Africa and other developing and developed economies of the world. In Nigeria, generally, and Ibadan city, in particular, UA was in existence, but there was no documentary evidence to show that the government's attention had been drawn to consciously and sufficiently incorporate UA into its development plans and policies. A study, sponsored by the International Water Management Institute (IWMI), was embarked upon with the aim of ascertaining the existence, extent, and relevance of Urban and Peri-urban Agriculture (UPA) to the socioeconomic development in Ibadan metropolitan area. Akinyele, Ibadan North, and Ibadan North-West Local Government Areas (as shown on the map in

Photo 33b) were purposively selected for the study due to the prominence of UA in them.


Photos 32a&b: Use of unsafe water source for pig production and Provision of safe well water source

Farms within Ibadan were classified into three major categories, namely livestock, crops, and non-traditional farming. The livestock farming activities comprised mainly poultry, pigs, sheep/goats, and aquaculture. For crop production, vegetables, fruits, and arable crops were the most prominent. A small proportion of the farmers were involved in non-traditional farming activities, such as spices and snail production. On the whole, most of the farmers were involved in vegetable production, and they had low social status. The majority of the farms are located in the backyards and vacant lands for livestock (Photo 32a) and crops (as shown on the cover page in (Photo 33a), respectively. The most important reason for people's involvement in UA was for adequate food supply to the family, while the most limiting constraint was the lack of funds.

The study concluded that Urban Agriculture was a reality in Ibadan city, as the farmers were involved in livestock, crop, and non-traditional farming practices. The majority of the UA practitioners were either medium or low-income earners. The source of water use was diverse, but well/boreholes and streams were predominant sources. Personal savings were the major source of finance for farming activities in the project area (Ibadan Metropolis).

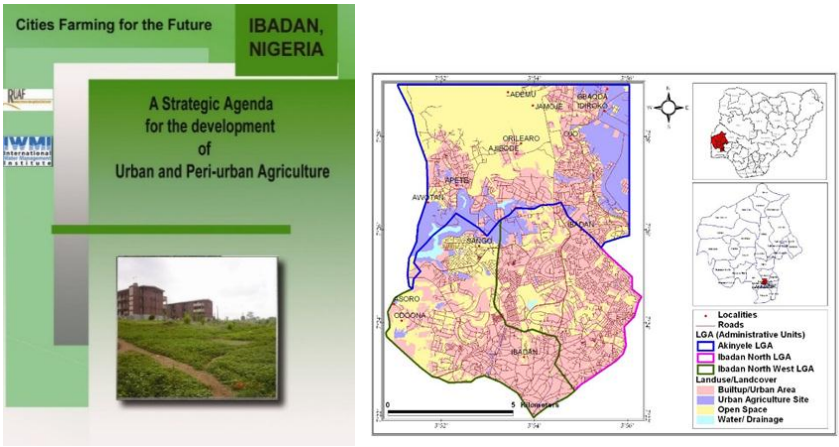

Photo 33a&b: Ibadan Urban Agriculture Strategic Agenda booklet & Study Area map

At the time of the study, there were no laws or policies hindering or encouraging UA in Ibadan. Given the enormous nutritional and socioeconomic potentials embedded in farming, in and around the city of Ibadan, the government was encouraged to consciously incorporate UA into the development efforts in the Ibadan metropolis (Olajide-Taiwo *et al*., 2007). The City Strategic Agenda on UPA in Ibadan has since been formally adopted and implemented through the Institutional work plans resulting in:

- Waste recycling due to large waste generation in the city.
- City beautification of the environment and pollution mitigation (in line with the state government's 'greening of the environment initiative)
- Employment generation, especially for youth (production, processing & marketing).

13.6 Commencement of IAR&T Annual Lecture

As Chairman of the Seminar and Ceremonials Committee of the Institute of Agricultural Research and Training, we saw the need to begin an Institute's Annual Lecture series, just as we have Faculty Lectures at the Home Campus. This initiative received the approval and support of the Vice Chancellor and Chairman of the Governing Board of the Institute, Prof. Eyitope Ogunbodede, through the Director of the Institute, who funded the programme.

The first edition of the lecture series titled "Research for Development in Agriculture Sector: The role of Research Institutes in Innovative Value Chain Transformation" was delivered by Prof. S.E Bogoro, the immediate past Executive Secretary, Tertiary Education Trust Fund, on the 2nd of August, 2021(Photo 34b).

Prof. Bogoro, in the introduction to his lecture, noted the importance of the agricultural sector in nations' civilization, being the oldest profession with huge potential for employment generation on a sustainable basis. He posited the sustainability of the agricultural sector to be based on a commodity value chain approach, from primary production through processing, packaging, transportation, distribution, and marketing. He revealed that the greatest problem facing food security in Nigeria was postharvest losses due to neglect of food processing, value addition, and the postharvest supply chain aspect of food storage, distribution, and marketing (Bogoro, 2021). He recommended an urgent transformation of the Agricultural value chains of Nigeria's economy that will necessitate the deployment of appropriate precision solutions that will encourage purposeful and focused R&D at the commodity level.

Furthermore, he advocated that the existence of only two livestock-based RIs, namely NAPRI and NVRI, to cater for the entirety of animal agriculture or the livestock production subsector was outdated and could not achieve the desired goal of self-sufficiency in animal protein production in Nigeria. It was therefore instructive, that he called for the unbundling of NAPRI into specie/commodity-specific RIs, to cater to the peculiarities of each species and their respective value chains for Nigeria to be globally competitive in livestock development. Its unavailability could be said to be responsible for why there has not been any significant advancement in the livestock R&D in Nigeria and why the Livestock sub-committee of the National Variety Release Committee has only been able to register two breeds/strains of chicken, as against the registration of several varieties by the Crop sub-committee to date.

The Guest Lecturer was later decorated with an "Award of Excellence of the Institute", which was jointly presented after the lecture by the Director of the Institute, Prof. Veronica Obatolu, Prof. Olufemi Bamiro (Former Vice Chancellor of the University of Ibadan), Prof. Isaac F. Adewole (Former Vice Chancellor of the University of Ibadan and Minister of Health), and Prof. Eyitope Ogunbodede, the immediate past Vice Chancellor of OAU and Chairman, IAR&T Governing Board, as shown in the photograph below (Photo 34a).

Photos 34a&b: 1st Institute lecturer, Prof S.E. Bogoro delivering his speech and later receiving an award from the OAU Ile-Ife VC & IAR&T Governing Council Chairman, Prof Eyitope Ogunbodede, flanked by Prof I.F. Adewole – Former VC, UI & Hon Minister of Health, Prof V.A. Obatolu – Director, IAR&T and Prof O.Bamiro – Former VC, UI.

14. CONCLUSION

Vice Chancellor Sir, In the story of the fox and the piglet, the fox chases the piglet, and the piglet seeks refuge in a hollow log. The fox, unable to reach the piglet, attempts to deceive the piglet into coming out of the log by praising its intelligence and beauty, ultimately revealing its true intentions of killing and eating the piglet. The piglet, realising the fox's true intentions, refuses to leave the log and remains safe.

This story can be seen as a metaphor for Nigeria's paradox of untapped resources. Nigeria has abundant natural resources that are valuable and should be a source of prosperity and development for the country. However, these resources are often wasted, overlooked, or exploited for the benefit of a few, while the

majority of Nigerians do not reap the benefits. In the same way that the piglet sought refuge in the hollow log to protect itself from the fox, Nigeria must protect and properly manage its resources to ensure they benefit the country as a whole.

Furthermore, the fox's attempt to deceive the piglet by praising its intelligence and beauty can be likened to the false promises and corruption that often surround the exploitation of Nigeria's resources. Just as the piglet saw through the fox's deception and refused to leave the log, Nigeria must be vigilant and wise to avoid falling victim to those who seek to exploit its resources for personal gain. However, this lecture, "The Fox and the Piglet: a paradox of untapped resource in Nigeria" is specifically talking about the pig in the story of the fox and the piglet, to emphasize the metaphorical significance of the piglet in the story, hence, the pig is being looked at as the untapped resource, that must be effectively managed, protected and harnessed for the benefit of all.

Vice Chancellor Sir, I have attempted to draw the attention of this august audience to the fact that Nigeria has all it takes for self-sustenance, in terms of her need for increased production of **pigs and its products**, using available and local **feed resources** and **improved technologies** by **relevant trained professionals**. However, it is yet to take advantage of these opportunities to increase the production of the much-needed animal protein to meet the needs of the ever-increasing human population of Nigeria and its contribution to the GDP of the livestock subsector. I have therefore highlighted my modest contribution in this regard by providing information on how Nigeria can meet its demand for meat or animal protein supply, thereby improving the nutrition of its populace, as well as, increasing its people's income generating potential, by taking advantage of the highly prolific, short generation interval, and fast growing attributes of pigs and its value chain - a currently untapped resource in Nigeria.

15. **RECOMMENDATIONS**

In order for the pig industry in Nigeria to be a huge contributor towards Nigeria's GDP and the attainment of the UN SDG on Zero Hunger and Poverty Eradication as a means of job creation, sustainable source of income, provision of poverty reduction businesses, source of nutrition and food security arising from pork and its by-products, the following should be taken into consideration:

i. Encouraging and supporting smallholder farmers for improved productivity. Smallholder pig production has great potential in bridging the animal protein supply gap and also mitigate the unemployment status of the farmers and the rural economy in general. The implications of higher animal productivity at the farmers' level can be seen in enhanced income and improved living standards of the farmers and their households as well as increased animal protein sources for Nigerians.

ii. Carefully planned and executed disease control, viz-a-viz adequate feeding programmes resulting in mortality reduction will improve the overall productivity of pigs. It is envisaged that a reduction in pig mortality, especially under traditional management, will go a long way in making more animal protein available to the general populace. However, the evaluation of the traditional remedies on a research station (National Veterinary Research Institute, Vom) to ascertain the efficacy in controlling diseases and parasites should be embraced.

iii. The quality of feed given to pigs by farmers should be improved upon. Hence, the resuscitation of the use of extension workers in the education of farmers on feeding methods, using agro-industrial by-products fortified with protein and the essential minerals and vitamin sources will enhance the growth and performance of the pigs. Without prejudice to the aforementioned, improved nutrition should be seen as the bottom line of any successful programme of improved and increased pig production in Nigeria.

iv. Pig farmers need to beef up their biosecurity measures now more than ever before as more cases of African Swine Fever (ASF) are being reported in various parts of Nigeria. It is a highly contagious and fatal viral disease which has led to heavy economic losses as a result of farmers, loosing hundreds of pigs daily, and may lead to total loss of stock.

v. Provision of low-interest loans with adequate moratorium could be a source of required funding by farmers to finance the enterprise and upscale their production.

vi. There is a need for the sustenance of research efforts in the development of cost- effective feeding systems focusing on the use of alternative feed resources. However, adequate attention should also be given to the expansion and competitiveness of the production system for the major feed resources (e.g. maize and soybean) to curtail the incessant increase in prices.

vii. There should be concerted multistakeholder efforts at developing virile disease surveillance, monitoring programmes and compensation systems against virulent diseases plaguing the swine industry. This should include the active participation of the farmers' associations, NGOs, private and public institutions across the three tiers of government.

viii. The establishment of farm estates is considered laudable; however, existing and subsequent efforts in this regard should pay adequate attention to the development, implementation, and constant review of regulatory frameworks to address unfolding realities, by regulatory agencies such as Nigerian Institute of Animal Science (NIAS), Veterinary Council of Nigeria (VCN) etc.

ix. The stock of indigenous breeds of pig appears to have been largely eroded. Therefore, there is a need for initiatives to drive the conservation of the seemingly endangered indigenous breed through institutionalized interventions. Similarly, efforts should be geared towards the development of a framework for the importation,

preservation, and use of imported genetic materials for the improvement of the existing stock.

x. Appropriate policies should be put in place to favour the establishment of private pig meat processing companies/plants. Such efforts should consider instituting aggregator schemes to ensure efficient production, collection, aggregation, and transport of pigs to processing factories. This may not necessarily require direct funding support from the government, rather, the creation of an enabling environment for access to credit and infrastructures for the growth of this segment of the pig value chain.

xi. The government should, as a matter of urgency and in line with global best practices, revisit the recommendation, as contained in the Vision 20-20-20 document and pleas from several other quarters to unbundle the legal framework establishing NAPRI to bring about Specie or Commodity-based Animal Husbandry Research Institutes. In this instance, the Pig Husbandry Research Institute, to drive and transform the value chain for nutritional security and participation in global market.

Vice Chancellor Sir, while at ABU, as a staff of any of the affiliated Research Institutes (RIs), that is the National Animal Production Research Institute (NAPRI), the National Agricultural Extension and Research Liaison Services (NAERLS), or the Institute for Agricultural Research (IAR), you are a full-fledged member of the Faculty but this was not exactly the situation at IAR&T. Rather, it was a case of one's personal decision or if those in the relevant Department at the home campus desired your service. Proper integration of the Institute into the University structure to allow the right synergy between the Institute and the Faculty of Agriculture, focusing on problem solving and nation fixing, multidisciplinary research that responds to our national aspiration with forex earning potentials should be the new focus. IAR&T, Obafemi Awolowo University, Ibadan, being a multi-commodity-based Agricultural Research Institute (ARI) with

responsibilities to lead value-added, innovative, and transformative research in crops and livestock within its mandate, in collaboration with other relevant institutions across the country, should be leveraged to lead Nigeria's agricultural sector towards becoming pivotal for the new knowledge economy.

This would be modelled on Innovation Systems and Partnerships to drive a knowledge-based economy through R&D activities and evidence generation, thus improving skills for adopting appropriate technologies at the start, with the end-in-mind approach. IAR&T should be seen to be working closely with the home campus (OAU) and other Research Institutes (RIs) using multidisciplinary approaches to create value for agro-commodities while developing capacities across the value chains. To this end, joint research proposals from members of the OAU Faculty of Agriculture and Researchers at IAR&T should be a good starting point, which presently is not officially the case.

16. **ACKNOWLEDGEMENT**

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