FEED BIO-HAZARDS: LIFE DESTROYERS AND LIFE ENHANCERS

AN INAUGURAL LECTURE, 2011/2012

ANTHONY DUROJAIYE OLOGHOBO

UNIVERSITY OF IBADAN

FEED BIO-HAZARDS: LIFE DESTROYERS AND LIFE ENHANCERS

An inaugural lecture delivered at the University of Ibadan

On Thursday, 6th September, 2012

By

ANTHONY DUROJAIYE OLOGHOBO
Professor of Animal Nutrition and Feed Toxicology
Faculty of Agriculture and Forestry
University of Ibadan
Ibadan, Nigeria.

UNIVERSITY OF IBADAN

Ibadan University Press
Publishing House
University of Ibadan
Ibadan, Nigeria.

First Published 2012

ISBN: 978 – 978 – 8414 – 89 – 6

Printed by: Ibadan University Printery

The Vice-Chancellor, Deputy Vice-Chancellor (Administration), Deputy Vice-Chancellor (Academic), Provost of the College of Medicine, Dean of the Faculty of Agriculture and Forestry, Dean of the Postgraduate School, Deans of other Faculties and of the Students, Distinguished Ladies and Gentlemen.

Preamble

It is with great humility and gratitude to God that I stand before you, representing the Faculty of Agriculture and Forestry, to present the second of the two inaugural lectures on behalf of the Faculty in the 2011/2012 inaugural lecture series. I give glory, honour and thanks to the Almighty God, my Lord and Saviour, for His enduring mercies over my life right from the moment He formed me in my mother's womb till this day which He has made to glorify His Holy Name. This lecture is dedicated to God and my parents who did everything to see me through life but are of blessed memory and to the entire academic moulders and builders of my life. It is not of my strength or ability but of the Lord who has been so merciful and gracious. May His Name be praised forever.

Mr. Vice-Chancellor Sir, I would like to inform you that this is the 37th inaugural lecture from the Faculty of Agriculture and Forestry and the sixth from the Department of Animal Science since its inception in 1967. The first inaugural lecture from the Department was by Professor G.M. Babatunde in 1975, entitled "The tottering Nigeria Livestock Sector" and the last one was by Professor Grace O. Longe in 2006 titled "Poultry: Treasure in the Chest". Between 2006 and 2011, a period of five years, no lecturer came from the Department though many professors have retired without opportunity to deliver inaugural lectures. I thank God that six years later, the mandate has fallen on me to deliver an inaugural lecture on the 6th day of September, 2012, on behalf of the Faculty of Agriculture and Forestry. Six is the number of man because God created man on the sixth day and it is also the number of unexpected blessings. To God be the glory, honour, praises and adoration in Jesus Name (Amen).

Why Animal Science?

Mr. Vice-Chancellor Sir, sometime ago, a friend of mine called from the United States of America and in the course of our conversation, he said, "Prof, you know you are blessed. God loves you". And I replied, "Sure, I am blessed. Why not? After all I am an animal scientist". And he asked, "What do you mean by that?" "God has special liking for animal scientists", I replied. He got confused but I am proud to declare that I was divinely inspired to study Animal Science. Proof? The very first sacrifice that God accepted from man was the one offered by an animal scientist. "And the Lord looked with favour on Abel and his offering ..." (Genesis 4: 3–5). The men God called to carry out great assignments for him were all shepherds. Moses, David, Elisha and Amos were tendering their sheep and oxen when they received the call of God. The birth of our Lord Jesus Christ in a manger underscores the importance of shepherds in the scheme of human history.

Again, when our Lord, Jesus Christ was born, the first people to receive the news of the great event were a group of local animal scientists, the shepherds looking after their sheep in the night. "You have nothing to fear", the angel said, "I come to proclaim good news to you – tidings of great joy to be shared by the whole people" (Luke 2:8–10). Our profession is therefore a unique one, divinely recognized as a special means of livelihood. I cherish it and I am proud to be an educated shepherd of modern age.

Mr. Vice-Chancellor Sir, when I contemplated the theme for this lecture, I didn't have to search far before settling for the title: Feed Bio-Hazards: Life Destroyers and Life Enhancers. The findings from my research works and experience convinced me of the truth of the statement in the concrete. My numerous researches in Animal Nutrition and Feed Toxicology have been aimed at one goal—to reduce toxic residues in animal feeds and feedstuffs for improved utilization of nutrients and increased yield of milk, meat and eggs. My quest for new feed resources led to the screening of myriads of alternative energy and protein sources capable of boosting livestock productivity in Nigeria. However, these vast assortments of indigenous feed resources have been implicated in patho-physiological anomalies in animals consuming them. Animal feeds derived from ingredients of plant origin were found to contain toxic and anti-nutritional substances which adversely influenced the utilization of feed nutrients and exerted effects contrary to optimum nutrition. The uses of these substances to plants were obscure for a long time, however research now shows that they are products of secondary metabolism used by plants to protect themselves against microorganisms (bacteria, fungi, and viruses), and herbivores. This means that plants use more than thorns, hairy surfaces and tough skins to discourage predators from taking a bite, rather they wield an arsenal of chemicals (secondary metabolites) to deter enemies, fend off pathogens, and protect themselves against cold and other environmental hazards. These secondary by-products have been put to use in the control of weeds, diseases or insects with little or no application of synthetic agrochemicals and have become one of the technologies for organic and ecosystem-friendly agriculture. Thus, animal feeds of plant origin whether processed, semi processed or raw, when consumed, furnish nutrients to meet the dietary requirements of animals for growth and development (**life enhancing**), and also produce anti-nutritional or toxic factors, which reduce animal performance and cause metabolic disorders leading to death (**life destroying**). Therefore, animal feeds which contain thousands of compounds, can have beneficial or deleterious effects in animals consuming them depending upon the circumstances.

The Nigerian Livestock Industry

The Nigerian livestock industry plays an important role in national food security, providing animal protein for a growing population of 160 million people, employment for over 70 percent of the adult labour force and raw materials for agro-industrial development. The total livestock population in Nigeria has been estimated to be four hundred and thirty million, nine hundred and one thousand and one hundred (430,901,100) with cattle accounting for 17 million, goats 41 million, sheep 23 million, pigs 3 million and chicken 85 million. Products derived from these animals constitute a significant portion of the Nigerian animal protein diet. They cover the spectrum from herbivores, the plant eaters (ruminants, horses and small animals such as rabbits and guinea pigs); omnivores, which eat all types of foods (pigs and poultry); to carnivores, which eat chiefly meat for example, dogs and cats (McDonald 2002). The specific feedstuffs these animals are able to utilize are dependent on the type of digestive system they possess. In simple terms, the digestive system is a portal for nutrients to gain access to the circulatory system. There are three basic types of digestive systems: monogastric (simple stomach), ruminant (multi-compartment stomach) and hind gut fermentor (simple stomach but very large and complex large intestine) (Coffey 2008) (figure 1).

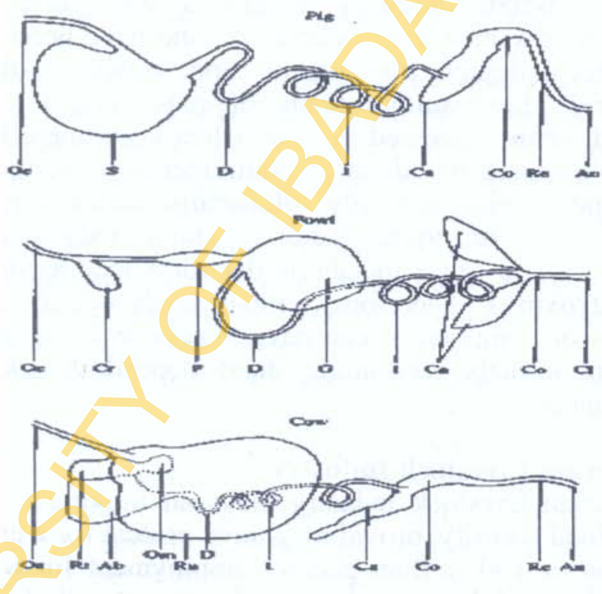


Fig. 1: Diagrammatic representation of the digestive tracts in the pig, fowl and cow.

An = Anus; Ab = Abomasum; Ca = Caecum; Cl = Cloaca; Co = Colon; Cr = Crop; D =Duodenum; G =Gizzard; I = Ileum; Oe = Oesophagus; Om = Omasum; P = Proventriculus; Re = Rectum; Rt = Reticulum; Ru = Rumen; S = Stomach

Source: McDonald *et al.* 1995.

Feed Bio-hazards affecting Animal Production

Feed is the material which, after ingestion by animals, is capable of being digested, absorbed and utilized. In a more general sense, it is edible material, components capable of being utilized by animals for nutrients to meet their basic needs (McDonald 2002). These nutrients could be categorized as either macronutrients (needed in relatively large amounts; carbohydrates, proteins, fats, fibre and water) or micro-nutrients (needed in smaller quantities; minerals and vitamins). The main components of feeds are illustrated in the figure 2.

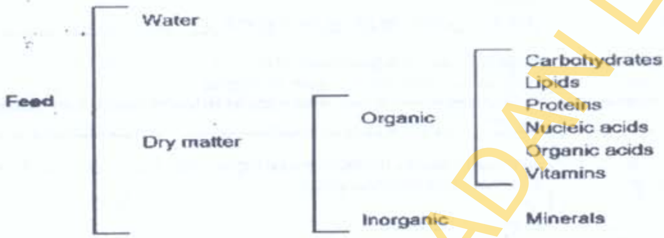


Fig. 2: The main components of feeds.

With the high rates of food production required to meet the needs of the ever increasing population, changes have had to be made to existing animal production systems. In recent years, industrial livestock production has grown at twice the rate of traditional mixed farming systems and at more than six times the rate of production based on grazing. Animals are raised in confinement and fed defined feeds formulated to increase growth rates and feed conversion efficiencies. Intensive poultry production especially, has increased considerably with poultry population in some commercial farms exceeding one million birds in a single facility (Obasanjo Farm Reports 2008). This has led to the increasing reliance on a wide range of manufactured products as feed for animals destined for human consumption. These animal feeds contain mixtures of plant-based products as well as other ingredients ranging from rendered animals and animal waste to antibiotics and organoarsenicals (table 1).

Table 1: Animal Feed Ingredients used in the Production of Animal Feeds

Origin, Raw Material	Examples
Plant	
Forage	Alfalfa meal and hay, Bemuda coastal grass hay, corn plant, and soybean hay
Grains	Barley, corn (organic and genetically modified), oats, rice, sorghum, and wheat
Plant protein products	Canola meal, cottonseed cakes and meals, peanut meal, safflower meal and soybean (organic and genetically modified) feed and meal
Processed grain by-products	
Molasses	
Miscellaneous	
Animal	
Rendered animal protein from the slaughter of food production animals and other animals	Meat meal, meat meal tankage, meat and bone meal, poultry meal, animal by-product meal, dried animal blood, bloodmeal, feather meal, egg-shell meal, hydrolyzed whole poultry, hydrolyzed hair, bone marrow, and animal digest from dead, dying, diseased, or disabled animals including deer and elk .
Animal wastes	Dried ruminant waste, dried swine waste, dried poultry little, and undried processed animal waste products.
Marine by-products	Fish meal, fish residue meal, crab meal, shrimp meal, fish oil, fish liver and glandular meal, and fish by-products
Dairy products	Dried cow milk, casein, wye products, and dried cheese.
Mixed	
Fats and oils	Animal fat, vegetable fat or oil and hydrolyzed fats
Restaurant food waste	Edible food waste from restaurants, bakeries, and cafeterias
Contaminated/adulterated food	Food adulterated with rodent, roach, or bird excreta that has been heat treated to destroy pathogenic organisms
Others	
Antibiotics	Tetracyclines, macrolides, fluoroquinolones, and streptogramins
By-products of drug manufacture	Spent mycelium and fermentation products
Arsenicals	Roxarsone and arsanilic acid
Other metal compounds	Copper compounds and metal amino acid complexes
Non-protein nitrogen	Urea, ammonium charcoal, calcium carbonate, chalk rock, iron salts, magnesium salts, and oyster shell flour
Minerals	
Vitamins	Vitamins A, D, B_{12}, E, niacin, and betaine
Direct-fed organisms	*Aspergillus niger, Bacillus subtillis, Bifidobacterium animalis, Enterococcus faecium*, and yeast
Flavours	Aloe vera gel concentrate, ginger, capsicum, and fennel
Enzymes	Phytase, cellulase, lactase, lipase, pepsin, and catalase
Additives generally regarded as safe (GRAS)	Acetic acid, sulfuric acid, aluminum salts, dextrans, glycerin, beeswax, sorbitol, and riboflavin
Preservatives	Butylated hydroxyanisole (BHA) and sodium bisulfite
Nutraceuticals	Herbal and botanical products
Plastics	Polyethylene roughage replacement

* Data adapted from AAFCO (2004)

Although, these ingredients are generally regarded as safe, many contain noxious compounds of biological, chemical and etiological origin which may render them unsafe for both humans and animals. These could be in the form of natural secondary metabolites found in crops used as feed ingredients, products of plant-associated microorganisms and bioactive proteins or chemicals used in storage or contaminants either directly admixed into feedstuffs or applied as feed additives which may not guarantee a level of safety. Residues of many chemicals such as fungicides, insecticides, rodenticides and herbicides or their metabolites remain in the plant crops or animal foods that may be hazardous to the consumers. The insecticides find their way into the food chain during storage of foods and feedstuffs and levels of infestation may vary from acute to chronic. Humans and animals are occasionally exposed to lethal and sub-lethal doses of pesticides and in case of regular applications lead to bioaccumulation, resulting in consumer toxicity (Milz *et al.* 2002).

In considering natural toxicants, Coon (2010) distinguished the toxicity of a substance as its intrinsic capacity to cause injury to tissues when tested by itself, and the hazard associated with ingestion of the feed containing it. The hazard of a substance is its capacity to cause injury under the circumstances of exposure. It refers to a biological, chemical, or physical agent in a feed which has the potential to cause adverse effects in farm animals. The agent may be introduced with resource materials or via carryover or contamination of products during handling, storage or transportation. Products of [bio-] transformation of the hazard present in edible products which affect human health could also be regarded as hazardous. Organic chemicals comprise the largest group and include plant toxins, mycotoxins, antibiotics, prion proteins and pesticides. Inorganic compounds include heavy metals and radionuclides.

Wide differences in susceptibility to these toxins exist between species of livestock, but the major differences occur between ruminants (figure 4) and non-ruminants, as ruminal microorganisms may enhance, destroy or markedly modify the pharmacological properties of various toxins or even convert non-toxic substances in the diets to toxins (Hegarty 1986). The following list of health hazards associated with animal feed and feed ingredients and factors affecting their occurrence (tables 2 and 3), is intended to describe the major categories of hazards, which may be present in feeds. The list is not exhaustive.

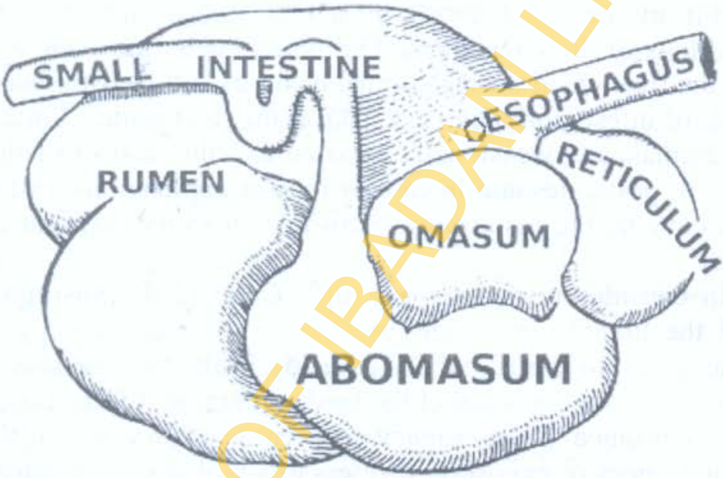


Fig. 4: Schematic diagram showing the compartments of the stomach of a ruminant.

Table 2: Factors affecting Occurrence of Hazards in Feeds and Feed Ingredients

Feed or Feed Ingredient	Risk Factor	Hazard
Plant origin		
Forages (pasture, hay, silage)	Botanical contamination, environment, field conditions, plant species	Bacteria, endo-parasites, mycotoxins, plant toxins, heavy metals, dioxin, organic chemicals, radionuclides
Plant feed or feed ingredient	Crop and harvest (environment, field conditions, plant species)	Residues, environment chemicals, heavy metal, plant toxins, mycotoxins, radionuclides, (pathogenic bacteria)
	Manufacturing (carry-over, cross-contamination), by-products from industrial food-production, processed feed ingredients, mixed feed	Residues of veterinary drugs, residues of feed additives and processing aids
	Treatment to eliminate toxins or for conservation (heat/acid/pressure etc.)	Plant toxins or bacteria
	Condition of storage, transport (moisture, temperature), manufacturing (cross-contamination)	Pathogenic bacteria, mycotoxins, toxic elements
Fat/oil	Origin, purity, blending	Dioxins, organochlorine pesticides
Algae	Environment, species	Plant toxins, heavy metals, dioxin, residues, (radionuclides)
Terrestrial animal origin		
Land animal and milk products	Livestock conditions (animal, environment)	Bacteria, viruses, endoparasites, prions
	Inadequate treatment (heat/acid/pressure etc.)	Bacteria, viruses, endoparasites or prions
	Condition of storage, transport (moisture, temperature), manufacturing (cross-contamination)	Bacteria, toxic elements
Aquatic animal origin		
Fish, other marine animals	Aquatic environment	Heavy metal, organic chemicals, bacteria, viruses, radionuclides
	Inadequate treatment (heat/acid/pressure etc.)	Bacteria
	Condition of storage, transport (moisture, temperature), manufacturing (cross-contamination)	Bacteria, toxic elements
Mineral origin		
Minerals, including additives (trace elements and binders)	Origin, purity, authorization (trace elements)	Heavy metal, dioxins
Fermentation by-products		
Protein concentrate from bacteria and yeasts	Processing, storage, transport	Bacteria, antibiotics

Source: Codex Alimentarius Commission; Proposed draft of prioritized list of hazards in feed CX/AF12/6/5Add.2

Table 3: Factors affecting Occurrence of Hazards in Edible Products

Hazard	Feed Sources and Risk Factors	Edible Products
Biological		
Bacteria (e.g. *Salmonella, Brucella, Listeria monocytogenes*)	Contaminated pasture, forages and feed (especially *Salmonella*), animal and vegetable protein meals. Sick animals close to feed production or storage. Diseased animal cadavers in storage. Poor hygiene during feed production, slaughter and processing of edible tissues	Eggs, meat and meat products (*Salmonella*), milk and milk products (*Brucella, Listeria monocytogenes*)
Endoparasites (e.g. *Toxoplasma gondii, Cysticercus, Trichinella*)	Contaminated pasture, forages, compound feed. Inadequate environmental monitoring or not treated in feed or animal.	Various tissues containing infective cysts
Prions	Contaminated animal [ruminant] protein (containing misfolded prion protein). Cross-contamination of feeds for ruminants with ruminant protein.	Nervous system tissue
Viruses: hepatitis E, rotavirus	Feed contaminated by body fluids of infected animals. Sick animals close to feed production or storage. Poor hygiene during feed production (slaughter and processing of edible tissues)	Various tissues contaminated during preparation by virus-containing body fluids
Chemicals		
Radionuclides: ^{90}Sr, ^{131}I, ^{134}Cs, ^{137}Cs	Contaminated feed and forages. Inadequate environmental monitoring	Milk (radioiodines, radiocesium), bone (radiostrontium), meat (radiocesium)
"Heavy metals"	Poor quality minerals, inadequate environmental monitoring	
Arsenic (inorganic)	Sea plants, fish products and minerals	Fish
Cadmium	Minerals (such as phosphate, zinc sources). Forage/grains (depending on geographical area). Soil contamination by manure, sewage, sludge or phosphate fertilizers	Higher concentrations in shellfish, oysters, salmon, also kidney and liver. Lower concentrations in dairy products, meat, eggs, poultry
Lead	Contaminated soil, lead paints and batteries, water from plumbing systems that contain lead. Minerals (e.g. copper sulphate, zinc sulphate, zinc oxide)	Bone, brain and kidney
Mercury/methyl mercury	Anthropogenic contamination, fish meal	Liver, kidney, fish products
Mycotoxins	Produced by carbohydrate-catabolizing fungi, found in cereals (especially wheat, sorghum and maize), in oilseed meals and cakes, and silage (e.g. aflatoxins from *Aspergillus flavus*, ochratoxins from *A. ochraceus*, zearalenone, fumonisins, trichothecenes such as deoxynivalenol). High humidity during growth and harvest; non-adherence to good agricultural practices. High humidity post-harvest. Hull, tip cap and outer layers not separated before milling	Meat (deepoxy-deoxynivalenol, zearalenol, ochratoxins), liver, milk, eggs (aflatoxins)
Plant toxins	Non-adherence to good agricultural practices, inadequate visual inspection or chemical analysis	
Tremetone	Contaminated forage	Milk
Pyrrolizidine alkaloids, terpenes, glycosides	Botanical contamination in forages (e.g. *Senecio jacobaea*), endogenous toxin in plants (e.g. gossypol in cottonseed)	Milk, meat
Other alkaloids (e.g. atropine, caffeine, cocaine, ephedrine, morphine, nicotine, solanine)	Botanical contamination in forages	Milk, meat
Organic chemicals		
Dioxins (polychlorinated dibenzodioxins, dibenzofurans and dioxin-like polychlorinated biphenyls)	Soil contamination (e.g. clay minerals). From combustion sources (e.g. fossil fuel power stations, waste incineration plants, exhaust gases), from biocide-treated wood used during feed ingredient production. Contaminated mineral sources. Oil in fish meal. Non-adherence to good agricultural practices. Non-certified source of oil/fat feed components	Fat (in meat, milk, egg yolk)
Organochlorine pesticides	Non-adherence to good agricultural practices. Environmental contamination	Fat
Veterinary drug, pesticide, processing aid residues	Milk of antibiotic-treated cows, nectar of antibiotic-treated fruit trees, cross-contamination of manufactured feed with veterinary drugs, meal from medicated fish and shrimps, fodder, grain and by-products (e.g. grape pomace) from crops treated with pesticides. Non-adherence to good agricultural practices. Non-adherence to recommended dose and drug withdrawal periods. Non-adherence to good manufacturing practices	Meat, milk, eggs, honey

Source: Codex Alimentarius Commission; Proposed draft of prioritized list of hazards in feed CX/AF12/6/5 Add.2

Biological Hazards

Bacteria

Microbial contamination of animal feed is a significant potential pathway for entry of pathogens into the human food chain, and at present, there is no comprehensive program that addresses it. The primary microbiological hazards in feeds that transfer to edible products of animals are zoonotic microorganisms which contaminate animal and plant protein meals fed to animals. They may be introduced into feed crops, forages and water from contaminated pastures, may be present in animal materials which are used for feed, and may be introduced to feed by cross-contamination or carry-over during processing, transport, and storage.

Brucella

In regions where *Brucella* is endemic, pastures may be contaminated by ruminants which deliver or abort offspring there, because the placentas of infected animals contain high levels of these microorganisms. Milk-producing animals may become infected by eating forage from contaminated pastures and excrete the microorganisms in their milk. This milk may be a risk to human health if not pasteurized prior to consumption. Spore-forming bacteria present in raw milk may survive during processing and subsequently grow in the milk, thereby producing a potential risk to human health.

Endoparasites

Some animal endoparasites, such as *Trichinella, Toxoplasma gondii,* and *Cysticercus*, are animal health hazards. Various life stages of these organisms may contaminate pasture and forages and the derived feed. Ingestion of contaminated feed by food-producing animals can result in the presence of infective cysts in edible products (e.g. meat), which may pose a risk to human health, particularly if not adequately heat-treated prior to consumption.

Viruses

Some viruses such as hepatitis E are pathogenic to both livestock and humans. Viral contamination of feed is possible via body fluids of infected animals. The most likely route of contamination of edible products of animals is probably external, by contamination with virus-containing faeces.

Prions

Prions are infectious agents composed of protein in a misfolded form which induce existing, properly-folded prion protein (a constituent of normal mammalian cells) to convert into the disease-associated prion form. Prions are responsible for the transmissible spongiform encephalopathies in a variety of mammals, including bovine spongiform encephalopathy in cattle (mad cow disease). Prions are extremely resistant to denaturation by chemical and physical agents including heat. Animals should not be given feed and feed ingredients that are recognized as likely to introduce zoonotic agents to the slaughter population.

Terrestrial Plant Toxins

Terrestrial plant toxins or anti-nutritional factors (ANFs) may be defined as those substances generated in natural feedstuffs by the normal metabolism of species and by different mechanisms, such as inactivation of some nutrients and inhibition of digestive enzymes which exert effects contrary to optimum nutrition. Anti-nutritional factors in feed can be grouped into:

1. Endogenous Substances

These are secondary metabolites present in the feedstuff by the natural metabolic activity of the plant. Being an anti-nutritional factor is not an intrinsic characteristic of a compound but depends upon the digestive process of the ingesting animal. Trypsin inhibitors, which are ANFs for monogastric animals, do not exert adverse effects in ruminants because they are degraded in the rumen (Cheeke and Shull 1985). Anti-nutritional factors which have been implicated in limiting the digestion of feeds and feedstuffs and utilization of nutrients in both ruminants and non-ruminants, include non-protein amino acids, glycosides, phytohemagglutinins, polyphenols, phytins, alkaloids, triterpenes and oxalic acid (tables 4 and 5). They also cause toxicity during periods of scarcity or confinement when feeds rich in these substances are consumed by animals in large quantities. Transfer of some of these toxins to edible products such as milk and meat has been demonstrated.

Table 4: Minerals, their Sources and Bioaccumulation in Animal Tissues

Mineral	Sources	Bioaccumulation in Animal Tissues
Arsenic (Inorganic)	Sea plants, fish products and supplemental minerals	Fish
Cadmium	Mineral supplements (such as phosphate, zinc sources) Forage/grains (depending on geographical area) Manure, sewage, sludge or phosphate fertilizers can enrich soil	Kidney and liver Shellfish, oyster, salmon and fungi, have the highest concentrations There are low concentrations in fruits, dairy products, legumes, meat, eggs and poultry
Lead	Contaminated soil, lead paints, water from plumbing systems that contain lead, batteries Mineral supplements (copper sulphate, zinc sulphate, zinc oxide) Lead is also a natural contaminant of calcium carbonate (limestone) in some regions	Bone, brain and kidney
Mercury/methyl mercury	Anthropogenic contamination, fish meal	Liver, kidney Fish, marine mammals

Source: NRC 2005. Mineral tolerance of animals. Washington DC, National Research Council

Table 5: Anti-nutritional Factors present in Plant Foodstuffs and Their Adverse Effects in Farm Animals

Anti-nutritional Factor	Common Occurrence	Nutritional or Biological Effects
Protease inhibitors	Soybean, navy beans, lima bean, kidney bean, chick pea, cow pea, lentil, peanut, beet, potato, rice, wheat, corn	Decreased protein digestibility; pancreatic hypertrophy; increased requirement for S-amino acids
Hemagglutinins	Seeds belonging to Leguminosae (i.e. Soybeans, Kidney beans, navy beans, peanuts, etc)	Interference with absorption of nutrients from intestines
Gossypol	Cottonseed	Increased requirement for protein and iron
Osteolathyrogens	*Lathyrus odoratus* (sweet peas)	Defect in collagen formation
Neurolathyrogens	*Lathyrus sativus* (chick-ling vetch), *Vicia sativa* (common vetch)	Neurotoxic effects
Cycasin	Cycads	Interference with synthesis of RNA
Goitrogens	Cabbage, turnips, rutabaga, mustard seed, rape seed, soybean	Interference with utilization of dietary Iodine
Phytic acid	Seeds of mono-and dicotyledons (i.e wheat, corn, rice, soybean, navy bean, peanut, etc.	Interference with absorption of calcium, zinc, magnesium; increased requirement for vitamin D
Oxalic acid	Rhubard, spinach, tea, cocoa	Increased requirement for calcium and vitamin D
Amylase inhibitor	Wheat, rye, barley, navy beans	Interference with digestion of carbohydrate
Ascorbic acid oxidase	Cabbage, cucumbers, pumpkin, lettuce, spinach, tomatoes, beets, potatoes, carrots, peaches	Destruction of vitamin C
Antivitamin D	Soybeans	Increased requirement for vitamin D
Antivitamin E	Kidney beans, alfalfa, peas	Increased requirement for vitamin E
Antipyridoxine	Linseed	Increased requirement for vitamin B
Anti-nutritional factor	Common occurrence	Nutritional or biological effects
Antivitamin B	Soybeans	Increased requirement for vitamin B
Choline esterase inhibitor	Potatoes, broccoli, asparagus, eggplant, turnip, radish, celery, carrot, orange, apple	Interference with transmission of nerve impulse
Metal-binding constituents	Soybeans, sesame meal, peas	Increased requirement for zinc, manganese, copper, and iron
Lipoxidase	Soybeans	Increased requirement for vitamin A
Factors causing favism	*Vicia faba* (broad beans)	Hemolytic anaemia

Table 6: Anti-nutritional Factors in the Leaves of Trees and Shrubs Documented as being Used in Livestock Feeding

Anti-nutritional Substances	Species
1. *Non-protein amino acids*	
Mimosine	*Leucaena leucocephala*
Indospecine	*Indigofera spicta*
2. Glycosides	
(A) Cyanogens	*Acacia giraffae*
	A. cunning hamii
	A. sieberiana
	Bambusa bambos
	Barteria fistulosa
(B) Saponins	*Manihot esculenta*
	Albizia stipulate
	Bassia latifolia
	Sesbania sesban
3. Phytohemagglutinins	*Bauhinia purpurea*
Ricin	*Ricinus communis*
Robin	*Robinia pseudoacacia*
4. Polyphenolic compounds	
(A) Tannins	All vascular plants
(B) Lignins	All vascular plants
5. Alkaloids	
N-methyl-B-phenethylamine	*Acacia berlandieri*
Sesbanine	
	Sesbania vesicaria
	S. drummondii
	S. punicea
6. Triterpenes	
Azadirachtin	*Azadirachta indica*
Limonin	*Azadirachta indica*
7. Oxalate	*Acacia aneura*

Cyanogenic Glycosides

Cyanogens are glycosides of a sugar or sugars, and cyanide containing aglycone. Table 6 provides a few examples of fodder trees and shrubs containing cyanogens. Cyanogens can be hydrolyzed by enzymes to release HCN which is volatile gas. However, the glycosides occur in vacuoles in plant cell, while enzymes are found in the cytosol. Damage to the plant results in the enzymes and glycosides coming together and producing HCN. The hydrolytic reaction can take place in the rumen by microbial activity. Hence, ruminants are more susceptible to CN toxicity than non-ruminants. The HCN is absorbed and rapidly detoxified in the liver by the enzyme, rhodanese, which converts CN to thiocyanate (SCN). Excess cyanide ion inhibits the cytochrome oxidase. This stops ATP formation; tissues suffer energy deprivation and death follows rapidly.

The lethal dose of HCN for cattle and sheep is 2.0–4.0mg per kg body weight. The lethal dose for cyanogens would be 10–20 times greater because the HCN comprises 5–10% of their molecular weight (Conn 1979). For poisoning, forage containing this amount of cyanogens would have to be consumed within a few minutes and simultaneous HCN production would have to be rapid. Recorded accounts of livestock poisoning by cyanogenic plants show that such situations do arise (figure 5). Amygdalin occurs in almonds (among others), dhurrin in sorghum, linamarin in cassava, lotaustralin in cassava and lima beans, prunasin in stone fruits, and taxiphyllin in bamboo shoots.

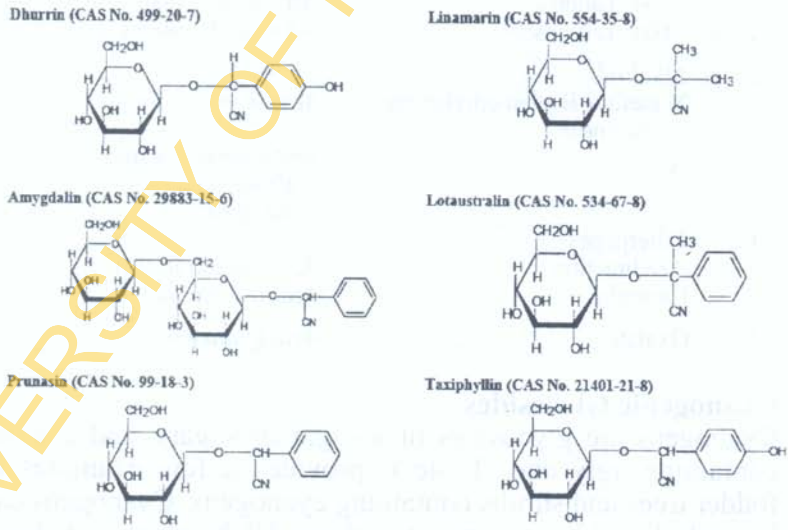


Fig. 5: Cyanogenic glycosides in major edible plants (JECFA, 1993).

Hydrolysable Tannins

Hydrolysable tannins (HTs) are esters of polyol (most often β-D-glucose) or hexahydrooxydiphenic acid (ellagitannins). In plant cells, hydrolysable tannins are located separately from the proteins and the enzymes of cytoplasm, but when tissue is damaged, for example when animals feed, tannins may react with proteins making them less accessible to the gastric juices of the animals. Hydrolysable tannins can intervene by binding to either digestive enzymes (e.g. trypsin) or the substrate (e.g. dietary proteins) or to both (Mole and Waterman 1987), rendering them unavailable to the host (figure 6).

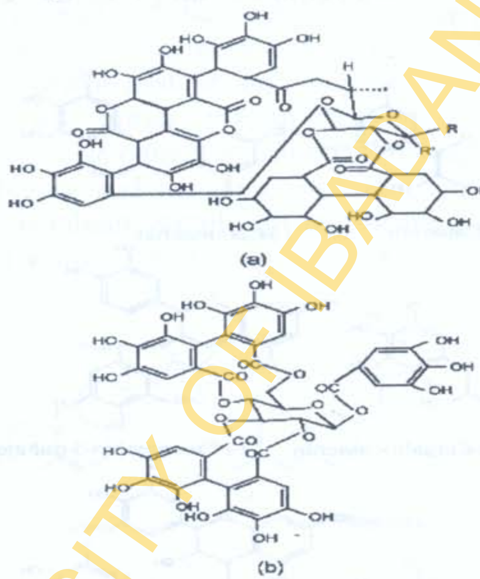


Fig. 6: Hydrolysable tannins: (a) punicalagin; (b) casuarictin, an ellagitannin.

Condensed Tannins

Condensed tannins (CTs) or proanthocyanidins are polymers of flavonol units. Condensed tannins (CTs) have adverse effects which include inhibition of nutritionally and therapeutically relevant gastro-intestinal microflora of the host through various mechanisms. CTs reduce the digestibility of proteins and carbohydrates in the rumen as the tannin-protein complex (T-PC) formed is stable over the pH range of 3.5-7.0 but dissociates at pH <3.0 and >8.0 (Mangan 1988). Tannins may possibly be beneficial to the host if they inhibit plant enzymes such as β-glucosidases and esterases that potentiate the toxic activity of plant phenolic compounds. CTs prevent bloat formation in ruminants (Jones *et al.* 1973) and protect dietary protein in the rumen, enhancing amino acid absorption and utilization by ruminants (Waghorn *et al.* 1994). It seems also plausible that CTs may prove an alternative to chemoprophylaxis in order to reduce or even exclude the use of antihelmintic drugs in the control of parasites (figure 7).

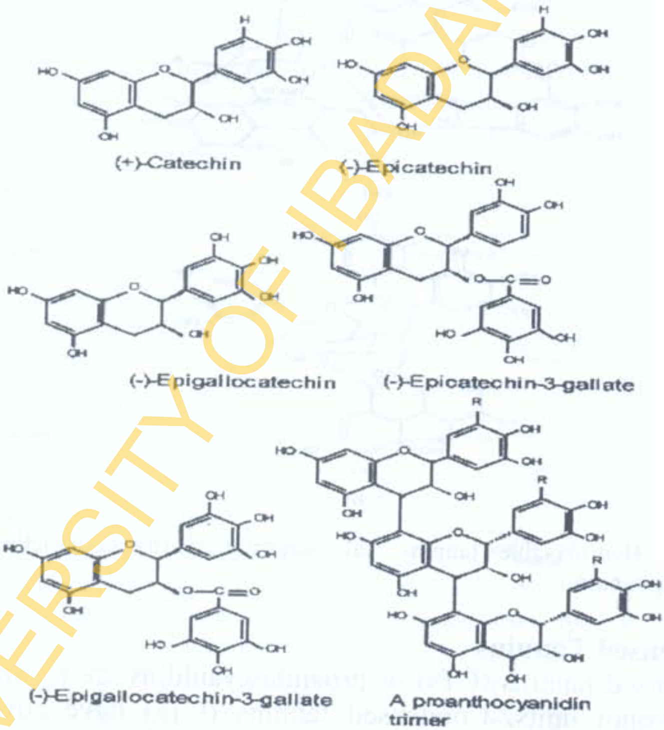


Fig. 7: Catechins and proanthocyanidins (R = H, procyanidins; R = OH, prodelphinidins).

Saponins

Saponins are glycosidic compounds of steroid (C_{27}) or triterpenoids (C_{30}) sapogenin nucleus with one or more side chains of carbohydrates. Many forage legumes grown in tropical areas contain various saponins and have varieties of biological effects with both positive and negative implications. As a consequence of their ampiphilic nature and surface active properties, saponins are excellent foaming agents, forming stable foam. Saponins inhibit productive performance of non-ruminant animals. Prolonged intake of saponin-enriched forage by animals reduced ruminal protozoal number, reduced degradation of feed protein, decreased amounts of the microbial proteins flowing to the intestine, hence reducing apparent digestibility. Saponins present on various pastures and range weeds have also been implicated in various toxicological problems. At high concentrations, saponins can cause cell damage by disrupting cell membranes and inducing apoptosis, and are known to react with membrane sterols, disrupt membrane function and, consequently arrest cell growth (figure 8).

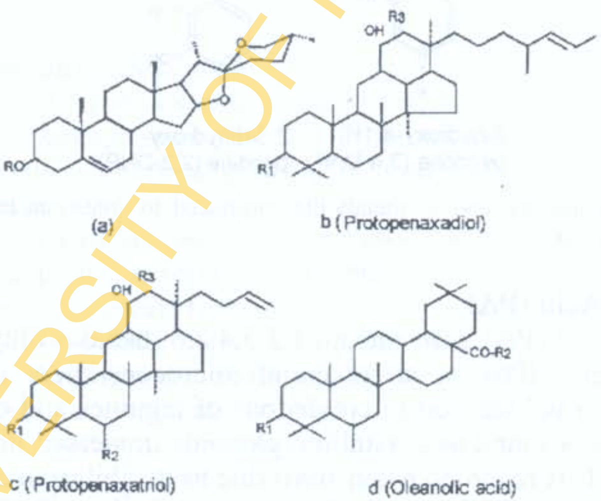


Fig. 8: (a) Typical structure of a steroidal saponin (R = sugars), sapogenin (R = H), and ginseng saponins (b-d).

Mimosine

Mimosine [β-[*N*-(3-hydroxy-4-oxypyridyl)]-α amino-propionic acid] is found in the plants of Mimosaceae, which include *Leucaena leucocephala, L. glauca*, and other legumes. Mimosine and 3, 4-DPH have been shown to reduce feed intake and cause alopecia, renal and liver dysfunction, general inefficiency and in extreme cases, death. In addition, mimosine has been reported to influence various serum enzyme activities and to possibly interfere with the metabolism of some amino acids, notably glycine (figure 9). Mimosine is a structural analogue of the amino acid tyrosine.

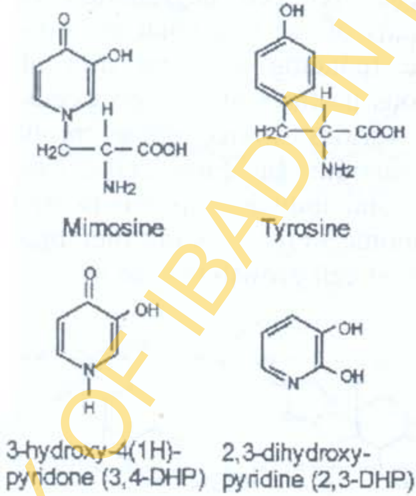


Fig. 9: Mimosine and its metabolites produced by intestinal bacteria or autolysis.

Phytic Acid (PA)

Phytic acid (PA), *myo*-inosito 1,2,3,4,5,6- hexakis dihydrogen phosphate (IP6), is an essential microconstituent of plant cells. IP6 is localized in cotyledons of legumes and oilseeds, where it is found as crystalline globoids immersed in protein bodies. It is regarded as an ANF due to its ability to complex with pectin and divalent cations such as Ca^{2+}, Fe^{2+}; Zn^{2+}, and Mg^{2+} to generate insoluble complexes in the digestive tract and hinder mineral metabolism in man and other monogastric animals. Its interaction with protein qualifies it to be called an enzyme inhibitor, especially α-amylase inhibitor, which limits starch digestion and lowers blood glucose (figure 10).

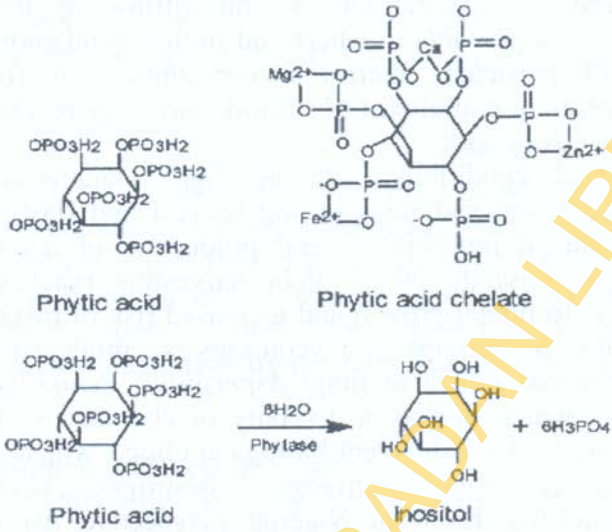


Fig. 10: Phytic acid, phytic acid chelate and enzymatic hydrolysis of phytic acid.

2. Exogenous Substances

These result from external contaminations of feeds through improper storage and less than optimal conditions during transportation, marketing and processing. Examples include **mycotoxins**.

Mycotoxins are secondary metabolites produced by fungi which catabolize carbohydrates, and are therefore found most commonly in cereals (especially wheat, sorghum and maize), but also in oilseed meals and cakes, and silage. They are considered to be some of the most toxic chemicals occurring as natural contaminants of animal feed and human food. Human exposure to mycotoxins may arise, therefore, either directly from plant products or indirectly through meat and milk from animals given feed containing high levels of mycotoxins. Some of the most important mycotoxins are the aflatoxins B, G, G1, (and the derivative aflatoxin M in milk), ochratoxin A, and citrinin. A recent survey of animal feed ingredients identified aflatoxin B, as the most common contaminant in rice bran, maize products, palm kernels and cottonseed, and ochratoxin A and citrinin as the most common contaminants in wheat and millet (Scudamore *et al.* 1997). Of particular interest as contaminants in foods of animal origin are aflatoxin M in milk and dairy products and ochratoxin A in pork.

Tropical conditions such as high temperatures and moisture, unseasonal rains during harvest and flash floods, lead to fungal proliferation and production of mycotoxins (Bhat and Vasanthi 2003). Poor harvesting practices also contribute to fungal growth and increased risk of mycotoxins production. Six groups of mycotoxins are produced by the three principal genera of fungi *Aspergillus*, *Penicillium* and *Fusarium* which display a diversity of chemical structures, accounting for their different biological effects which may be carcinogenic, mutagenic, tetraogenic, oestrogenic, neurotoxic or immunotoxic. From the Nigerian perspective, two classes of mycotoxins—aflatoxins and fumonisins, have been estimated to be widespread in major staple foods. The exposure to mycotoxins is greater in Nigeria where cereal grains and legumes form the staple diets and the intake of animal products, including meat, is low.

Chemical Hazards

Chemical hazards to animals result from external contamination of feeds from chemical residues and excess feed additives. These include radionuclides and elements commonly referred to as "heavy metals", such as arsenic, cadmium, lead and mercury. Arsenic is found in minerals and (mainly in the less toxic organic form) in marine plants, fish and shellfish. Cadmium is a contaminant in many feeds and feed ingredients, in particular in minerals such as phosphate and zinc sources, and in forages and grains grown near smelting and mining areas, or where the soil has been treated with contaminated manure, sewage, sludge or phosphate fertilizers. Lead may occur in grain or forage grown on contaminated soil, water from lead-containing plumbing systems, and also as a contaminant in minerals. Levels of methyl mercury in terrestrial animals and plants used for feed are usually very low, but the use of fish meal as animal feed can result in relevant mercury levels in edible products (table 5).

Organic Chemicals

Dioxins in feed may arise by contamination, for example from dioxin-containing preservatives in wood, or from combustion sources (e.g. waste incineration plants, fossil fuel power stations, bush fires, exhaust gases). Dioxins may be present as contaminants in mineral sources, such as clays, recuperated copper sulphate, zinc oxide, and in food by-products, including fish by-products such as fish meal and fish oils.

Life enhancing Effects of Feeds

Mr. Vice-Chancellor Sir, I mentioned at the beginning of this lecture that animal feeds of plant origin, whether processed, semi-processed or raw, contain toxic, potentially toxic and anti-nutritional constituents which produce deleterious effects in animals. The same constituents have also been shown to enhance animal performance and wellbeing. Public outcry against the potential health risks and environmental problems associated with excessive use of feed antimicrobials, growth hormones and synthetic pharmaceuticals, has led to agitation for safe natural alternatives to antimicrobial growth promoters. Dietary inclusion of extracts of tannins in botanicals has the potential to increase the antioxidant capacity of chicken meat (Lopez-Bote *et al*. 2008; Tang *et al*. 2000). The phenolic OH groups present in tannins act as hydrogen donors to the free radicals (peroxy) produced during the first step of lipid oxidation, thus retarding the hydroxy peroxide formation that characterizes spoilage of foods (Farag *et al*. 2009). There is also great interest in saponins as phytonutrients because of their pharmaceutical action. Using a variety of approaches, saponins have been shown to have anti-cancer, anti-inflammatory, anti-virus, anti-ulcer and various other activities. They are found in greatest concentrations in legumes especially soyabeans which are the richest source of plant protein in animal feed formulations. Most of the soyabeans available in Nigeria contain both isoflavones and saponins and it is quite likely that some of the biological actions attributed to isoflavones are actually due to saponins. These benefits have led to the widespread consumption of phytonutrients in the form of diet supplements (e.g., vitamins, minerals, feed additives and other phytochemicals) and the emphasis on increased intake of fruits, vegetables and grains in human diets. Thus, animal feeds which contain thousands of compounds, have both life enhancing and life destroying effects in animal production thereby behaving as two sides of the same coin. Some beneficial botanicals indigenous to Nigeria which are gaining importance for their therapeutic and biotechnological applications are listed in table 7.

Table 7: Botanicals Indigenous to Nigeria

Common Name	Local Name	Botanical Name	Plant Parts Used
Calabash nutmeg	*Ariwo* (Yoruba) *Ehuru, Ehiri*	*Monodora myristica*	seed
Black pepper/Ashanti pepper	*Uziza* (Igbo) *Iyere* (Yoruba)	*Piper guineense*	Seed, leaves
Cloves	*Kaanafuru* (Yoruba)	*Syzygium aromaticus*	Seeds
Aromatic ginger/Red ginger	*Ata ile* (Yoruba)	*Kaempferia galanga*	Rhizpome
Garlic	*Aayu* (Yoruba) *Ayo-ishi* (Igbo)	*Allium sativum*	Bulb
Alligator pepper/cardamom	*Ataare* (Yoruba)	*Aframomum melegueta*	Seed
Winged pod	*Aidan* (Yoruba)	*Tetrapleura tetraptera*	Fruit
Lemon grass	*Koriko-oba* (Yoruba)	*Cymbopogon citratus*	Leaves
Pepper	*Ata wewe* (Yoruba)	*Capsicum annum*	Fruit

Figures listed 11 to 18 show the beneficial effects of feeds as can be seen in the animals' performance, development and health.

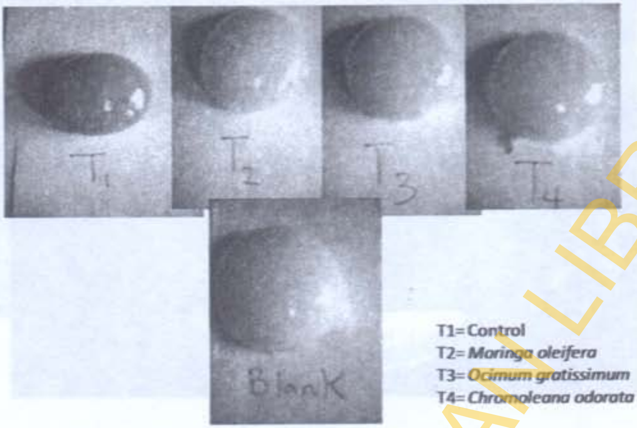


Fig. 11: Single yolk in eggs.

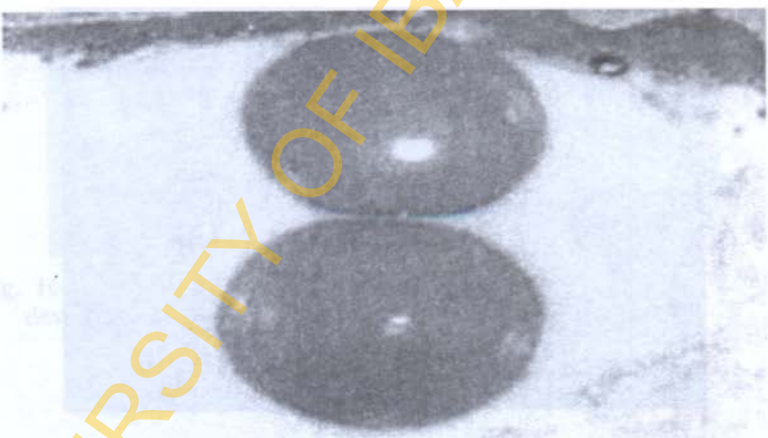


Fig. 12: Double yolk from *M. oleifera* based diet.

Fig. 13: Double yolk from *M. oleifera* based diet.

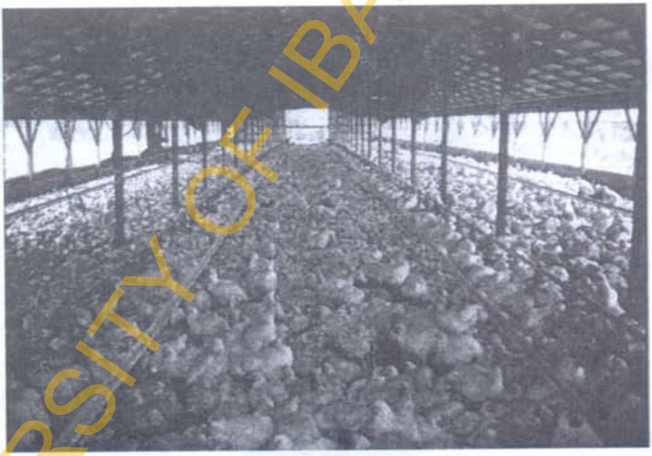


Fig. 14: Birds are healthy and productive when adequate nutrients are available to them.

Fig. 15: Turkeys are well developed.

Fig. 16: Appetite is enhanced and animals feed well when feeds are devoid of antinutritional factors.

Fig. 17: Cattle are well developed and can be sold profitably.

Fig. 18: The animals are healthy looking.

Life-destroying effects due to toxic and anti-nutritional factors in feeds result in poor animal performance, metabolic disorder and death (see figures 19 to 21).

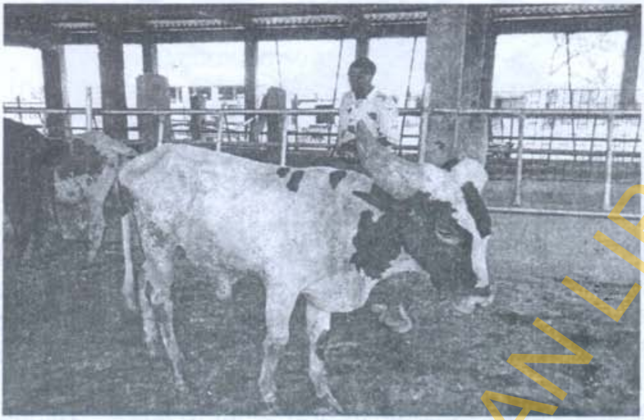


Fig. 19: A sick cattle due to the effect of antibiotics in feed.

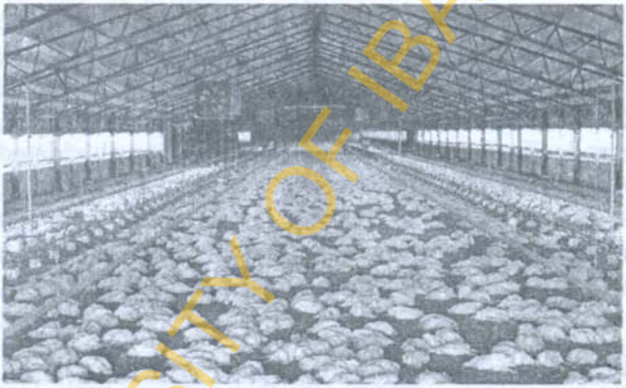


Fig. 20: Chemical residues in feeds can be lethal and result in total mortality of birds.

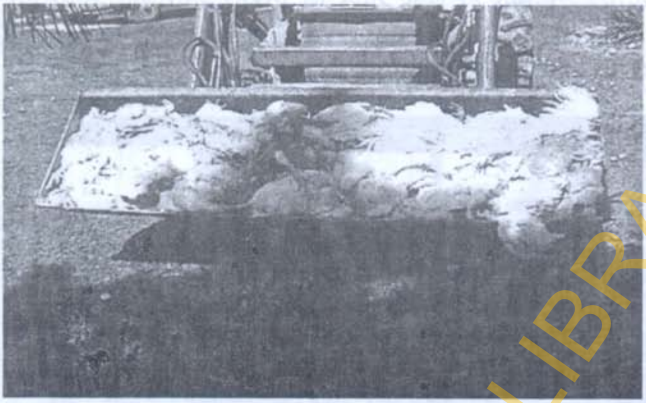


Fig. 21: This is an economic loss to the animal producer as dead birds are thrown away.

Contributions to Scholarship

Mr. Vice-Chancellor, ladies and gentlemen, my areas of specialization are Animal Nutrition and Feed Toxicology, with a focus on the effects of toxic, potentially toxic and anti-nutritional factors in feeds—on livestock productivity. There are some 195 publications arising from my research, conducted singly or in groups with students and partners, covering the fields listed above in relation to yields of meat, egg and reproduction. Each of these investigations elucidated and resolved one problem or the other within the complex systems of feed resource utilization in livestock, with the objective of providing sufficient animal protein for human consumption. My contributions centre on ten principal areas, namely:

1. Chemical characterization of tropical feedstuffs,
2. Effects of toxic, potentially toxic and anti-nutritional factors in feeds and feedstuffs in animals,
3. Improving the nutritional value of feedstuffs through processing treatments,
4. Residual toxic factors in feeds,
5. Solid State Fermentation (SSF) technique for processing plant residues,

6. Feed quality and stress,
7. Reducing nutrient loss in feaces of farm animals using microbial phytase in feeds,
8. Use of prebiotics as alternatives to antibiotics in feeds,
9. Feed resource utilization: formulating least-cost diets from indigenous resources, and
10. Non target effects of pesticides on farm animals.

(1) Chemical Characterization of Tropical Feedstuffs

My first hands-on involvement with animal nutrition and feed toxicology started with the characterization of tropical feed-stuffs with promise as livestock feeds. Extensive breeding studies in Nigeria have resulted in the availability of improved varieties of seeds which are resistant to insect pests and microbial infection, and combine desirable characteristics such as early maturity, high harvest index and good yield potentials. Some of these improved seeds were being used as feedstuffs in formulating animal feeds without information about their chemical composition and nutritional value and there was no screening of genetic stock for protein content and quality. They had to be tested chemically, then biologically for their overall nutritional characteristics for which they were selected. My research works characterized several varieties and accessions of soyabean (*Glycine max*) (Ologhobo and Fetuga 1982, 1983, 1984); Cowpea (*Vigna unguiculata*) (Ologhobo and Fetuga 1983b; Oke Tewe and Ologhobo 1999); kidney bean *(Phaseolus vulgaris)* (Ologhobo and Fetuga 1983c, 1984; Emiola *et al.* 2006); pigeon pea (*Cajanus cajan*) (Ologhobo and Fetuga 1983a, 1984, 1984b); bambara groundnut (*Vigna subterranean*) (Ologhobo and Fetuga 1987; Ologhobo 2000; Ologhobo and Fetuga 1986, 1987); lima beans *(Phaseolus lunatus)* (Ologhobo, Fetuga and Kasali 1982; Ologhobo, Fetuga and Tewe 1984, 1987); Jack bean (*Canavalia ensiformis*) (Ologhobo *et al.* 1997, 2001, 2004) and sesame seed (*Sesmum indicum*) (Ologhobo and Mosenthin 2002, 2003, 2005); Mucuna (*Mucuna utilis)* (Emiola *et al.* 2003, 2005, 2006). These publications provide information on the levels of nutrients and toxic factors in different varieties of tropical legumes and their nutritional potentials as food for man and feed for livestock. Our results are constantly used by plant breeders in breeding objectives to provide seed varieties with improved nutrient and anti-nutrient constituents in their overall chemical profile. The International Foundation for Science, Sweden, provided funds for this research which lasted ten years and resulted in 28 publications in international journals.

(2) Effects of Toxic, potentially Toxic and Anti-nutritional Factors in Feeds and Feedstuffs in Animals

The occurrence of bioactive substances in feed ingredients prompted interest in this research, aimed at determining the levels of nutrients and anti-nutrients in different varieties of tropical feedstuffs. Feed ingredients of plant origin contain a variety of constituents which interfere with animal growth, nutrient utilization and produce other physiological and biochemical anomalies. The effects of these substances on the utilization of nutrients by livestock and the role of the type, quantity and quality of other nutrients on their detoxification or conferment of protective effects, were investigated. Protease inhibitors, tannins and phytic acid were found to be present in most tropical feeds and feedstuffs and were responsible for growth inhibition in all types of poultry, reduced protein digestion, increased endogenous loss of sulphur amino acids and resulted in pancreatic hypertrophy (figures 22, 23 and 24). Phyto-hemaglutinins (lectins) were less common except in jack beans where they resulted in enlargement of the small intestine and mortality of birds. Pathological lesions in the organs of animals injected with lima bean hemaglutinins showed fatty degeneration of the liver and focal necrosis (figures 25, 26, 27, 28, 29 and 30).

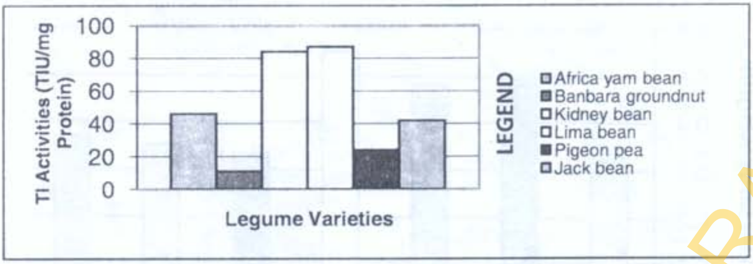


Fig. 22: Trypsin inhibitor activities in raw legumes.

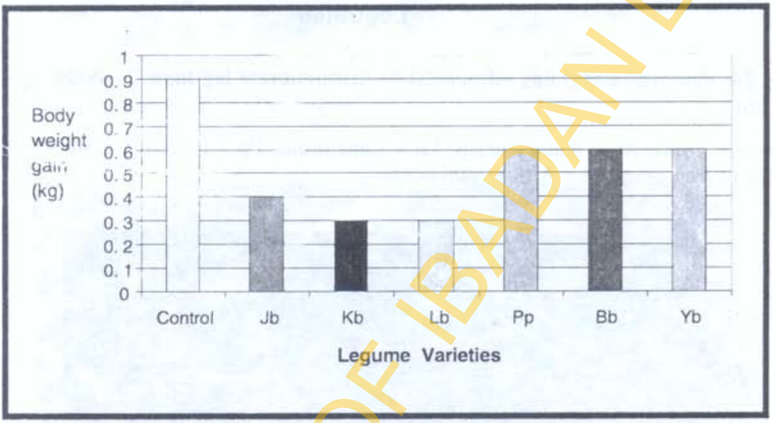


Fig. 23: Body weight gain by broilers fed different legume-based diets.

Jb = Jack beans; Kb = Kidney beans; Lb = Lima beans; Pp = Pigeon pea; Bb = Bambara groundnut; Yb = African yam beans.

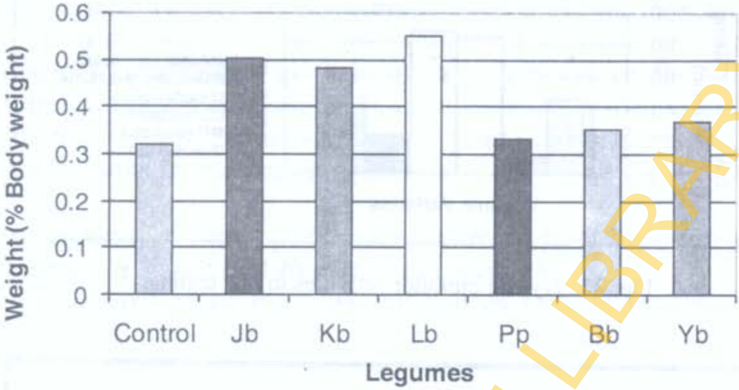


Fig. 24: Pancreas weight as influenced by different raw legumes (% body weight).

Jb = Jack beans; Kb = Kidney beans; Lb = Lima beans; Pp = Pigeon pea; Bb = Bambara groundnut; Yb = African yam beans.

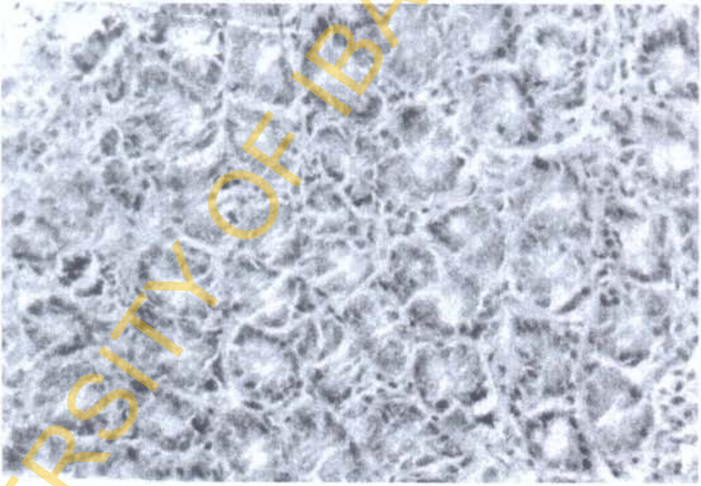


Fig. 25: Section of Pancreas from chick fed control diet (HE × 250).

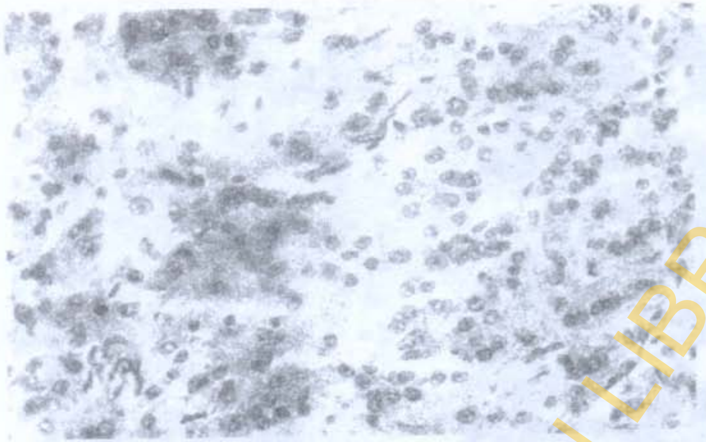


Fig. 26: Section of Pancreas from chicks fed 500g Kg^{-1} jackbean showing acinar hypertrophy (HE × 400).

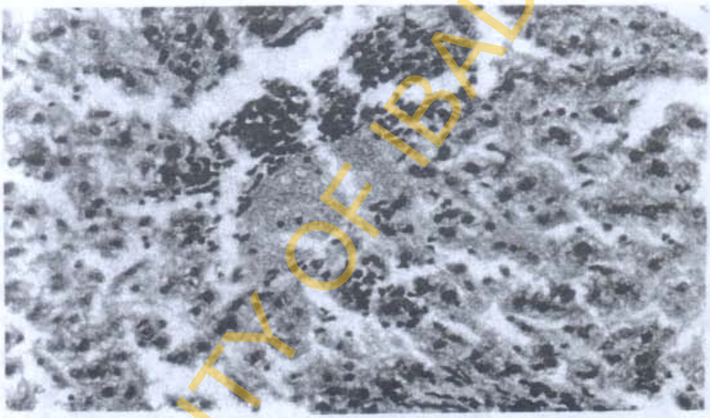


Fig. 27: Liver from chick fed 500g kg^{-1} Limabean showing multiple foci of necrosis and periportal mononuclear cell infiltration (HE x 250).

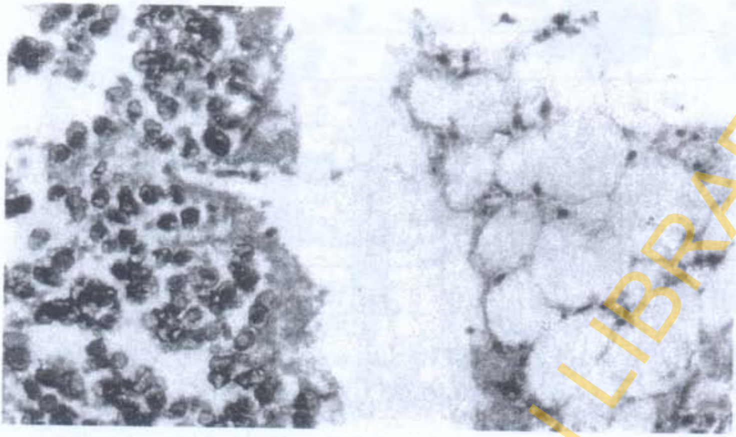


Fig. 28: Pancreatic section of chick fed 500g kg^{-1} Limabean showing severe hypertrophy and hyperplasia (HE × 400).

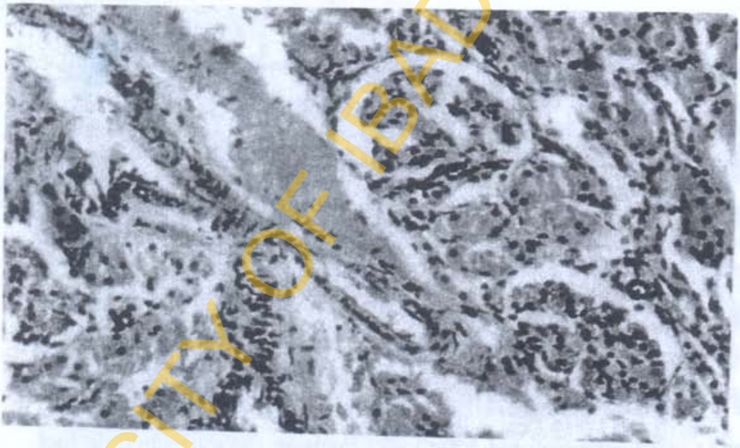


Fig. 29: Kidney section from chick fed control diet (HE ×250).

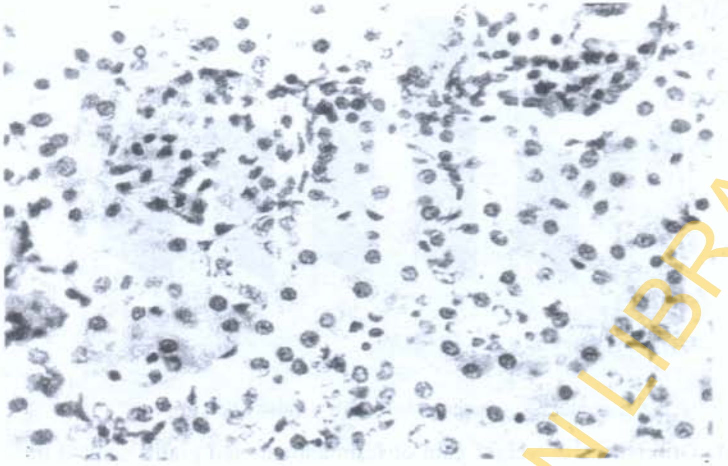
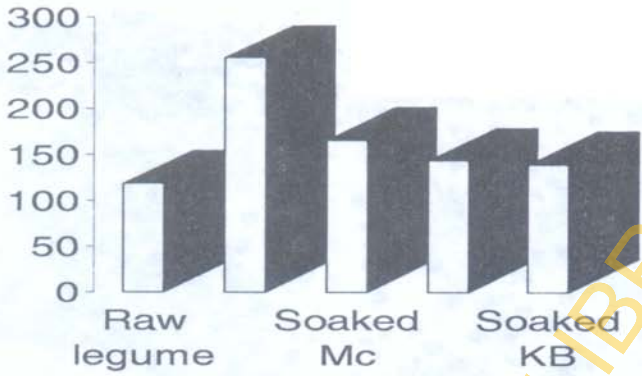


Fig. 30: Section of Kidney from 500g kg-1 Jackbean showing glomerulary congestion (HE × 400).

(3) Improving the Nutritional Value of Feedstuffs through Processing Treatments

Several feedstuffs in the natural state are rejected by animals due to offensive odour and bitter taste. The physical structure of a feedstuff may be too coarse and fibrous due to high structural fiber and lignin contents. Even if animals succeeded in eating the feed, they would not be able to digest it due to natural constituents which are toxic and bind the animal's digestive enzymes, making them ineffective. My research works in this category used various processing treatments—physical, chemical, thermal and micro-biological—to detoxify and reduce undesirable components in feedstuffs to acceptable levels (Fetuga and Ologhobo 1988, 1990, 1991) and improve feed palatability and digestibility (Fetuga and Ologhobo 1989; Adebiyi *et al.* 2009). The processing methods developed in these studies have been adopted in many livestock farms for routine screening and processing of feedstuffs before they are used as animal ingredients (figures 31, 32, 33, 34).



Legend: Mc = mucuna bean; Kb = kidney bean

Fig. 31: Differences in weight gain of farm animals fed grains soaked in water improved gain compared to the raw bean.

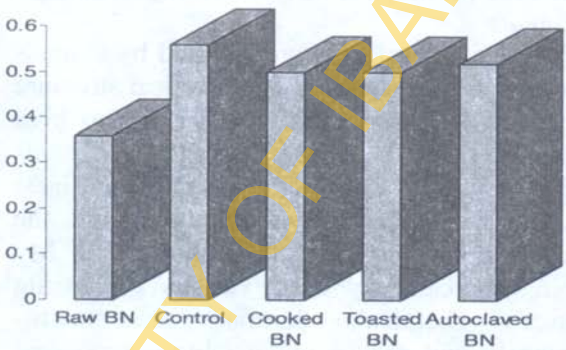


Fig. 32: Effect of heat treatment on feed intake of animals fed legume-based diets. BN = Bambara nut.

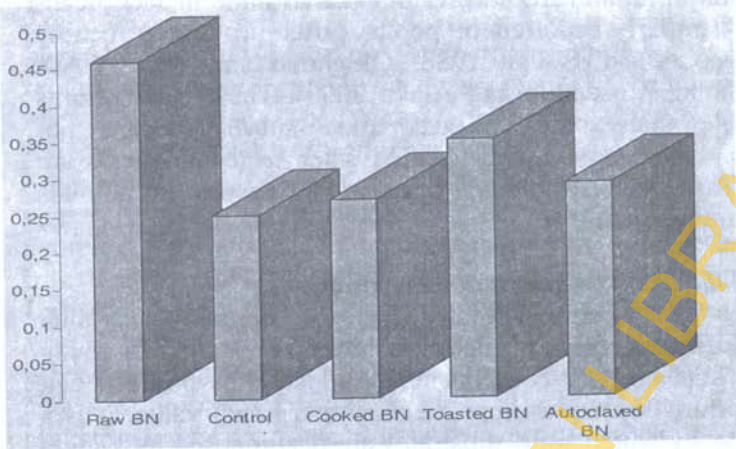


Fig. 33: Weight of the pancreas in animals fed raw and processed legumes. BN = Bambara nut.

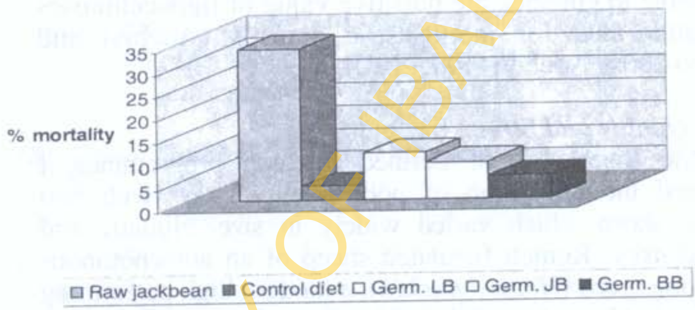


Fig. 34: Effect of raw and sprouted legume-based diets on chick mortality. LB = Limabean; JB = Jackbean; BB = Bambara bean.

(4) Residual Toxic Factors in Feeds

My various studies have shown that feeding processed groundnut cake to laying birds over a period of 52 weeks, produced sudden mortalities in the birds due to the effect of residual aflatoxin while post mortem examination of the dead birds revealed morphological changes in the liver and pancreas (Ologhobo *et al*. 2008). The toxic effects of residual gossypol in processed cotton seed cake, residual hydrogen cyanide in lima beans and residual canavanine in Jack beans were similarly reported in poultry after prolonged feeding (Ologhobo and Fetuga 1988; Ologhobo and Tewe 1990; Ologhobo, Mosenthin and Alaka 2006). These observations indicate that some residual toxic substances are not completely removed or detoxified when feed ingredients are processed, but still exert negative influences in animals consuming them.

(5) Solid State FermentationTechnique

Solid State Fermentation (SSF) or aerobic microbial transformation of solid materials is the application of living organisms and their components to industrial by-products and agricultural wastes to improve their nutritional value. It is a process by which solid substrates are decomposed by known mono or mixed cultures of microorganisms under controlled environmental conditions, with the aim of producing high quality products. Using microbial biodegradation technique, it was possible to enhance the nutritive value of lignocelluloses as potential feed for monogastric animals (Adebiyi and Ologhobo 2009; Adebiyi *et al.* 2010).

(6) Feed Quality and Stress

Within the framework of defined research programmes, I investigated the utilization of poor quality straw with two breeds of sheep which varied widely in size, climatic and nutrient density. Rumen fistulated sheep of an autochotonous low yielding breed (*Heidschnucken*), a modern high performing meat breed (*Deutches Schwarzkopfscharf*) and the West African dwarf sheep (each kept in metabolic cages in climatic chambers) were used. The studies ascertained how animals with different genetic potentials reacted to various combinations of forage quality and stress, and to what extent differences in adaptive mechanisms of animals could be exploited to make better use of low quality feed during inclement weather conditions.

(7) Use of Microbial Phytase in Animal Feeds

One of the current approaches to reducing the excretion of environmentally sensitive nutrients by livestock is through improved feeding practices, including optimizing energy, protein and mineral intakes by using feed additives such as microbial phytase. The use of microbial phytase could provide a method for reducing nitrogen and phosphorus excretion in monogastric farm animals which lack intestinal phytase to hydrolyze phytate phosphorus and protein-phytate complex. Ologhobo and Mosenthin carried out joint research investigations over a period of six years at Hohenheim University in Stuttgart, Germany, funded by the Alexander von Humboldt Foundation. Our joint research showed that preparations of microbial phytase from *Aspergillus ficuum*, added to corn-soybean meal diets effectively hydrolyzed phytate phosphorus in the alimentary tract of poultry. Phytase supplementation yielded significant improvements in the apparent retention of dry matter, nitrogen, phosphorus and calcium (Ologhobo and Mosenthin 2002, 2003; Ologhobo, Mosenthin and Adeyemo 2007). The ability of phytase to liberate phytate-bound phosphorus and improve protein and amino acid utilization allow for a reduction in the excretion of phosphorus and nitrogen by farm animals.

(8) Use of Prebiotics as Alternatives to Antibiotics in Feeds

Antibiotics are chemical compounds that kill or inhibit the growth of organisms. They are produced naturally by microorganisms such as fungi (e.g. penicillin) and bacteria (e.g. tetracycline), or can be produced synthetically or semi-synthetically (e.g. fluoroguinolone and amoxicillin respectively).

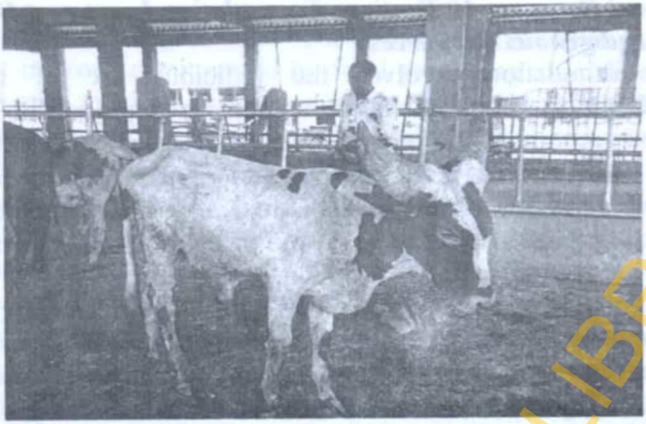
A 66-year-old woman was recovering from a heart bypass in a hospital near Detroit when she suddenly developed respiratory failure and a serious infection. Doctors quickly gave her an antibiotic that usually works. This time, however, it didn't. The bacteria causing the woman's infection were resistant to the drug. The woman's doctors immediately turned to a more potent new generation antibiotic, a powerful one designed specifically to attack the kind of dangerous antibiotic-resistant microbes that had infected her. But her physicians were dismayed to find that the drug didn't work either—the bacteria in her body were resistant to it as well. The woman died soon after. What caused this woman's problems?

The problem of this woman arose because she ate beef or pork obtained from an animal given antibiotics in its feed or water. Many farmers feed livestock a low-level diet of antibiotics, not because the animals are sick but to make them grow more quickly and utilize feed more efficiently. But this practice has increasingly become the focus of concern. Giving animals antibiotics in their feed has been found to cause microbes in the livestock to become resistant to drugs.

In Europe, following recommendations from the World Health Organization the use of growth-promoting antibiotics in feeds and water has been banned. Legislation to impose a similar ban in the United States was introduced in Congress last year by Rep. Sherrod Brown (D-Ohio).

My quest for alternatives to antibiotics in animal feed has resulted in the discovery of prebiotics, which are defined as "selectively fermentable ingredients that allow specific changes, both in the composition and activity in the gastro-intestinal microflora and confer benefits upon host wellbeing and health. They are resistant to gastric acidity, to hydrolysis by mammalian enzymes, and to gastrointestinal absorption. Prebiotics are a safer, easier to handle, non-allergenic alternative to antibiotics and probiotics and they do not leave residues in animal products.

I carried out research studies to screen locally available feedstuffs as prebiotics. These studies were carried out *in vitro*, using a 2-sheep enzymatic model simulating foregut digestibility in monogastric animals.



This cow was sick and drugs given to it were not effective because its feed contained low levels of antibiotics and the animal became resistant to drugs.

A patient suffering from anaphylactic reaction (Anaphylactic reactions have been reported to result from consumption of beef or pork containing penicillin).

(9) Feed Resource Utilization: Formulating Least-cost Diets from Indigenous Resources

Feed formulation involves the judicious use of feed ingredients to supply adequate amounts and proportions of nutrients required by animals. Feedstuffs vary in composition. From a nutritional point of view, there is no "best" diet formula in terms of ingredients that are used. Ingredients should therefore, be selected on the basis of availability and quality of the nutrients they contain.

A fellowship awarded by CIDA/NSERC of Canada gave me the opportunity to study the biological availabilities of proteins and amino acids in pigs fed with different feedstuffs, measured by the ileal and faecal methods of analysis. I mastered the technique for surgical insertion of canula across the ileocecal juncture which allowed digesta to be collected at the terminal ileum for amino acid analysis. With all humility and Glory to God, my visits to Canada in 1991, 1992 and 1993 brought recognition to the University of Ibadan as God used me to take three first class graduates from this University along with me to start their PhD programmes in the University of Alberta on full scholarship awarded by the University. Today, Dr. Olasunkanmi Adegoke, a First Class graduate of Agricultural Biochemistry and Nutrition, Dr. John Olaniyi Moibi, First Class in Animal Science and Dr. Adewale Eniade, First Class in Chemistry, have completed their PhD programmes in flying colours and are currently professors in different universities in Canada and the United States of America.

(10) Non-target Effects of Pesticides on Farm Animals

Humans and animals are occasionally and unintentionally exposed to lethal and sub-lethal doses of pesticides resulting in consumer toxicity. The rate at which Nigerians have been dying from insecticide-treated foodstuffs is alarming. Post-harvest treatment of grains and tubers with chemicals such as fungicides, insecticides, rodenticides and herbicides are only meant for storage but greedy Nigerians sell chemical-treated grains as feed ingredients. These undesirable substances present in feeds are ingested by food producing animals and carried over to edible products and pose risk to human health. Several cases of food poisoning due to residues of harmful chemical substances in stored grains have been reported by the Consumer Protection Council of Nigeria. The alert came on the heels of reported cases of death after suspected poisoned food intakes. *The Guardian* Newspaper of September 18, 2010, reported cases of food poison in a family of five in Abuja and, another family of six including a pregnant woman in Port-Harcourt, after eating treated maize they obtained from grain storage reserves. Similarly, *The Punch* Newspaper of 5 August, 2008, reported the death of three persons of the same household in Maugi, in Niger State, after consuming *dambu*, a local delicacy made from guinea corn. Investigations revealed that the guinea corn was treated with chemicals for planting but the remaining after planting was taken home for consumption. *THISDAY* Newspaper of 13 July, 2008, also reported that four persons were admitted in a private hospital in Ilorin, Kwara State, after eating beans suspected to be "poisonous". After eating the beans, they complained of stomach ache, which later resulted to blood gushing out of their mouths. These tragic stories point to the fact that many chemicals used traditionally in food storage, though regarded as safe, actually contain noxious compounds which make them unsafe for humans and animals.

I studied the effect of insecticide-treated grains (figure 35) on the performance of meat-type chickens, focusing on serum biochemical parameters and histopathology of organs which are indicators of toxicity in animals. I found that the performances of the experimental animals were significantly reduced and most of them died as a result of non-separating entiritities in the small intestine (figure 36), focal necrosis in the pancreas, while the kidneys showed distended capillary vessels with numerous thrombi and myocardium (Ologhobo *et al*. 2004; Ologhobo 2011).

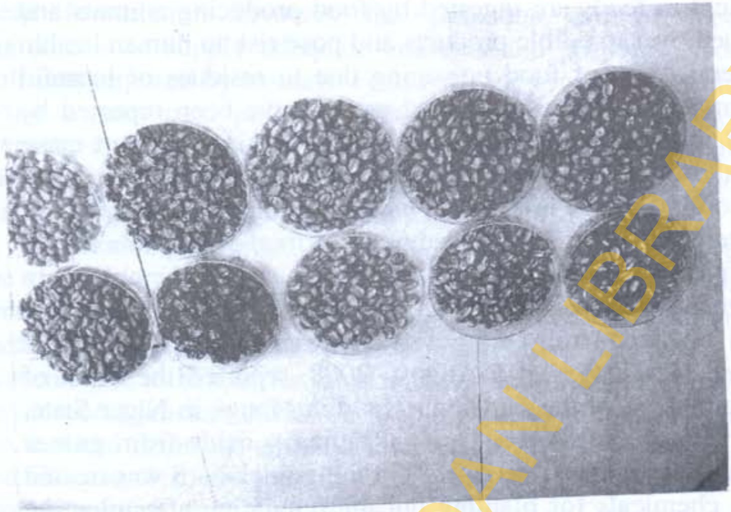


Fig. 35: Grains treated with various pesticides should be planted but are eaten by humans and animals with devastating effects.

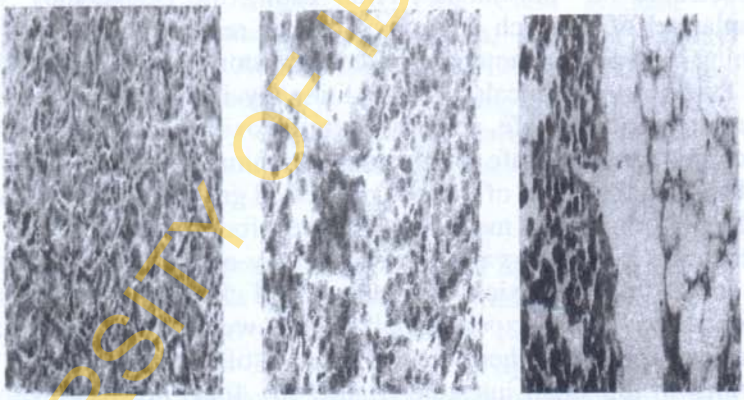


Fig. 36: Effect of insecticide-treated grains on the liver (systematic destruction of the liver). A = control diet with untreated grains; B = grains treated with sub-lethal dose of insecticide; C = grains treated with lethal dose of insecticide showing parenchymatic and fatty degeneration of the liver.

Conclusions and Recommendations

Mr. Vice-Chancellor Sir, in 1952, here in the city of Ibadan, Chief Obafemi Awolowo spoke to the Western House of Assembly, that:

> Poverty in Nigeria is caused by abject state of peasant class; their inertia through want of health; their enslavement by ignorance and superstition; their antediluvian methods of bad animal husbandry, and also their hopelessly unorganized system of marketing their livestock products.

May I say that the words of the Sage are as true today as they were five decades ago. Today, 65% of Nigerians are very poor; these families wear a look of pity and defeat showing the symptoms of food insecurity.

Food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs for an active and healthy life. Nigeria has the potential, not only to meet its growing food needs, but also to become one of the leading food exporting countries in the sub-region and the world at large. Nigeria is blessed with over 160 million people, with about 70 per cent engaged in peasant or commercial farming. Nigeria has about 79 million hectares of arable land (less than half of which is under cultivation); and is blessed with highly diversified ecological conditions suitable for the production of a wide range of agricultural products. Yet, we cannot feed ourselves. The state of nutrition in Nigeria is still characterized by inadequate consumption of animal protein.

I make bold to say, that there is no shortage of animal protein in Nigeria; the major problem is that of distribution, cost and affordability. Surveys have shown that meat and meat products are available in every Nigerian market even in the most remote village. Everywhere in Nigeria, it is common sight to find chickens, goats and sheep roaming, yet their owners, instead of eating them, prefer to sell them (figure 37). This is due to low per-capita buying power, unvarnished poverty and preference for monetary considerations to meet other pressing needs. Only 5.5g of animal protein is consumed in Nigeria, while in some advanced countries at least 60g of animal protein is consumed per caput per day. Also, data from the FAO (2012) show that the daily average protein intake in developed countries is 96.7g per caput per day out of which 65.4g is derived from animal sources, while for Nigeria; it is 52.7g of which only 9.2g or 15.6% of total protein is of animal origin. The frequent reports of protein-calorie malnutrition such as kwashiorkor and marasmus are evidence of the poor state of nutrition in the country.

Fig. 37: Meat and meat products are available in Nigeria but expensive.

Mr. Vice-Chancellor, ladies and gentlemen, I have tried in this lecture to give a holistic picture of animal feed hazards and remedies that can minimize their effects on animal production and productivity. Considering that the quality of animal products is directly related to animal feeding, animal feeds and feed ingredients can be said to be a critical component of the food-chain that has a direct impact on animal health and welfare, food safety and public health. Proper animal feeding should therefore ensure the supply of a diet balanced in all nutrients and free from deleterious components and generate animal products that are safe for human consumption. Improving feed safety is an essential element of food security. Thus, it is necessary that feed safety forms an essential component of health based nutrition policies and nutrition education. Consequently, the following recommendations are made for consideration in formulating national feed safety policy for Nigeria.

1. Development of Feed Safety Standards

Safety standards for undesirable substances in feeds produced for different species and categories of animals should be developed based on the "tolerable daily intake" (TDI) approach. Many feed ingredients are produced as by-products from other production and industrial processes, including but not limited to distillers grains from the production of biofuel, agriculture and food processing, etc. Since these products are sold to animal producers they should be properly stored to prevent fungal contaminations. They should provide rapid and semi-quantitative screening methods for detection of aflatoxin B1 in the brewer's grains. The methods should be simple enough for use by non-technical personnel and inexpensive so that livestock producers can adopt them.

2. Surveillance Testing of susceptible Feedstuffs

Toxic levels of naturally occurring toxins are often produced only under certain environmental conditions. Identification and prevention of these environmental conditions will play an important role in minimizing the adverse effects of these toxins. However, because many environmental conditions cannot be controlled, surveillance of animal feed for microbial contamination is necessary. This measure will monitor and improve our understanding of the flow of feed contaminants through the food chain.

3. Develop Integrated Feed Management Systems

Public health concerns are resulting in greater attempts to evolve effective feed control systems in several countries of the world. The use of various integrated feed management systems like the Hazard Analysis Critical Control Points (HACCP) for the prevention, monitoring and control of feed hazards is being emphasized by international organizations such as FAO, WHO and the Codex Alimentarius Commission and they are gaining increased acceptance worldwide. HACCP is an approach that applies seven principles to identify, rectify, and prevent problems in animal feed production that could result in food borne illness. Microbial contamination of animal feed is a significant potential pathway for entry of pathogens into the human food supply, and at present, there is no comprehensive programme that addresses it in Nigeria. Ensuring that animal feed is free of bacterial pathogens should help reduce human food borne illnesses.

4. Develop Dietary Strategies for Optimizing Nutrient Utilization

While agronomists and plant breeders are making great strides in developing varieties of crops as a way to improve food security, an integrated approach is needed to develop dietary strategies for optimizing their utilization as animal feed resources and reduce excretion of nutrients in faeces. Establishing feeding strategies and developing feed products for improved animal nutrition, would result in increased productivity of local and exotic animal breeds, provide ecological balance and increase the level of animal protein intake by Nigerians.

5. Public Enlightenment

With increasing awareness of global warming, environmental issues continue to be among the biggest challenges faced by livestock producers. Government should embark on public enlightenment campaigns to educate people on the hazards of global warming associated with animal production. Global warming is here with us and its devastating effects are seen everywhere. It is now realized that development that does not take into consideration the environment is self-defeating.

6. Increased Investment in Research for Sustainable Animal Productivity

Although animal agriculture is strategic to alleviating the suffering of the poor and guaranteeing food security, paying particular attention to research and enacting enabling policies that are animal-agriculture-friendly, is the only way to assure accelerated progress in this achievement. Supportive players who are critical to the integration of the attributes of research, education, and information include government, universities, research institutes and the private sector among others. Policy makers should make adequate funds available for feed safety-oriented researches that promote environmental sustainability. In other words, there is a need to increase resources allocated to research and development on improved animal feeds and new eco-friendly technologies. With government's support and willingness to act, there are sufficient mechanisms to keep the adverse effects of livestock production within tolerable limits and enact policies regarding feed safety.

The Nigerian Institute of Animal Science has a coordinating role to play by working closely with relevant professional associations, government agencies, and the private sector. It is also their duty to review current standards of practice in the production, transportation, storage, processing and marketing of animal products.

The states and local governments need to collaborate with the private sector to develop standard abattoirs and sale outlets for animal products. They should also legislate against open and unwholesome transportation, preparation and sales of livestock products. The livestock producers should accept new technologies instead of sticking to outdated methods of animal production, especially in terms of animal welfare, feeding practice and prevention of environmental hazards.

7. Diversification from Oil-dependent Economy

Nigeria's economy today remains monocultural and heavily dependent on the oil sector, which accounts for around 80% of government revenues, 90-95% of export revenues and over 90% of foreign exchange earnings. Policies adopted globally to mitigate climate change (global warming) will have negative implications for specific sectors, such as the coal, oil and gas industries. Nigeria stands to suffer income losses when the global community begins to substitute renewable energy alternatives for fossil fuels. Diversification of the economy from oil producing and channelling resources to manufacturing and service sectors including animal agriculture, provides the key to Nigeria's economic stability. This will ensure that the global shift away from fossil fuel energy sources will not create any significant negative impact on the economy in the future. Nigeria needs to act fast in this regard.

Mr. Vice-Chancellor, ladies and gentlemen, past inaugural lecturers from the Faculty of Agriculture had always mentioned the state of the Teaching and Research Farm which was neglected almost to extinction. I am delighted that my inaugural lecture has come up at a time the Teaching and Research Farm is no longer a festering sore but a beautiful sight to behold. The glorious days are gradually coming back when the farm can be regarded as a credible unit of training and research. On behalf of the Faculty of Agriculture, I want to express our profound appreciation to the current administration for its efforts in giving us a farm that befits the status and calibre of the University of Ibadan. I pray that the development is sustained so that the farm will continue to serve as a vital component in technology transfer.

Acknowledgements
Mr. Vice-Chancellor, ladies and gentlemen, kindly allow me to acknowledge with gratitude, all those who have had a positive impact on my academic life and my total being as a person. I am indebted to so many people; time may not permit me to mention them all. First of all, I thank God for all things, great and small, known to me or not. I truly appreciate with gratitude His saving grace, mercies, gift and good health. His hands have upheld me and pulled me out of an early grave. I am eternally grateful to God, my Father, my Saviour, my Peace, my Joy and the Lifter-up of my head.

I remember with gratitude my late parents who did their best to give me education and to be properly trained. They ran well, finished well and so, rest well. Amen. I greet members of the Idumegwa-Oje and Ologhobo family and all guests who came from all over the country to grace this occasion. I thank all my teachers at all levels of my schooling from primary, secondary and university, who invested resources to shape my thoughts the best way they knew how. I am so grateful that each of them was chosen by God to touch my life when they did. I am grateful to my undergraduate and PhD supervisor, Professor Babatunde Lambard Fetuga, who contributed in no small measure to shape my teaching and research work. Right from Kings College, Lagos, he took me up as his boy, nurtured me and imparted into me the prudence, scholarship and excellence required in academics. Thank you sir, may God bless you richly. Professor A.U. Mba of blessed memory saw virtue in me and made up his mind to employ me as an academic staff when employment into the Department was a taboo for many years. May his soul rest in peace. I whole heartedly appreciate Professor B.K. Ogunmodede who had shown more than a keen interest in my career growth and development. It was him God used to accelerate my promotion from Senior Lecturer to Professor after he saw my CV. I also appreciate the very positive roles Professors G.N. Egbunike and J.A. Oluyemi played in my life when I was a student and later became a lecturer in the Department of Animal Science. Professor Egbunike opened opportunities for me to apply for and win fellowships, get grants and attend international conferences from the early stages of my career. I am truly grateful.

Funds for research and travels were provided at various times by the International Foundation for Science (IFS) (Sweden); Ford Foundation; the Third World Academy of Science; Nigerian Environmental Study Action Team (NEST); the American Farm School, Thessaloniki, Greece; Haggai Institute for Advanced Leadership, Maui, Hawaii, USA; MacArthur Foundation; Hohenheim University, Stuttgart, Germany; British Council, London, Penns State University, Pennsylvania, USA; Alexander von Humboldt (AvH) Foundation; Canadian CIDA/NSERC; German Academic Exchange (DAAD); Royal Society London; Japan Science and Technology Agency (STA); American Fulbright Commission; the International Atomic Energy Agency (IAEA), Vienna, Austria; Organization for the Prohibition of Chemical Weapons in The Hague, Netherlands (OPCW); and Novus International Inc., USA. The research support I got from these international bodies went a long way to expose me to modern trends in research in my field and establish me as a feed toxicologist.

I must not forget to acknowledge my long term collaboration with Professor Rainer Mosenthin of the Institute of Nutrition, who almost turned Hohenheim University in Stuttgart, Germany into my second university. I also thank my Canadian friends, Dr. William Gabert and Professor Willem Sauer who made their homes available to me each time I was in Edmonton, Canada. I enjoyed excellent working relationships with Professor D'Mello, University of Edinburgh, Scotland, Professor Edwin Rajotte, Penns State University and Professor Weniger, Technical University, Berlin, Germany. My Christian brother, research partner and friend, Professor Chris Mullin of Penns State University, shed tears when he saw me off at the JFK International Airport and only let me go on the assurance that we must surely make heaven as Christians. So deep was the love of Christ between us. God bless you Brother Chris. I fondly remember my Japanese host, Dr. Shigeru Miyazaki, of the National Institute of Animal Health, Tsukuba, Ibaraki, Japan. He always called me "Anthony San" (Japanese word for Mr. Anthony) when he handed over to me the keys of the laboratory after everybody had closed at 7.00 pm. For both of us work had just started at this time and continued throughout the night. Here was a man who was dedicated to sheer hard work per excellence. I am grateful for the value they have all added to my life over the years. I also appreciate all other collaborators too numerous to mention.

I have enjoyed an excellent working relationship with the academic staff in my Department over the three decades that I have spent there. I acknowledge the wonderful support I have enjoyed since I became Head of Department; I am truly grateful to you all for standing by me at all times. I pray that none of them shall go stale in academic ideas and innovations. I truly appreciate the working relationship I have with every member of the non-teaching staff, the technologists, secretarial staff and all other workers in the Department and Faculty of Agriculture over the years for which I thank them all. I thank members of the Fulbright Alumni Association of Nigeria, University of Ibadan Chapter, for supporting me as their leader.

In the past 31 years, I have been privileged to supervise very many students at the M.Sc., M.Phil. and PhD levels. I appreciate each of them for allowing me to mentor them as I was mentored. They have contributed immensely in most of the papers cited in this lecture. I sincerely thank the present Dean Professor V.A. Togun and immediate past Dean of the Faculty of Agriculture and Forestry, Professor E. A. Aiyelari, whose enforcement of due process made it possible for me to present this inaugural lecture. I must not fail to mention friends who always provide encouragement whenever needed to make life more pleasant. They are Professor and Dr. Stella Odebode, Professor and Dr. Folajogun Falaye, Dr. Salako, Professor Oderinde, Professor Kola Ewete, Dr. Folarin Payne, Dr. and Mrs. Isaac Oluwatoye, Dr. Dayo Omoba, Dr. and Mrs. Babatunde Omojola and my prayer partners, Pastor Adeoti, Pastor Oyewo and Pastor Oluwasina.

I say Floreat Collegium to the Kings College Old Boys and especially my class mates, Tosin Atewologun, Yomi Opaneye, Jacob Akindele and Muyiwa Sekoni who are here seated. You are all wonderful guys. Thank you. They have been of great inspiration to me and my family. I pray the Lord will continue to depend on you.

I will never forget my special friends, Adeoye Ojo, Demola Ojo and Kola Ojo, the three brothers who took me like their own brother during those formative years in Lagos.

I am eternally grateful. How can I ever forget the Ipayes, Nelson and Rasco, who stood by me; come rain, come shine they were always there for me. I thank you.

I have had strong personalities in my life that God has used to contribute to shaping the person I am today. I appreciate always the contributions of Dr. and Dr. (Mrs.) U. Obed, pioneer General Pastor and Associate Pastor of Glory Tabernacle (GT) Ministry, Dr. and Mrs. G. Akinbola, the General Pastor of GT, members of the Eldership Council, the Glory Men's Team, Glory Men's Cooperative, Glory Skills Acquisition Programme (GSAP), Rev. and Pastor Mrs. Solomon Adebara, Pastor Mrs. Ade-Ojo, Pastor Prince Malumi, Pastor Yemi Ayodele, Evangelist Mrs. Sarah Egharevba, Evangelist Mrs. Osawaru, Pastor and Mrs. Edwin Umunna, Pastor Oladele, and Pastor JesuYinka Samuel. I thank God for the lives of these people and others like them—some of whom are also in this audience. The wonderful story of my life would not be complete without their mention and I am sure they know how much I cherish them.

I thank my siblings and their spouses, Elizabeth Omotunde Aduagba (Mama Kola); Peter Kayode and Asabe; Iyabo and Dada; Augustine and Nike; Olaolu and Funke; and their children. I also want to appreciate my in-laws, Mrs. Helen Salami, Dr. and Mrs. Taiwo Malumi, Mr. and Mrs. Gregory Salami, Barrister and Mrs. Ignatius Salami and Dr. Thomas Salami. I thank you all for your prayers and support.

I salute my children, Olufemi, Titilayo, Oluwatoyin and Olubunmi for being so loving and caring. Daddy had to be hard when you were growing up so that the beauty of God latent in you could shine forth as gold to the glory of His Name. Today, you have all grown up to become wonderful children daddy and mummy are so proud of.

Mrs. Veronica Funmilayo Ologhobo, nee Salami, my love, my jewel, my best friend, my adviser, the apple of my eyes, how can I truly thank you for being such a loyal, committed, devoted and loving wife. You were chosen by God, to be my companion in my pilgrimage journey on earth and what a wonderful partner you have been. I cherish every moment of my life with you and the children God has given us. Many thanks for keeping the home front during my extensive travels sometimes at short notice for academic and professional engagements.

Finally, I humble myself before God and vow to be in His presence all the days of my life, by His grace. "Now unto Him Who is able to keep us from falling, and to present us faultless before the presence of His glory with exceeding joy; to the only wise God, our Saviour, be glory and majesty, dominion and power, both now and forever," Amen.

Mr. Vice-Chancellor, I have another dream that the best is yet to come, better days are ahead, better opportunities, and a brighter future. Distinguished ladies and gentlemen, thank you for your patient attention. May God bless us all!

Bibliography

Aaerstrup, F.M., Agerso, Y., Gerner-Smidt, P., Madsen, M. and L.B. Jensen (2000) Comparison of antimicrobial resistance phenotypes and resistance genes in *Enterococcus faecalis* and *Enterococcus faecium* from humans in the community, broilers and pigs in Denmark. *Diagnostic Microbiology and Infectious Disease* 37:127-137.

Adebiyi, O. and A. Ologhobo (2007) Enhancement of the nutritional potentials of cowpea seedhulls subjected to solid state fermentation using three monoculture fungi. *Animal Science Journal*, (in press) (Nigeria).

Adebiyi, O.A., Ologhobo, A.D., Adeleye, O.O. and S.K. Moiforay (2008) Effect of supplementing fungi degraded cowpea seedhulls in broiler diets. *Proceedings of Conference on International Research on Food Security, Natural Resource Management and Rural Development. Competition for resources in a changing world: New Drive for a Changing World.* Tropentag, October 7-9, 2008, Hohenheim University, Stuttgart, Germany.

Adebiyi, O.A., Ologhobo, A.D. and A.S. Agboola (2009) Effects of microbial phytase supplementation on mineral composition of tibia and mineral utilization in broiler fed maize-based diets. *International Journal of Poultry Science* 8(6):570-573.

Adeleye, O.O., Ologhobo A.D. and O.A. Adebiyi (2008) *In vitro* assessment for prebiotic potentials of some carbohydrate/ fibrous feedstuffs fed in broiler diets. *Proceedings of International Research on Food Security, Natural Resource Management and Rural Development*, Tropentag, October 7-9, 2008, Hohenhein University, Stuttgart, Germany.

Adeleye, F. and A.D. Ologhobo (2007) Solid state fermentation of some agro-industrial by-products (AIBs) using microbial enzymes of *Aspergillus niger* to enhance their utilization in broiler diets. *Poultry Science* (in press) (USA).

Apata, D.F. and A.D. Ologhobo (1989) Influence of phytic acid on the availability of minerals from some selected tropical legumes. *Nigerian Journal of Science*, 23:88-91. (Nigeria).

Athansiadou, S., Kyriazakis, I., Jackson, F. and R.L. Coop (2000) Effects of short-term exposure to condensed tannins on adult *Trichostrongylus colubriformis*. *Veterinary Record* 146:728-732.

ATSDR (1997) *Toxicological profile for cyanide*, Atlanta, GA: Agency for Toxic Substances and Disease Registry.

Bager, F., Madsen, M., Christensen, J. and F.M. Aarestrup (1997) Avoparcin used as a growth promoter is associated with the occurrence of vancomycin-resistant *Enterococcus faecium* on Danish poultry and pig farms. *Preventive Veterinary Medicine* 31: 95-112.

Balogun, A.M. and A.D. Ologhobo (1989) Growth performance and nutrient utilization of fingerlings of *Clarias garietpinus* (Buchell) fed raw and cooked soyabean diets. *Journal of Aquaculture* 76, 119-126 (UK).

Bankole, S., Schollenbeger, M. and W. Drochner (2006) Mycotoxin contamination in food systems in sub-Saharan Africa. Mykotoxin Workshop Hrsg.: Bydgosczz (Polen), 29-31 May, 2006, pp37.

Bhat, R.V. and S. Vasanthi (1999) Mycotoxin contamination of foods and feeds. MYC-CONF/99/4a. Third joint FAO/WHO/ UNEP International Conference on Mycotoxins, 3-6 March 1999, Tunis, Tunisia. Food and Agriculture Organization, World Health Organization and United Nations Environment Programme.

Behl, C.R., Pande, M.B., Pande, D.P. and N.S. Radadia (1986) Nutritive value of wilted castor (*Ricinus communis* L.) leaves for crossbred sheep. *Indian Journal of Animal Science* 56:473-474.

Bjork, I.M. and M. Nyaman (1987) *In vitro* effects of phytic acid and polyphenols on starch digestion and fibre degradation. *Journal of Food Science* 52:1588-1594.

Capucille, D.J., Poore, M.H. and G.M. Rogers (2004) Growing and finishing performance of steers when fed recycled poultry bedding during the growing period. *Journal of Animal Science* 82: 3038-3048.

Chaplin, A., Rule, A., Gibson, K., Buckley, T. and K. Schwab (2005) Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation. *Environmental Health Perspectives* 113:137-142.

Chawli, S.R. and J.B. Campbell (1987) Adjuvant effects of orally administered saponins on humoral and cellular immune responses in mice. *Immunobiology* 174: 347-349.

Chee-Sanford, J.C., Aminov, R.I., Krapac, I.J., Garrigues-Jeanjean, N. and R.I. Mackie (2001) Occurrence and diversity of tetracycline resistance genes in lagoons and groundwater underlying two swine production facilities. *Applied Environmental Microbiology* 67:1494-1502.

Cheeke, P.R. and L.R. Shull (1985) *Natural toxicants in feeds and livestock.* AVI Publishing Inc., West Port, Connecticut.

Chung, K.T., Lu, Z. and M.W. Chou (1998) Mechanism of inhibition of tannic acid and related compounds on the growth of intestinal bacteria. *Food and Chemical Toxicology* 36:1053-1060.

Coelho, M. and F. McKnight (1994) Phytase amino acids, energy equivalencies examined. *Feedstuffs* March 23:14.

Coffey, R. (2008) Digestive physiology of farm animals. Introduction to animals and food sciences. University of Kentucky.

Conn, E.E. (1979) Cyanide and cyanogenic glycosides. In: *Herbivores: Their interaction with secondary metabolites.* Rosenthal, G.A, D.H. Janzen (Eds.) A.P., New York pp. 387-412.

Central Sheep and Wool Research Institute (CSWRI) 1987, 1988, 1989. *Proceedings of tannin feeds for their increased utilization.* Report. Central Sheep and Wool Research Institute, Avikanagar, India 304501.

D'Mello, J.P.F. and T. Acamovic (1989) *Leucaena leucocephala* in poultry nutrition. A review. *Animal Feed Science and Technology* 26:1-28.

Economic Survey of Nigeria (1959) Federal Government Printer, Lagos.

Emiola, I.A., Ologhobo, A.D., Adedeji, T.A. and M. Akanji (2007a) Performance characteristics of broiler chicks fed differently processed kidney bean as replacement for two conventional legumes. *Moor Journal of Agriculture* 4 (2):236-241 (Nigeria).

Emiola. I.A., Ologhobo A.D. and R.M. Gous (2007b) Influence of processing of mucuna (*Mucuna pruriens va rutilis*) and kidney bean (*Phaseolus vulgaris*) on the performance and nutrient utilization of broiler chickens. *Japan Journal of Poultry Science,* 44:168-174 (Japan).

Emiola, I.A., Ologhobo, A.D. and R.M. Gous (2008) Performance and histological responses of internal organs of broiler chickens fed raw, dehulled, and aqueous and dry -heated kidney bean meals. *Poultry Science* 86:1234-1240 (USA).

Fabiyi, Y.L. and E.O. Idowu (2004) *Poverty alleviation and food security in Nigeria.* Agricultural Economics Society of Nigeria. Pp. 155 – 163.

Faniyi, G.F. and A.D. Ologhobo (1998) Replacement value of biodegraded cowpea and sorghum seedhulls for brewers dried grain in broiler diets. *Proceedings of the 3rd Annual Conference of the Animal Science Association of Nigeria,* 22-24 September, 1998, Lagos, Nigeria pp. 87-89.

FAO (1991) *Distribution and impact of helminth diseases of livestock in developing countries:* FAO Animal Production and Health Paper 96; Food and Agriculture Organization of the United Nations: Rome, Italy, 1991.

Fielder, H. (1996) Sources of PCDD/PCDF and impact on the environment. *Chemosphere* 32:55.

Gatlin, L.A., See, M.T., Hansen, J.A. and J. Odle (2003) Hydrogenated dietary fat improves pork quality of pigs from two lean genotypes. *Journal of Animal Science* 81:1989-1997.

Gibbs, S.G., Green, C.F., Tarwater, P.M., Mota, L.C., Mena, K.D. and P.V. Scarpino (2006) Isolation of antibiotic-resisl nt bacteria from the air plume downwind of a swine confin 1 or concentrated animal feeding operation. *Environmental H alth Perspectives* 114:1032-1037.

Gorbach, S.L. (2001) Antimicrobial use in animal feed- time to stop. *New England Journal of Medicine* 345:1202-1203.

Harland, B. and D. Oberleas (1987) Phytate in foods. *World Review of Nutrition and Dietetics* 52:235-258.

Hayes, J.R., English, L.L., Carter, P.J.. Proescholdt, T., Lee, K.Y. and Wagner, D.D. (2003) Prevalence and antimicrobial resistance of enterococcus species isolated from retail meats. *Applied Environmetal Microbiology* 69:7153-7160.

Hegarty, M.P. (1978) Toxic amino acids of plant origin. In: *Effect of poisonous plants on livestock*. Keeler, R.F., Van Kampen, K.R. and L.F. James (Eds.) Academic Press New York. pp. 575-585.

Hiremath, N.B. (1981) Subabool (*Leucaena leucocephala*) - A wonder plant. *Indian Dairyman* 33:351-356.

Iyayi, E.A., Ologhobo, A.D. and O.O. Tewe (2002) A new and simple technology for the conversion of poultry manure to animal protein by composting for small holder farms in Nigeria. In: *Composting and compost utilization* (Eds. Micheal, F. C., Rynk, R. and Hoitink, H.A). Proceedings of an International Symposium, May 6-8, 2002.

Jensen, L.B., Agerso, Y. and G. Sengelov (2002) Presence of erm genes among macrolide-resistant gram-positive bacteria isolated from Danish farm soil. *Environ Int.* 28:487-491.

Jones, R.J., Blunt, C.G. and B.I. Nurnberg (1978) Toxicity of *Leucaena leucocephala*. The effect of iodine and mineral supplements on penned steers fed a sole diet of *Leucaena*. *Australian Veterinary Journal* 54:387-392.

Jones, R.J. and M.P. Hegarty (1984) The effect of different proportions of *Leucaena leucocephala* in the diet of cattle on growth, fed intake, thyroid function and urinary excretion of 3-hydroxy-4 (1H)-pyridone. *Australian Journal of Agricultural Research* 35:317.

Jones, R.M., McLennan, M.W. and Dowsett, K.F. (1989) The effect of *Leucaena leucocephala* on the reproduction of beef cattle grazing leucaena/grass pastures. *Tropical Grasslands* 23:108-114.

Joshi, D.C., Katiyar, R.C., Khan, M.Y., Banerji, R., Misra, G. and S.K. Nigam (1989) Studies on Mahua (*Bassia latifolia*) seed cake saponin (Morwin) in cattle. *Indian Journal of Animal Nutrition* 6:13-17.

Keeler, R.W. (1984) Teratogens in plants. *Journal of Animal Science* 58:1029-1039.

Khalil, A.H. and T.A. El-Adaway (1994) Isolation, identification and toxicity of saponins from different legumes. *Food Chemistry* 50:197-201.

Kumar, R. (1983) Chemical and biochemical nature of fodder tree leaf tannins. *Journal of Agriculture and Food Chemistry* 31:1364-1367.

Kumar, R. and T. Horigome (1986) Fractionation, Characterization and protein Precipitating Capacity of the condensed tannins from *Robinia pseudoacacia* L. leaves. *Journal of Agriculture, and Food Chemistry* 34: 487-489.

Kumar, R. and M. Singh (1984) Tannins: Their adverse role in ruminant nutrition. *Journal of Agriculture and Food Chemistry* 32: 447-453.

Kyriazakis, I., Anderson, D.H., Oldham, J.D., Coop, R.L. and F. Jackson (1996) Long-term subclinical infection with *Trichostrongylus colubriformis*: Effects on food intake, diet selection and performance of growing lambs. *Veterinary Parasitology* 61:297-313.

Liener, I.E. (1985) Antinutritional factors. In: *Legumes, chemistry, technology and human nutrition*. Matthews, R.H (Ed.) Marce Dekker Inc. New York pp. 339-382.

Lorber, M., Cleverly, D., Schaum, J., Phillips, L., Schweer, G. and T. Leighton (1994) Development and validation of an air-to-beef food chain model for dioxin-like compounds. *Sci. Total Environ.* 156:39.

Low, A.G. and T. Zebrowska (1989) Digestion in Pigs. In: *Protein metabolism in farm animals: Evaluation, digestion, absorption, and metabolism*, H.D. Bock, B.O. Eggum, A.G. Low, O. Simon and T. Zebrowska (Ed.). Oxford University Press, Berlin, Germany.

Lowry, J.B. (1990) Toxic factors and problems: Methods of alleviating them in animals. In: *Shrubs and tree fodders for farm animals*, C. Devendra (Ed.) IDRC, Canada pp. 76-88.

Lu, C.D. and Jorgensen, N.A. (1987) Alfalfa saponins effect site and extent of nitrient digestion in ruminants. *Journal of Nutrition* 117:919-927.

Malinow, M.R., Connor, W.E., McLaughlin, P., Stafford, C., Lin, D.S., Livingston, A.L., Kohler, G.O. and W.P. McNulty (1981) Cholesterol and bile acid balance in *Macacs fascicularis*. Effects of alfalfa saponins. *Journal of Clinical Investigation* 67:156-162.

Mantovani, A. and C. Frazzoli (2010) Risk assessment of toxic contaminants in animal feed. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 5(46):1-14.

Mba. A.U. (1965) Evaluation of local feeding stuffs in Nigeria. *Ranchers' News* 1.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and C.A. Morgan (1995) *Animal nutrition*. Longman Group Limited, Harlow (United Kingdom).

McKellar, Q.A. (1997) Ecotoxicology and residues of antihelmintic compounds. *Veterinary Parasitology* 72:413-435.

Ministry of Trade and Industry, Northern Nigeria (1963) *The industrial potentialities of northern Nigeria*, Kaduna.

Mitchell, H. H. (1962) *Comparative nutrition of man and domestic animals*. Vol. 1 p. 587. Academic Press, New York.

Modgill, R., Mehta, U. and S.K. Singhal (1993) Effect of oil treatment on levels of antinutritional factors in *Callosobruchus chinensis* (L) infested stored pulses. *Nahrung* 317:602-606.

Molan, A.L., Waghorn, G.C., Min, B.R. and W.C. McNabb (2000) The effects of condensed tannins from seven herbages on *Trichostrongylus colubriformis* larval migration *in vitro*. *Folia Parasitologica* (*Praha*) 47:39-44.

Molyneux, R.J., Stevens, K.L. and L.F. James (1980) Chemistry of toxic range plants. Volatile constituents of Broomweed (*Gutierrezia sarothrae*). *Journal of Agriculture and Food Chemistry* 28:1332-1333.

Muthomi, J.W., Oerke, E.C., Dehne, H.W and E.W. Mutitu (2002) Susceptibility of Kenyan wheat varieties to head blight, fungal invasion, and deoxynivalenol accumulated inoculated with *Fusarium graminearum*. *Journal of Phytopathology* 150:30-36.

National Research Council (2005) *Mineral tolerance of animals*. Washington DC. National Research Council.

Nestrick, T.J., Lamporski, L.L., Shadoff, L.A. and T.L. Peters (1983) Methodology and preliminary results for the isomer-specific determination of TCDDs and higher chlorinated dibezo-ρ-dioxins in chimney particulates from wood-fueled domestic furnaces located in eastern, central and western regions of the United States. In: *Human and environmental risks of chlorinated dioxins and related compounds*, R.E. Tucker, A.L. Young and A.P. Gray (Eds.), pp 95. Plenum Press, New York.

Niezen, J.Y., Waghorn, T.S., Charlston, W.A.G. and G.C. Waghorn (1995) Growth and gastrointestinal nematode parasitism in lambs grazing either Lucerne (*Medicago sativa*) or sulla (*Hedysarum coronarium*) which contains condensed tannins. *Journal of Agricultural Science* 125:281-289.

Oakenful, D. and G.S. Sidhu (1990) Could saponins be a useful treatment for hypercholesterolemia? *European Journal of Clinical Nutrition* 44: 79-88.

Oboh, S., Ologhobo, A.D and O.O. Tewe (1989) Some aspects of the biochemistry and nutritive value of the sweet potato (*Ipomoea batatas*). *Food Chemistry* 31:9-18 (UK).

Odebode, S.O. (2000) Poultry Farmers Access to Extension service in Iddo Local Government Area of Oyo State, Nigeria: In: *Re-inventing animal production in the 21st century*, U.I. Oji, O.O. Mgbere (Eds). Proceedings of the 5th Annual Conference of Animal Science Association. Pp. 213 – 216.

Ofongo, S.T. and A.D. Ologhobo (2007) Processed kidney bean (*Phaseolus vulgaris*) in broiler feeding: Performance characteristics. *Proceedings of International Research on Food Security, Natural Resource Management and Rural Development*, Tropentag, University of Kassel-Witzenhausen and University of Göttingen, October 9-11, 2007.

Ologhobo, A.D. and B.L. Fetuga (1982) Chemical composition of promising cowpea (*Vigna unguiculata*) varieties. *Nutrition Reports International* 25:913-919 (USA).

__________ (1982) Polyphenols, phytic acid and other phosphorus compounds of limabean (*Phaseolus lunatus*). *Nutrition Reports International* 26, 606-611 (USA).

Ologhobo, A.D. (1984) Fractionation of protein from limabean. *Journal of Food Technology* 19(5):569-574 (UK).

__________ (1985) Variations in total protein contents of the Adenohypo-physis, Neurohypophysis and eight brain areas of phytohemagglutinin-poisoned rats. *Current Science* 52(19):938-939 (USA).

__________ (1985) Biochemical assessment of Nigerian (*Dioscorea*) species of yams and yam peels. *Journal of Tropical Agriculture* 62(2):166-168 (West Indies).

__________ (1986) Composition and food potentials of germinated legume seeds and sprouts. *Nigerian Food Journal* 4(1):34-44 (Nigeria).

Ologhobo, A.D. (1987) Effects of cassava and limabean based diets on protein utilization, intestinal and pancreatic nitrogen in the rat. *Nigerian Journal of Science*, 21:61- 64 (Nigeria).

__________ (1987) The availability of methionine contained in soybean for the rat. *Journal of Animal Production Research* 7(2):103-111 (Nigeria).

__________ (1988) The effect of dried poultry droppings (DPD) and dried activated sewage sludge (DASS) on broiler carcass quality. *Biological Wastes*, 23(2):99-104 (UK).

__________ (1989) Improving the nutritive value of soybean (*Glycine max* L. Merril) through processing. *Tropical Agriculture* (Trinidad) 66(4):289-295 (West Indies).

__________ (1992) Nutritive values of some tropical (West Africa) Legumes for poultry, *Journal of Applied Animal Research*, 2:93-103 (India).

__________ (1996) Overcoming environmental pollution through reutilization of human and animal wastes as feed ingredients for poultry. *Nigerian Journal Environmental Study Team* (NEST). Publications, 5, 15 – 26 (Nigeria).

__________ (2007) Livestock productivity and the environment: The sustainability approach. *Workshop on setting research agendas for improved livestock productivity.* Department of Animal Science, University of Animal Science, 19 October, 2007.

__________ (2007) Livestock productivity and the environment: The sustainability approach. *Workshop on setting research agendas for improved livestock productivity.* Department of Animal Science, University of Animal Science, 19 October, 2007.

Ologhobo, A.D. (2008) Effect of long-term feeding of raw and sun-dried garlic (*Allium sativum*) on performance and lipid metabolism of broiler chicks. *Proceedings of International Research on Food Security, Natural Resource Management and Rural Development*, Tropentag, October 7-9, 2008, Hohenhein University, Stuttgart, Germany.

Ologhobo, A.D., Adebiyi, O.A.. and Adebiyi, F.G. (2005) Response of broiler chicken to microbial phytase supplementation: effect on apparent nutrient bioavailability and serum mineral concentration. *Tropical Journal of Animal Science*, (2): 67-73 (Nigeria).

Ologhobo, A.D. and B.L. Fetuga (1987) Pathological observations in rats dosed with limabean and cowpea hemaglutinins. *Toxicology Letters*, 18, 301-306 (USA).

Ologhobo, A.D. and B.L. Fetuga (1982) Carbohydrate constituents of some limabean (*Phaseolus lunatus*) varieties. *Nutrition Reports International* 26(6):981-987 (USA).

__________ (1983a) Compositional differences in some limabean (*Phaseolus lunatus*) varieties. *Food Chemistry* 10:297-307 (UK).

__________ (1983b) Investigations on the trypsin inhibitor, hemaglutinin, phytic acid and tannic acid contents of cowpea (*Vigna unguiculata*). *Food Chemistry* 12(4):248-254 (UK).

__________ (1983c) Toxicity effects of some legume seed hemaglutinins on some liver enzyme activity. *Zeitschrift fur Tierphysiologie, ierernahrung and Futter-mittelkunde*, 49: 62-66 (Germany).

__________ (1983d) Trypsin inhibitor activity in some limabeans (*Phaseolus lunatus*) varieties. *Nutrition Reports International* 27(1):41-49 (USA).

__________ (1984a) Biochemical assessment of some varieties of soybeans. *Food Chemistry* 13(2):103-115 (UK).

__________ (1984b) Hemaglutinin extracts from raw, sprouting and differently processed limabean. *Cambridge Journal of Agricultural Science* 102:221-224 (UK).

__________ (1984c) The distribution of phosphorus and phytate in some Nigerian varieties of legumes and some effects of processing. *Journal of Food Science* 49:199-203 (USA).

__________ (1984d) The effect of processing on the trypsin inhibitor, hemaglutinin, tannic acid and phytic acid contents of seeds of ten cowpea varieties. *Journal of Food Processing and Preservation* 8(1):31-35 (USA).

__________ (1985) Changes in carbohydrates contents of germinating cowpea seeds. *Food Chemistry* 20:117-125 (UK).

__________ (1986) Effect of processing on the energy values of limabean. *Nigerian Journal of Animal Production* 13:86-93 (Nigeria).

__________ (1987) Energy values in differently processed cowpea. *Nigerian Food Journal* 5:18-23 (Nigeria).

__________ (1988a) Effect of different processes on the carbohydrates of limabean. *Die Nahrung* 32(2):173-177 (Germany).

Ologhobo, A.D. and D.O. Adejumo (1988b) Effect of dietary raw and cooked soyabean on the phospholipids and cholesterol content of the rat brain. *Nutrition Reports International* 38(2):275-283 (USA).

Ologhobo, A.D. and D.O. Adejumo (1988c) Effects of dietary soya-bean and methionine on total protein and acethycholinesterase activity in the rat brain. *Nutrition Reports International* 37(5): 1047-1054 (USA).

Ologhobo, A.D. and H.I. Adegede (1996) Occurrence of nitrate, nitrite and volatile nitrosamines in certain feed stuffs and animal products. *Journal of Nutrition and Health* 11:109 -114 (UK).

Ologhobo, A.D. and S. Oyewole (1987) Replacement of groundnut meal by dried poultry droppings (DPD) and dried activated sewage sludge (DASS) in the diet for broilers. *Biological Wastes* 27:275-282 (UK).

Ologhobo, A.D., Adebiyi, O. and O. Adeyemo (2007) Studies on recovery of nutrients from human and animal wastes. *Proceedings of 22nd International Conference on Solid Waste Technology and Management*, Widener University, Chester, Pennsylvania, USA, 18 – 22 March, 2007.

Ologhobo, A.D., Adebiyi, O. and Moiforay S.K. (2007) Overcoming the problem of municipal waste disposal through bioconversion and re-use of solid wastes as animal feed. *Proceedings of 22nd International Conference on Solid Waste Technology and Management*, Widener University, Chester, Pennsylvania, USA, 18 – 22 March, 2007.

Ologhobo, A.D., Apata, D.F. and A. Oyejide (1992) Utilization of raw jackbean and jackbean fractions in diets for broiler chicks. *British Poultry Science*, 34:323-337 (UK).

Ologhobo, A.D., Balogun, A.M. and B.B. Bolarinwa (1986) The replacement value of fish silage for fishmeal in practical broiler diets. *Biological Wastes* 25, 117-125 (UK).

Ologhobo, A.D., Fetuga, B.L. and O.O. Tewe (1984) The cyanogenic glucoside contents of raw and processed limabean varieties. *Food Chemistry* 13(2):117-128, (UK).

Ologhobo, A.D., Idowu, J.I. and A.A. Sadiq (1998) Tannins and phytic acid in cooked legumes on apparent protein digestibility in the intestinal tract of broiler chicks. In: *Recent advances in research on antinutritional factors in legume seeds and rapeseed*, Jansman, A.J.M & Huisman, J (Eds). pp 44-51; A.B Wageningen, The Netherlands.

Ologhobo, A.D., Mosenthin, R. and G.O. Adeyemo (2006) Optimizing the utilization of mucuna beans in poultry feeds through dietary supplementation with commercial enzymes. *Journal of Raw Materials Research* 3 (2) 16 - 30.

Ologhobo, A.D., Fetuga, B.L. and O.B. Kasali (1982) Toxicity to rats of hemagglutins extracted from limabean (*Phaseolus lunatus*) and cowpea (*Vigna unguiculata*). *Nigerian Journal of Nutrition Science* 3(2):103-108 (Nigeria).

Onyekeru, J., Amubode, F. and A.D. Ologhobo (1987) Comparative utilization of cooked and raw soyabean by adult and weanling African giant rat. *Nutrition Reports International* 35(1):117-122 (USA).

Oyenuga, V.A. (1965) The importance of application of science to the agricultural sector of the Nigerian economy. *Symposium Proc. World Fed. Sci. Workers*. Budapest/Hungary.

__________ (1966) Problems of nutrition in developing countries: Nigeria, a country report. *Seminar Proceedings*.1:1-13. Berlin and Giessen/Germany.

Porres, J.M., Stahl, C.H., Cheng, W., Fu, Y., Roneker, K.R., Pond, W.G and X.G Lei (1999) Dietary phytate protects colon from lipid peroxidation in pigs with a moderately high dietary iron intake. *Proceedings of the Society for Experimental Biology and Medicine* 221:80-86.

Price, K.R., Johnson, I.T. and G.R. Fenwick (1987) The chemistry and biological significance of saponins in foods and feedingstuffs. *CRC Critical Reviews in Food Science and Nutrition* 26:27-135.

Rao, A.V. and M.K. Sung (1995) Saponins as anticarcinogens. *Journal of Nutrition* 125: 717S-724S.

Rao, N.P., Reddy, B.S. and M.R. Reddy (1988) Utilization of autoclaved castor bean meal in concentrate rations for sheep. *Indian Journal of Animal Nutrition* 5:121-128.

Reed, J.D., Soller, H. and A. Woodward (1990) Fodder tree and straw diets for sheep: Intake, growth, digestibility and the effect of phenolics on nitrogen utilization. *Animal Feed Science and Technology* 30:39-50.

Robertson, H.A., Niezen, J.H., Waghorn, G.C., Charleston, W.A.G. and M. Jinlong (1995) The effect of six herbages on liveweight gain, wool growth and faecal egg count of parasitized ewe lambs. *New Zealand Society of Animal Production* 55:199-[illegible]1.

Roeder, R.A., Garber, M.J. and G.T. Schelling (1998) Assessment of dioxins in foods from animal origins. *Journal of Animal Science* 76:142-151.

Rosenthal, G.A. and D.H. Janzen (1979) *Herbivores. Their interaction with secondary plant metabolites*. Academic Press. New York.

Russel, J.B. and D.B. Wilson (1988) Potential opportunities and problems for genetically altered rumen microorganisms. *Journal of Nutrition* 118:271-279.

Russel, R.W. and J.R. Lolley (1989) Deactivation of tannin in high tannin milo by treatment with urea. *Journal of Dairy Science* 72:2427-2430.

Sapkota, A.R., Lefferts, L.Y., McKenzie, S. and P. Walker (2007) What do we feed to food-production-animals? A review of animal feed ingredients and their potential impacts on human health. *Environmental Health Perspectives* 115(5): 663-670.

Shaw, T. and O. Colville (1950). *Report of Nigerian Livestock Mission* pp. 62-67. H.M.S.O., London

Shamsuddin, A.M. (1995) Inositol phosphate has novel anticancer function. *Journal of Nutrition* 125:725S-732S.

Sharma, D.D., Chandra, S. and S.S. Negi (1969) The nutritive value and toxicity of OHI (*Alnizzia stipulate* Bovin) tree leaves. *Journal of Research Ludhinia* 6: 388-393.

Sidhu, G.S. and D.G.A. Oakenful (1986) A mechanism for the hypocholesterolemic activity of saponins. *British Journal of Nutrition* 55:643-649.

Singh, R.V. (1982) *Fodder trees of India*. Oxford and IBH Publishing Co., New Delhi pp. 303.

Singh, B. and T.K. Bhat (2001) Tannins revisited-changing perceptions of their effects on animal system. *Animal Nutrition and Feed Technology* 1:3-18.

Swanson, S.E. (1988) Dioxins in the bleach plant Ph.D Thesis. University of Umea, Sweden.

Swanson, S.E., Rappe, C., Malmstrom, J. and K.P. Kringstad (1988) Emissions of PCDDs and PCDFs from the pulp industry. *Chemosphere* 17:681.

U.S. Food and Drug Administration (2004) FDA Approved Animal Drug Products (Green Book). Blacksburg, VA:Drug Information Laboratory, Viginia/Maryland Regional College of Veterinary Medicine.

Tangendijaja, B., Rahardjo, Y.C. and J.B. Lowry (1990) *Leucaena* leaf meal in the diet of growing rabbits: Evaluation and effect of a low mimosine treatment. *Animal Feed Science and Technology* 29:63-72.

Tanner, J.C., Reed, J.D. and E. Owen (1990) The nutritive value of fruits (pods with seeds) from four *Acacia* spp. Compared with nong (*Guizotia abssinica*) meal as supplements of maize stover for Ethiopian high land sheep. *Animal Production* 51:127-133.

Tewe, O.O. and A.D. Ologhobo (1986) Performance, nutrient utilization, carcass characteristics and economy of production in broilers. *Nigerian Journal of Animal Production* 13:107-111 (Nigeria).

Tewe, O.O. and A.D. Ologhobo (1987) Performance, nutrient utilization and economy of production in broilers fed sweet potato and soyabean-based rations. *Nigerian Journal of Science* 20:48-52 (Nigeria).

Thompson, L.U. (1989) Nutritional and physiological effects of phytic acids. In: *Food Proteins*; Kinsella, J.E., Soucie, W.G., (Eds.); AOCS: Champaign, IL, pp. 410-431.

Vaithiyanathan, S. and M. Singh (1989) Seasonal changes in tannin contents in some top feeds in arid region. *Indian Journal of Animal Science* 59:1565-1567.

Van Bruchem, J., Bongers, L.J., G.M., Lammers-Wienhoven, G.A. Bangma and P.W.M. van Adrichem (1989) Apparent and true digestibility of protein and amino acids in the small intestine of sheep as related to the duodenal passage of protein and non-protein dry matter. *Livestock Production Science* 23(3-4): 317-327.

Van Es, A.J.H. (1980) Energy costs for protein deposition. In: *Protein deposition in animals*, P.J. Buttery and D.B. Lindsay, (Eds.), pp 215-224. Butterworths, London.

Waller, P.J. (1997) Nematode parasite control of livestock in the tropics/subtropics: The need for novel approaches. *International Journal of Parasitology* 27:1193-1201.

Waltner-Toews, D. and S.A. McEwen (1994) Insecticide residues in foods of animal origin: A risk assessment. *Preventive Veterinary Medicine* 20:179-200.

Wegener, H.C. (2003) Antibiotics in animal feed and their role in resistance development. *Current Opinions in Microbiology* 6:439-445.

White, D.G., Hao, S., Sudler, R., Ayers, S., Friedman, S. and S.Chen (2001) The isolation of antibiotic-resistant salmonella from retail ground meats. *New England Journal of Medicine* 345:1147-1154.

Yu, L., Ma, R., Wang, Y., Nishino, N., Yakayasu, J., He, W., Chang, M., Zhen, J., Liu, W. and S. Fan (1992) Potent antitumorigenic effect of tubeimoside 1 isolated from the bulb of *Bolbostemmi paniculatum (Maxim) franquet*. *International Journal of Cancer* 50: 635-638.

Zaghini, A., Martelli, G., Roncada, P., Simioli, M. and L. Rizzi (2005) Mannanoligosaccharides and aflatoxin B1 in feed for laying hens: effects on egg quality, aflatoxin B1 and M1 residues in eggs, and aflatoxin B1 levels in liver. *Poultry Science* 84:825-832.

BIODATA OF
PROFESSOR ANTHONY DUROJAIYE OLOGHOBO

Professor Anthony IbukunOluwa Durojaiye Ologhobo was born on 31 May 1952 in Ibadan, Oyo State. He had his secondary and higher school education at Kings College, Lagos, where he obtained Grade 1 in the West African School Certificate (1967) and the Higher School Certificate (1970). At King's College, he distinguished himself in sports as a member of the senior football team and captain of athletics and hockey team. Thereafter, he proceeded to the University of Ibadan for his Bachelor of Science degree in Agricultural Biochemistry and Nutrition (1974), Masters in Analytical Chemistry (1977) and Ph.D in Animal Nutrition and Feed Toxicology (1981).

Professor Ologhobo joined the services of the University of Ibadan in March, 1981 as lecturer II in Agricultural Biochemistry and Nutrition. He was promoted Lecturer 1 in 1983, Senior Lecturer in 1985 and Professor in 1991. He has produced 15 Ph.D holders till date, out of which 4 are already full professors, two associate professors and five senior lecturers. Two more are likely to join by the end of this academic session.

Professor Ologhobo has made his mark in the academic community with 195 publications in both local and international outlets, out of which 6 are books authored singularly or co-authored with others, 15 Chapters in books and the rest are journal articles. Since attaining professorship in 1991, he has published 146 articles in international journals most of which are quoted worldwide in Standard Science Literature for Tropical Animal Feeds.

Professor Ologhobo was a recipient of Senate Research Grants (four times), three times winner of the Alexander von Humbolt (AvH) Fellowship, three times winner of the Canadian CIDA/NSERC Research fellowship, two times winner of the German Academic Exchange (DAAD) Fellowship; Leventis Foundation Fellowship; Royal Society of London Research

Fellowship; The Netherlands CTA Fellowship; Japanese Science and Technology Agency (STA) Fellowship and the American Senior Fulbright Fellowship. He was the founding Editor-in-Chief of the Tropical Journal of Animal Production (TJAS). The TJAS currently has one of the highest citation indexes among all African journals. Professor Ologhobo is a reviewer to 10 international journals and a technical consultant to many international agencies including the International Atomic Energy Agency. He is a Fellow of the Animal Science Association of Nigeria (FASAN).

Professor Ologhobo facilitated the release of ten million naira grant from the Nigerian Deposit Insurance Corporation (NDIC) for the construction of the new General Studies Programme (GSP) building. He attracted a grant of $50,000.0 (fifty thousand United States Dollars) from the International Atomic Energy Agency (IAEA), Vienna, Austria, for Postgraduate Training of Academic Staff from Njala University, Sierra Leone and another grant of $10,000.0 (US Dollars) from Novus International Inc., USA, to the University for Collaborative Research.

Professor Ologhobo has served his Department, Faculty and University in many capacities. He was Sub Dean, (Post Graduate), Faculty of Agriculture and Forestry (1986-1988); Chairman, Faculty Committee on Restructuring of the Teaching and Research Farm (1994-1995); Chairman, Faculty of Agriculture Committee on Internationalization and Linkage Development (2006-2008); Member of Senate (1986 till date); Director, General Studies Programme (1999- 2005 - Renewed for two terms); Member, Senior Staff Disciplinary Committee (2001-2004), Member, University of Ibadan Governing Council Committee on "Vision and Mission for the University of Ibadan in the 21st Century" (2000-2002). He was also Hall Master, Nnamdi Azikiwe Hall (1993-1999) and General Abdulsalam Abubakar Post Graduate Hall (2006 -2009).

Outside the University, Professor Ologhobo has contributed immensely to other Universities and the Nation in general. He has served as external examiner to Federal University of

Agriculture, Abeokuta; Federal University of Technology, Akure; University of Ilorin; Obafemi Awolowo University; Ambrose Alli University, Babcock University, Ilisan; Delta State University, Asaba, Bowen University and University of Abuja. He served as a member of selection panel for the American Senior Fulbright Fellowship and member of interview panel for Academic Staff, in Igbinadion University. He was a member of NUC Accreditation Team to some Universities in the South South and Chairman of an accreditation team to the North. He was a Visiting Professor to Hohenheim University, Stuttgart, Germany, Pennsylvania State University, USA, University of Alberta, Canada, University of Edinburgh, Njala University, Sierra Leone and Usman Dan Fodiyo University, Sokoto.

Professor Ologhobo is the current Head, Department of Animal Science and Director, Animal Production Venture. He is happily married to Mrs. Veronica Funmilayo Ologhobo and blessed with four children.