IN VITRO AND *IN VIVO* SYNC: THE SYNERGY THAT ACTIVATES THE WORLD

88th

Inaugural Lecture

Delivered by

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DEDICATION

Dedicated to the Almighty God,
my late parents, my wife, children and grand children.

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Provosts of Postgraduate School and Colleges,
Deans of Faculties,
Heads of Department,
Other Members of Senate,
Directors of Units and Programmes,
Distinguished Colleagues (Academic & Non-Teaching from OOU),
Distinguished Colleagues and friends from sister Universities and other Institutions,
Pastors and other Ministers of the Gospel,
Your Excellency, Royal Majesties and Highnesses,
My Lord Spiritual and Temporal,
Family members and Friends,
Gentlemen of the Press,
Distinguished Ladies and Gentlemen,
Great NAASITES,
Great OOUITES,
Great Nigerian Students.

1.0 PREAMBLE

"It is not by power, or by might but by My Spirit says the Lord of Host". I give glory to the Almighty God to whom power, majesty, wealth, honour, dominion, wisdom, knowledge and understanding belong and who makes all things work for good for those who love and fear Him. It is by His special grace that I stand before you this afternoon to present the Inaugural Lecture titled *"In vitro* and *in vivo* sync: The synergy that activates the world" being the **first** in the area of **Nutritional Biochemistry** from Animal Production Department, the **third** from the Department of Animal Production, the **eighth** from the Faculty of Agricultural Production and Renewable Resources and the **fifteenth** from the College of Agricultural Sciences of our great University. Being the 88th Inaugural Lecture, it symbolizes maturity in academic excellence which corroborates recent upward ranking in academia of Olabisi Onabanjo University.

The title of my lecture aims at adding to our knowledge that the entire globe will continue to be a flux in productivity when we know the bio-contents of a "food", "feed" and "feedstuff" and their bio-availability after being mixed in the right proportion.

Mr.Vice-Chancellor, Sir, having an insight into what a locally available feedstuff or biological material can provide to sustain life (animal and human), it will ensure increased productivity which by extension will influence the world. Undoubtedly, there is no better time to draw the attention of this audience to the inseparable relationship that exists between the external and internal environments of a living organism as it affects the dynamics of the entire world. If the nutritional contents of biological materials after chemical elucidation serve as the external environment and their bio-availability and utilization constitute the internal environment, then, their harmonization will have positive effects on both animals and humans thus activating the world.

2.0 INTRODUCTION

It cannot be faulted historically that Agriculture is the first profession ordained and ordered by God because its practice can be traced to the beginning of creation by God as stated in Genesis 2:15 "The Lord God took the man and put him in the Garden of Eden to work it and take care of it". Agriculture and civilization cannot be separated. In fact, the cradle of civilization which is large scale stage of societal development is the alluvial plain created by

Rivers Tigris and Euphrates (Genesis 2:14). The plain is characterized by deposits of sediments (soil nutrients) which stimulated the practice of agriculture thus making agriculture the origin of civilization because agriculture is the bedrock of industrialization.

Mr. Vice-Chancellor Sir, it is also a fact that agriculture gave birth to nutrition. The first nutrition experiment was conducted over 2500 years ago in which Daniel and his three Hebrew friends were the subjects of the experiment as recorded in Daniel 1:5, 8, 12-15 " The king assigned them a daily amount of food and wine from the king's table. But Daniel resolved not to defile himself with the royal food and wine, and he asked the Chief Official permission not to defile himself this way. He requested: Please test your servants for ten days by giving us legume to eat and water to drink. Then compare our appearance with that of the young men who ate the royal food. At the end of the ten days, Daniel and his Hebrew friends looked younger and healthier and better nourished than the young men who ate the royal food"

In addition over 3200 years ago, God as a Nutritional Biochemist, provided the Israelites in the wilderness with quails, as a source of protein; manna as a source of carbohydrate and honey, as source of medicinal substances (Exodus 16: 13, 31).

Mr Vice-Chancellor, Sir, the centrality of the importance of food to man can therefore not be over-emphasized. Universally, food is regarded as the first basic need of man which applies to the people of all creed, irrespective of their race, religion, social status or habitat. Food for all is a necessity like water and air, it should therefore be available to all. Food has been proved severally and globally that it is the body fuel because without fuel, the body wants to shut down. Man, used in generic sense, cannot function productively and creatively without food; but also, it is virtually impossible to have a peaceful and harmonious society where hunger and poverty thrive. The great French Chemist, Lavoisier, is frequently regarded as the founder of the science of nutrition (Maynard, 1954; Kon, 1962). Lavoisier was reported to have established the chemical basis of nutrition in his famous respiration experiments which made Chemistry and by extension, Biochemistry became important tools in nutrition (Nelson and Cox, 2017).

Knowledge of the content of any biological material through chemical analysis outside living organisms (*in vitro*/in glass/ in the test tube) would throw light on the extent of utilization of such material by both animal and humans (*in vivo*/in the living) .Therefore, if the harmony that exists between *in vitro* and *in vivo* is properly harnessed, it would serve as a catalyst that would activate the world. What to analyze include proteins, carbohydrates, lipids/fats, vitamins, mineral elements, enzymes and hormones as gross analysis while as detailed analysis, information on amino acids, monosaccharides, fatty acids, individual vitamins, macro-elements and micro-elements should be known. Many equipment and devices abound that are employed to carry out the analyses. They include atomic spectrophometer, soxhlet apparatus, bomb calorimeter, pH meter and the highly sophisticated and versatile HPLC among others.

It is in this strength that the principle of complementarity emerged. The principle involves combining feedstuffs in which one supplies nutrients that the other lacks. This is the bedrock of nutrition which would provide solution of the problems of food crisis.

It is worthy of note that results of *in vitro* analysis also provide information on endogenous toxic factors which can limit nutritive value of some biological materials by exerting antinutritional effects. Education on the components of hereditary materials, to be precise, deoxyribonucleic acid (DNA) is not left out by *in vitro* analysis. Infact, Pharmacy, Pharmacology and Medicine are also involved. Hence, the ubiquitous importance of *in vitro* analysis is overwhelming and undoubted. As nutrition becomes ever more central to the understanding of virtually all metabolic processes, so also the scientific dimension of the field of nutrition will increasingly dominate the training of tomorrow's nutrition professionals.

3.0 INFLUENCE OF NUTRITION ON ACTIVATION OF THE WORLD

Among myriads of influence of nutrition on activation of the world, the following can be considered as key:

3.1 Food Insecurity:

This can be aptly explained as the situation that arises when people cannot, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for active and healthy life (FAO, 2017). Food Insecurity was also measured by Food Insecurity Experience Scale (FIES) as an indicator which refers to limited access to food, at the level of individuals or households due to lack of money or other resources. The severity of food insecurity measured by FIES is a global measurement standard established by FAO in 2017.

Food insecurity is on the increase, particularly in Sub – Sahara Africa with an increase of almost 3% points from 2014 to 2016. Higher food insecurity was also observed in Latin America, rising from 4.7% to 6.4%. In Asia, the prevalence of severe food insecurity declined slightly between 2014 and 2016 from 7.7% to 7.0% driven mainly by the reduction observed in Central Asia and Southern Asia (FAO, 2017).

Application of FIES data makes it possible to compare food insecurity levels among men and women. The data showed that the prevalence of food insecurity was slightly higher among women at the global level as well as in every region of the world. In April 2016, the United Nations (UN) General Assembly endorsed the outcome documents of the Second International Conference on Nutrition (ICN2), aimed at achieving the global nutrition targets set by the World Health Assembly, and declared the period 2016 – 2025 as the UN Decade of Action on Nutrition (WHA, 2014). The decade marks a new ambition and direction with a view to eradicating hunger and putting an end to all forms of malnutrition, providing a clearly defined time – band, cohesive framework to implement the ICN2 commitments, along with the Sustainable Development Goals (SDGs). It also provides an enabling environment for national, regional and international policies and programmes to respect, protect and fulfill the right of everyone to have access to safe, sufficient and nutritious food consistent with the right to adequate food and the fundamental right of everyone to be free from hunger.

The primary objective of the Decade of Action on Nutrition is for the various countries of the World to increase/improve/sustain nutrition investments, as applicable, in view of its multi-dimensional effects (FAO/WHO, 2017). For instance, children's linear growth in the first five years of life was assessed by the stunting indicator. Stunting is an evidence that children are too short for their age, which in turn is a reflection of a chronic state of undernutrition. This will affect labour productivity, income – earning potential and social skills later in life. If widespread, stunting also drags down the economic development of entire communities and nations. According to the estimates for 2016 released by UNICEF/WHO/World Bank (2017), it is found that 155 million children under five years of age across the globe suffered from stunted growth. Globally, the prevalence of stunted growth fell from 29.5% to 22.9% between 2005 and 2016.

3.2 Global Livestock Population and Productivity: Influence on Human Nutrition

Livestock systems occupy about 30 percent of the planet's ice-free terrestrial surface area (Steinfeld *et al.*, 2006) and are a significant global asset with a value of at least $1.4 trillion. The livestock sector is increasingly organized in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600 million poor smallholder farmers in the developing world (Thornton *et al.*, 2006). Keeping livestock is an important risk reduction strategy for vulnerable communities, and livestock are important providers of nutrients and traction for growing crops in smallholder systems. Livestock products contribute 17 percent to kilocalorie consumption, and 33 percent to protein consumption globally, but there are large differences between rich and poor countries (Rosegrant *et al.*, 2009).

The global livestock sector is characterized by a dichotomy between developing and developed countries. Total meat production in the developing world tripled between 1980 and 2002, from 45 to 134 million tons (World Bank 2009). Much of this growth was concentrated in countries that experienced rapid economic growth, particularly in East Asia, and revolved around poultry and pigs. In developed countries, on the other hand, production and consumptions of livestock products are now growing only slowly or stagnating, although at high levels. Even so, livestock production and merchandizing in industrialized countries account for 53 percent of agricultural GDP (World Bank, 2009)

3.2.1 Livestock Population

In 2016, Spain, Germany, France, United Kingdom and Italy held the largest population of livestock in the EU-28. The highest numbers of pigs were recorded in Spain and Germany (29.2 and 27.4 million respectively), while the highest number of bovines was recorded in France (19.0 million), sheep in the United Kingdom (23.8 million) and goats in Greece (3.9 million) FAO (2016).

Livestock population in the EU-28, for bovine animals, grew by 1.4% from 2010 to 2016, following a slow but relatively stable growth path. From 2015 to 2016, the bovine population remained stable with a decrease of only 0.1%. The population of pigs decreased by 3.4% over the period 2010-2016. The population of sheep fell by 1.5% over the period with slight increase of 1.1% from 2015-2016. The largest relative decrease in the livestock population was reported for goats, with a fall of 3.7% from 2010 to 2016. **(Table 1)**

Meeting the substantial increases in demand for food will have profound implications for livestock production systems over the coming decades. In developed countries, carcass weight growth will contribute an increasing share of livestock production growth as expansion of numbers is expected to slow; numbers may contract in some regions. Globally,, however, between 2010 and 2050, the global cattle population may increase from 1.5 billion to 2.6 billion, and the global goat and sheep population from 1.9 billion to 2.7 billion (Rosegrant *et al.*, 2009). Ruminant grazing intensity in the rangelands is projected to increase, resulting in considerable intensification of livestock production in the humid and sub-humid grazing systems of the world.

3.2.2 Consumption of Livestock Products

As incomes increase, demand for greater food variety grows. Demand for higher-value and quality foods such as meat, eggs and milk rises, compared with food of plant origin such as cereals. These changes in consumption, together with sizeable population growth, have led to large increases in the total demand for animal products in many developing countries, and this trend will continue (FAO, 2010).

Between 1997/99 and 2030, annual meat consumption in developing countries is projected to increase from 25.5 to 37 kg per person, compared with an increase from 88 to 100 kg in developed countries. Consumption of milk and dairy products will rise from 45 kg/person per year to 66 kg in developing countries and from 212 to 221 kg in developed countries. For eggs, consumption will grow from 6.5 to 8.9 kg in developing countries and from 13.5 to 13.8 kg in developed countries (FAO, 2016).

Table 1: Animal Population (1970-2050)

Name of Animal	1970	2010	2030*	2050*
		(Million)		
Buffalo	107	194	272	381
Camels	16	24	30	38
Cattle	1081	1428	1657	2600
Goats	377	921	1088	1232
Pigs	547	965	1174	1383
Sheep	1063	1078	1050	1540
Ducks	256	1876	2036	2876
Rabbits	136	769	1773	2777
Turkeys	178	449	785	1121
Geese	54	359	952	1546
		(Billion)		
Chickens	5.20	9.40	26.40	33.40
		(Billion)		
Total	9.01	26.70	37.40	48.90

*Projected figures using percent increase from 1970-2010

Sources: UN Food and Agriculture Organization, FAOSTAT updated 23, February, 2012.

3.3 Demography and Nutrition

In demographics, the world population is the total number of humans currently living. The world population was estimated to have reached 7.6 billion and it will further increase to 11.8 billion by the year 2100 (UN, 2017). The world population has experienced continuous growth since the end of the Great Famine of 1315 – 1317 and the Black Death in 1350 when it was near 370 million. The highest global population growth rate increase (1.8% per year) occurred between 1955 and 1975 with a peak of 2.06% between 1965 and 1970. The growth rate was reported to decline to 1.18% between 2010 and 2015 and it has been projected to decline to 0.13% by the year 2100 (UN, 2017). However, the global population by the year 2050 was expected to reach between 8.3 and 10.9 billion.

According to the same source, **Table 2** shows the estimates of world's Top Ten most populous countries up to 2030. Inferentially, the interplay between the world population and nutrition would have led to the average global life expectancy of 70.5 years estimated by WHO in 2012. For proper human and livestock nutrition, growth and productivity to be achieved, there would be synergy between demographic record and livestock population/productivity in order to prevent famine and attendant global economic meltdown. This, among other reasons, would have prompted the United Nations at its General Assembly in 2016 declared the period 2016 – 2025 as the Decade of Action on Nutrition (FAO/WHO, 2017).

3.4 Man – Hour and its Effects on Gross Domestic Product (GDP)

It is the amount of work performed by the average worker in one hour (Merriam – Webster Online Dictionary, 2019). It is used to estimate the total amount of uninterrupted labour required to perform a task. Man – hour does not take cognizance of the breaks that people generally require from work. For instance, for rest, eating and other bodily functions. It only counts pure labour. Managers count the man – hours and add break time to estimate the amount of time a task will actually take to complete. The advantage of the man – hour concept is that it can be used to estimate the impact of staff changes on the amount of time required for a task.

This is done by dividing the number of man – hour by the number of workers available. It is often used when considering individual work where the activity being managed consists of discrete activities having simple dependencies and where other factors can be over – looked. It is a globally agreed phenomenon that it will take a person 8 hours to work effectively in a day (OECD, 2009).

Table 2: World Population (million UN estimates)

#	Top ten most populous countries	2000	2015	2030
1	China	1,270	1,376.	1,416
2.	India	1,053	1,311	1,528
3.	United States	283	322	356
4.	Indonesia	212	258	295
5.	Brazil	176	208	229
6.	Pakistan	138	189	245
7.	Nigeria	123	182	263
8.	Bangladesh	131	161	186
9.	Russia	146	146	149
10	Mexico	103	127	148
	World Total	**6,127**	**7,349**	**8,501**

Source: United Nations Publication on Demography (2017)

Mr. Vice-Chancellor Sir, it is not contestable that it is a well nourished person that can work effectively. By inference, nutrition would influence man – hour which will in turn influence the Gross Domestic Products (GDP). The Organization for Economic Cooperation and Development (OECD, 2009) defined GDP as an aggregate measure of production equal to the sum of the gross values added of all residents and institutional units engaged in production. An International Monetary Fund (IMF), European

Union, OECD, UN and World Bank publication states that "GDP measures the monetary value of final goods and services, that is, those that are bought by the final user, produced in a country in a given period of time" (Callen, 2016).

Mr. Vice – Chancellor, Sir, I do not intend to bore us with the history of GDP. The aim is to establish the fact that the importance of GDP had been identified as far back as 1652 (Dickson, 2012). It was in 1944, as reported by Dickson (2012), that GDP became a tool for measuring a country's economy.

3.5 Nutrition and Health

Over the past century, essential nutrient deficiencies have dramatically decreased, many infectious diseases have been conquered and majority of the people all over the world, where the knowledge of nutrition is illuminated, can now anticipate a long and productive life (Fakunle, 2013). Nutrition is therefore important considering consumption of a balanced diet which by corollary is vital for good health and wellbeing. Food provides the body (animals and humans) with the energy, protein, essential fatty acids, vitamins and mineral elements required to live, grow and produce (function properly). There is need for a wide variety of different foods/feeds to provide the right amounts of materials for good health. An unhealthy diet increases the risk of many diet-related diseases (Fakunle, 2013).

The major causes of death, illness and disability in which diet and nutrition play an important role include coronary heart disease, stroke, hypertension, atherosclerosis, obesity, some forms of cancer caused by free radical accumulation, Type 2 diabetes, osteoporosis, dental caries, gall bladder disease, dementia and nutritional anaemia. The equation "Genotype + Environment = Phenotype" where genotype is the internal chemical component of life represented by deoxyribonucleic acid (DNA), environment is feeding/nutrition while phenotype is the observable trait or productivity or GDP, it follows that malnourishment will envelop genotypic expression. Inferentially, illness and disability due to poor nutrition will depress the GDP of a nation, region and the world. The common saying that "a hungry man, is an angry man" is naturally true and practically indisputable. Mr. Vice-Chancellor, Sir, I will hasten to submit that a hungry or under- fed or malnourished person or animal cannot contribute to the GDP of a nation and by extension, the world.

Animal-source foods(ASF) are particularly appropriate for combating malnutrition and a range of nutritional deficiencies. First, ASF are energy-dense and good sources of protein and a large number of key micronutrients, deficiencies of which have severe consequences. Thus ASF can measurably enhance nutritional quality in diets, for especially vulnerable groups such as young children and pregnant and lactating woman. Second, in many cases, nutrients in ASF (eg iron and zinc) exhibit greater bioavailability than those from plant sources. Moreover, meat and fish are effective dietary enhancers of non-heme iron absorption. Third, in undernourished populations, ASF consumption is very low, in both absolute and relative terms. At these levels, moderate increase in ASF consumption provide critical nutritional benefits with little potential of crossing the threshold of significant risk of chronic diseases.

The available evidence indicates that for the diets typical of most poor in developing countries, the beneficial role of meat outweighs the uncertain association with cancer (Biesalski, 2002; Hill, 2002) or cardiovascular diseases (Glew *et al.*, 2001). Finally, the nutrient density of ASF makes them attractive as a food-based intervention for populations that have difficulty consuming large volumes of food, including very young children (who have limited gastric capacity relative to their high nutritional requirement during this stage of rapid growth), and people living with HIV/AIDS whose nutritional requirements can double while at the same time they suffer poor appetite due to secondary digestive tract infections and nausea (Roubenoff, 2000). Efforts are needed to raise awareness among policy makers and researchers about the benefits of ASF consumption for the poor and the negligible risks of negative (nutritional mediated) health impact (and similarly, the small negative environmental impacts of livestock kept by the poor and relative to much larger societal benefits of livestock keeping for their livelihoods).

4.0 MY RESEARCH ACTIVITIES

The field of Animal Science opens the door of animal management involving housing, feeding, health and reproduction with the aim of enhancing production and ensuring sustainability through breeding.

Mr. Vice – Chancellor, Sir, my training as an Animal Scientist spurred my interest in finding solution to the problem of feeding especially in the area of Monogastric Animal Nutrition. The fact that monogastric animals have short generation interval and very prolific, directing effort to increasing their population will provide solution to the problem of inadequate protein intake characteristic of humans in developing and under – developed countries within a short period. It is against this background that I felt seriously challenged to go to probing the nutritional potentials of food resources which when combined, in appropriate proportion, can lead to producing cheap animal feed thereby reducing cost of production of animal products (egg, meat, and milk). To realize this goal, I was fascinated by Nutritional Biochemistry right from my M.Sc tutelage, a field which I have flair for till this very moment, thus triggering the following researches:

4.1 Elucidation of Chemical Components/Nutritional Potentials of Biological Substances and Feeding Trials:

To allow proper utilization, information on the nutrient status of foodstuffs/food resources are undoubtedly useful. Grain legumes should not be left out in the search for this vital information in view of the fact that they are widely cultivated in the tropics and also that legumes are referred to as "the meat of the poor". The high value of lysine in cowpea makes it an excellent improver of the protein quality of cereal grains. Oke *et al.*(1995) found that raw cowpea gave crude protein to range from 25.80% to 28.95% among different varieties while the ether extract ranged from 1.83% to 2.05% and total carbohydrate content averaged 52.72%. My investigation further revealed that cowpea seeds were found to contain appreciable amounts of phosphorus, calcium, potassium, magnesium, iron, copper and zinc required to satisfy human needs but strikingly low amount of sodium **(Table 3).** No wonder therefore that cooked cowpea seeds virtually have no taste.

Table 3 : Mineral Composition of Raw Cowpea Varieties

Cowpea Varieties	TP (%)	Ca (%)	Mg (%)	K (%)	Na (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)
TVU 3000	0.465	0.022	0.382	1.439	0.059	30.20	118.50	4.10	65.80
IT84E 1-108	0.389	0.017	0.351	1.228	0.037	37.80	88.15	6.05	60.20
IT82D-889	0.402	0.020	0.293	1.279	0.058	31.05	116.25	4.55	64.15
IT81D-1137	0.368	0.020	0.299	1.215	0.038	43.95	76.00	5.65	51.20
IT84E-124	0.378	0.018	0.402	1.241	0.038	31.40	90.00	4.40	58.90
IT82E-60	0.409	0.019	0.310	1.168	0.039	36.15	91.20	4.60	56.00
IT81D-1064	0.360	0.016	0.258	1.164	0.046	38.45	87.00	2.90	48.85
IT82D-716	0.387	0.017	0.289	1.192	0.035	30.65	44.55	2.85	44.75
IT82E-16	0.417	0.028	0.321	1.349	0.061	34.15	117.15	6.90	63.85
FEBROWN	0.361	0.018	0.345	1.254	0.048	40.45	96.25	3.15	49.20
Mean	0.393	0.019	0.325	1.253	0.046	35.43	92.51	4.52	56.29
SE of means	0.007	0.001	0.006	0.026	0.001	1.19	2.31	0.24	1.41

Values are means of three determination. TP (Total Phosphorus), Ca (Calcium), Mg (Magnesium), K (Potassium), Na (Sodium), Mn (Manganese), Fe (Iron), Cu (Copper) and Zn (Zinc).

Legumes have low content of sulphur – containing amino acids, but those nutrients can be determined using a rapid method with a view to screening different varieties and identifying those with appreciable concentration. This was achieved through determination of total sulphur of cowpea seeds as percentage of crude protein thus providing information on protein qualify of legumes **(Table 4).** Investigation on the nutrient content of other food resources was not left out. These include cashew nut shell liquid, palm oil, fermented corn cob, kolanut testa meal, sawdust, dried poultry dropping among others. Palm oil was found to be replaceable by cashew nut shell liquid at 3% inclusion level in broiler starter and finisher diets due to the presence of unsaturated fatty acids determined by iodine value thus reducing pressure on the demand for palm oil (Oke, 1993). The proximate composition of corn cob was determined by Adeyemi *et al.* (2008) to assess what it has to offer **(Table 5)** and then fed to weaner rabbits to replace maize. Kolanut testa meal and sawdust were successfully fed to broilers to replace maize (Tables 6 and 15) having determined their chemical compositions (Oke *et al.*, 2008).

Table 4: Seed size, protein weight/seed, total Sulphur and total Sulphur as percent crude protein

Cowpea Varieties	Seed Size (g/100seeds)	Protein weight Perseeds (mg)	Total Sulphur (mg/100g)	%Total Sulphurofraw cowpeaseeds	Total Sulphuras% crudeprotein
IT84E-1-108	13.410	38.000	195.000	0.200	0.690
IT82D-889	10.490	31.000	185.000	0.190	0.640
IT81D-1137	15.070	39.000	164.000	0.160	0.650
1T82E-16	10.980	32.000	182.000	0.018	0.620
Ife Brown	11.960	31.000	153.000	0.150	0.600
Mean	12.380	34.300	175.800	0.180	0.634
SE of mean	±0.600	±1.250	±5.370	±0.010	0.001

Table 5: Proximate and detergent fibre components and gross energy (MJ/Kg. DM) of Corn Cob

	Corn-cob	Rumen- filtrate fermented corn-cob
Dry matter (%)	90.20	88.10
Crude fibre (%)	41.50	26.55
Crude protein (%)	3.15	10.06
Ether extract (%)	1.32	1.00
Ash (%)	2.54	3.21
Neutral detergent fibre	975.00	922.00
Acid detergent fibre	433.50	310.70
Acid detergent lignin	302.00	122.50
Gross Energy	17.10	15.05

Table 6: Chemical Composition of Kolanut testa meal (KTM)

Component	g Kg^{-1} Dry matter
Crude protein (N x 6.25)	132.30
Crude fibre	143.30
Ash	121.20
Ether extract	14.30
Carbohydrates (by difference)	588.90
Metabolizable Energy (keal/kg)	3220.0

Furthermore, Apata and Oke (2012) found that the performance and meat characteristics of broiler chickens fed graded levels of dried poultry droppings meal supplemented with DL- methionine and lysine corroborated the possible replacement of fish meal by fortified dried poultry droppings meal. Evaluation of blood chemistry of albino rats treated with cucumber and water melon extracts; and moringa leaves and seed meals was carried out to confirm that composition of these food resources supported their utilization. In a quest to either reduce/remove methionine inclusion in/from monogastric animals diets due to its being expensive, alternative biochemical means of ensuring its dietary availability was investigated. Being a sulphur – containing amino acid, which has limiting effect on performance, elemental sulphur was added to the diets of albino rats and broilers at graded levels taking cognizance of the percentage of sulphur in one molecule of methionine. It was discovered that 1.5 -2.0% dietary elemental-sulphur level would conveniently replace methionine at 0.5 -1.0% inclusion level (Oke *et al.*, 2017). Outcome of these researches, if adopted by feed millers and stakeholders (Nutritional Biochemists) would activate the world.

4.2 Studies on Toxins and Processing of feedstuffs and food Resources

Having got the knowledge of the nutrient content of food resources, it is not possible to overlook possession of substances that could inhibit utilization of the food resources. This led to the next set of researches. Investigations have revealed that leaving food resources and feedstuffs unprocessed before being fed to animals, especially monogastric animals has led to reduction in bioavailability of their chemical constituents such food resources/feedstuffs investigated include cowpea seeds, jathropha and corn cob to mention a few.

4.2.1 Effect of autoclaving on antinutritional factors

Mr. Vice – Chancellor, Sir, Oke *et al*. (1996) found a startling number of toxins in some feedstuffs and food resources. Legumes are however not left out. They contain trypsin inhibitors, amylase inhibitors, cyanogenic glycosides, haemaglutinins (lectins) polyphenols, saponins, phytins and a host of others. The amounts vary with species and variety, but in general, legumes tend to contain more toxic materials than cereals. The word "toxin" is used to mean any adverse physiological response produced in man or animals by a particular food or a substance derived therefrom. In spite of the presence of toxins, legumes can be safely eaten provided they are well prepared especially by adequate heating (Oke *et al.*, 1996). There were total losses in trypsin inhibitor and lectin activities; and appreciable losses (50 – 70%) in the concentrations of hydrocyanic acid (HCN) while tannic acid and phytic acid recorded losses ranging from 15 to 30% after subjecting raw cowpea seeds to autoclaving (Oke *et al*, 1996) indicating that trypsin inhibitor and lectins are heat labile while tannic and phytic acids are heat resistant but HCN cannot be totally eliminated by heat application. The inference is that to prevent exhibition of deficiency symptoms of the chelated mineral elements following consumption of legumes, dietary supplement should be provided but could be cheaply obtained from leafy vegetables. Therefore, in nutritional context, phytic acid in cooked beans would not pose any threat to health.

4.2.2 Effect of autoclaving on protein quality of feedstuffs

Using albino rats as experimental animals, feed intake, weight gain, protein efficiency ratio (PER), corrected PER (C-PER), net protein retention (NPR), protein retention efficiency (PRE), apparent protein digestibility (AD), true protein digestibility (TD), biological value (BV) and net protein utilization (NPU) were determined by Oke *et al.* (2004) found that autoclaving increased feed intake, protein intake and weight gain appreciably because this processing method (heat applicating) completely destroyed trypsin inhibitor (TI) and haemagglutinin (lectin) while other antinutritional factors were reduced to somewhat low level. Repression analysis results showed that, in the raw samples, TI, tannic acid (TA) and phytic acid (PA) were not significant explanatory variables while lectin and hydrocyanic acid (HCN) were significantly (P< 0.001 and P<0.01) respectively) explanatory variables for feed intake. In the autoclaved samples, though TI and lectin have been destroyed by heat, TA, HCN and PA were not significant variables. Using the quadratic model, response was explained by the correlation coefficient values: TI (raw) , r = 0.08; lectin (raw), r = 0.46; TA (raw), r = - 0.17; TA (autoclaved), r = -0.37; HCN (raw), r = -0.41; HCN (autoclaved), r = -0.42; PA (raw), r = -027; PA (autoclaved), r = -0.35.

In the raw samples, stepwise repression analysis showed that variability in feed intake due to TI was 6.48% while lectin, TA, HCN and PA accounted for 40.31, 1.72, 35.32 and 16.17% respectively. For the autoclaved samples, TA, HCN and PA accounted for 40.38, 35.18 and 24.44% variability in feed intake respectively. It is worthy to note that complete destruction of TI by autoclaving may suggest absence of disulphide linkages which provide structural rigidity characteristic of Bowman – Birk inhibitors. In other words, the cowpea varieties used in the investigation may have preponderant amount of Kunitz inhibitor. Bowman- Birk inhibitor is known for its potency in inhibiting trypsin and chymotrypsin activities simultaneously because if these digestive enzymes are inhibited, protein digestibility would be impaired which would eventually affect feed intake. Another explanation to support effect on feed intake is that the combination of the Kunitz inhibitor with trypsin was accompanied by a decrease in the sum of the free – amino groups which suggests that the combination occurred through ionic groups at pH values below 2.9. Where carboxyl groups were no longer charged, trypsin inhibitor – trypsin complex was completely dissociated showing that TI activity was not undermined. Exhibition of the greatest variability in feed intake by lectin may be explained in terms of the non-specific interference it had on absorption of nutrients

That is, if it combines with the carbohydrate moiety of substances present in the cells lining the intestinal wall, animals may have the tendency to increase its feed intake as exemplified by positive correlation coefficient (r=0.46).

Tannic acid had little or no effect on feed intake in the raw samples probably because it was less potent than TI in combining with protein though a non-significant negative correlation coefficient was obtained and it had adverse flavor potentials which may reduce palatability and acceptability of a diet as a result of its action with proteins of the palate. This may explain the negative correlation. Among other antimetabolities, since trypsin inhibitor had been destroyed during autoclaving, tannic acid being heat-stable was left as the most potent in combining with protein. This is confirmed by the fact that it accounted for the greatest variability in feed intake.

Tannic acid had binding property on dietary protein thus converting it into an indigestible form resistant to the action of the digestive enzymes.
Oke *et al*. (2004) found that protein-tannin complex appeared to be formed by multiple hydrogen-bodning between phenol and hydroxyl groups of the protein peptide bonds of enzyme proteins. Tannic acid reduced trypsin activity and was also bound to dietary protein and inhibit proteolytic enzyme activity. Tannic acid significantly reduced the activities of trypsin and alpha –amylase. HCN was next to lectin in accounting for the greatest variability in feed intake in the raw samples. HCN combined with hemoglobin and that in inhibited the oxygen activating enzyme, indophenol oxidize, thus decreasing the release of energy by oxidation which may result into weakness and anorexia. This may explain the negative relationship between feed intake and dietary HCN content.

Although autoclaving significantly reduced the HCN content in the diet, the residual HCN could still set into motion the trend of events outlined above. That HCN accounted for a significant proportion of the variability in feed intake in autoclaved samples further serves as an attestation to this view. Even though phytic acid had little effect on the feed intake in both raw and autoclaved samples, its influence may not be overlooked. Studies by Oke *et al*. (2004) have shown that formation of phytate-protein complex was the main causal agent of reduction in mineral bioavailability which probably occurred as a consequence of decreased solubility of the complex and possibly digestibility of the protein-phytate metal complex.

The roles of these minerals in adenosine triphosphate (ATP) forming reaction cannot be over emphasized. They catalyse enzymatic steps in the first stage of glcolysis and the oxidation of pyruvate to acetyl- CoA which is the genesis of the Kerbs cycle. Impaired energy production can lead to weakness and slight loss of appetite. This trend of events may therefore explain the observed negative correlation between feed intake and phytic acid content of the diet.

Protein intake:

Protein intake, in the raw samples, ranged from 5.11g to 7.05g 5.03g to 7.80g in the autoclaved cowpea diets. Variety and processing significantly ($p<0.001$) influenced protein intake. Regression analysis results (Tables 8-13) followed the same trend with feed intake in raw and autoclaved cowpeas. It follows that all the reasons

Table 7.1 Effect of autoclaving on the protein quality of cowpea varieties (PER, C-PER, NPR, PRE)

Raw and autoclaved cowpea diets	Feed intake (g)	Protein intake (g)	Weight gain (g)	PER	Corrected PER	NPR	PRE
CASEIN	54.85	7.06	17.84	-	-	-	-
RAW							
IT82D 889	53.21	6.00	7.36	1.23	1.21	2.64	42.27
IT81D 1137	55.31	6.15	6.53	1.06	1.05	2.44	39.01
IT84E 1-108	44.19	5.11	9.76	1.91	1.89	3.57	57.12
IT82E – 16	50.66	5.91	6.70	1.13	1.12	2.57	41.07
Ife Brown	61.42	7.05	8.87	1.26	.24	2.46	39.31
Mean	52.96	6.05	7.84	1.32	1.30	2.73	43.75
Se of Means	±1.06	±0.12	±0.38	±0.04	±0.04	±0.04	±0.62
AUTOCLAVED							
IT82D 889	65.75	7.37	15.39	2.08	2.06	3.24	51.76
IT81D 1137	72.96	7.21	11.14	1.55	1.53	2.72	43.52
IT84E 1-108	54.56	5.03	13.97	2.78	2.75	4.47	71.47
IT82E – 16	59.45	6.79	12.87	1.90	1.88	3.24	51.89
Ife Brown	68.30	7.80	17.35	2.22	2.20	3.31	52.96
Mean	64.20	6.84	14.15	2.10	2.08	3.40	54.32
Se of Means	+1.14	+0.12	+0.46	+0.04	+0.04	+0.06	−0.95

Values are means of six rats. Metabolic (Endogenous) faecal protein

Table 7.2: Effect of autoclaving on the protein quality of cowpea varities (AD, TD, BV, NPU)

Raw and autoclaved cowpea diets	Feed intake (g)	Nitrogen intake (g)	Weight gain (g)	Faecal nitrogen	Urinary nitrogen	AD	TD	BV	NPU
CASEIN	24.97	0.514	8.11	0.040	0.084	92.22	95.19		
IT82D 889	24.42	0.439	4.55	0.106	0.210	75.95	79.08	47.77	37.77
IT81D 1137	25.14	0.447	3.35	0.100	0.217	77.66	81.10	48.02	38.94
IT84E 1-108	20.09	0.372	2.98	0.079	0.164	78.86	82.98	55.91	46.39
IT82E – 16	22.83	0.426	3.14	0.123	0.195	71.10	74.70	47.62	35.56
Ife Brown	27.92	0.512	4.00	0.125	0.225	75.49	78.47	51.16	40.14
Mean	24.08	0.439	3.60	0.107	0.202	75.81	79.27	50.10	39.7
Se of Means	±0.48	±0.009	±0.09	±0.003	±0.004	±0.46	±0.44	±0.67	±0.44
AUTOCLAVED									
IT82D 889	29.86	0.537	6.47	0.095	0.259	82.29	85.14	49.60	42.22
IT81D 1137	33.33	0.528	7.03	0.099	0.238	81.33	84.23	52.87	44.53
IT84E 1-108	24.79	0.366	5.03	0.056	0.162	84.73	88.92	58.96	52.42
IT82E – 16	27.02	0.494	5.90	0.104	0.233	79.01	82.13	49.59	40.72
Ife Brown	31.06	0.0567	7.90	0.109	0.232	80.72	83.42	55.24	47.44
Mean	29.22	0.499	6.46	0.093	0.225	81.61	84.76	53.25	45.46
Se of Means	±0.52	±0.009	±0.09	±0.003	±0.006	±0.50	±0.51	±0.75	±0.83

Values are means of six rats.
Metabolic (endogenous) faecal nitrogen for basal (protein - free) diet= 0.0153

Table 8: Prediction equations and correlation coefficients relating response criteria (y) with trypsin inhibitor (x) in raw cowpea varieties

Dependent variable	Model	Prediction equation	Correlation coefficient
Feed intake	Quadratic	$y = 39.40 + 1.28x - 0.02x^2$	0.076
Protein intake	Quadratic	$y = 5.05 + 0.086x - 0.002x^2$	0.132
Weight Gain	Quadratic	$y = 11.12 - 0.19x + 0.002x^2$	-0.724
PER	Quadratic	$y = 2.23 - 0.06x + 0.001x^2$	-0.617
Corrected PER	Quadratic	$y = 2.21 - 0.06x + 0.001x^2$	-0.615
NPR	Quadratic	$y = 3.96 - 0.09x + 0.001x^2$	-0.502
PRE	Quadratic	$y = 63.9 - 1.46 + 0.02x^2$	-0.500

Table 9: **Prediction equations and correlation coefficients relating response criteria (y) with Hemagglutin (x) in raw cowpea varieties**

Dependent variable	Model	Prediction equation	Correlation coefficient
Feed intake	Quadratic	$y = 140.50 -3.02x+0.02x^2$	0.463
Protein intake	Quadratic	$y = 15.09 - 0.3331x + 0.003x^2$	0.453
Weight Gain	Quadratic	$y = 12.06 - 0.16x+0.001x^2$	-0.099
PER	Quadratic	$y = -0.01 + 0.04x-0.0003x^2$	-0.341
Corrected PER	Quadratic	$y = -0.02+0.04x-0.0003x^2$	-0.345
NPR	Quadratic	$y = -0.66+0.11x-0.001x^2$	-0.398
PRE	Quadratic	$y = -10.40+1.82x-0.01x^2$	-0.404

Table 10: **Prediction equations and correlation coefficients relating response criteria (y) with Tannic acid (x) in cowpea varieties**

Dependent variable	Model	Prediction equation	Correlation coefficient
RAW			
F1	Quadratic	$y = 58.30 - 19.00x + 12.00x^2$	-0.168
P1	Quadratic	$y = 7.02 - 5.00x + 6.10x^2$	-0.112
WG	Quadratic	$y = 3.85 + 30.50 - 49.90x^2$	-0.391
PER	Quadratic	$y = 0.40 + 6.58x - 10.41x^2$	-0.243
C- PER	Quadratic	$y = 0.41 + 6.45x\ 10.21x^2$	-0.241
NPR	Quadratic	$y = 1.54 + 8.15x - 12.50x^2$	-0.137
PRE	Quadratic	$y = 25.50 + 125.00x\ 192.00x^2$	-0.139
AUTOCLAVED			
F1	Quadratic	$y = 94.70 - 117.00x236.00x^2$	-0.371
P1	Quadratic	$y = 8.44 - 10.80x - 17.90x^2$	-0.060
WG	Quadratic	$y = -1.92 + 113.30x - 174.30x^2$	0.083
PER	Quadratic	$y = -0.77 + 20.39x - 32.10x^2$	-0.025
C- PER	Quadratic	$y = -0.77 + 20.17x - 31.75x^2$	-0.023
NPR	Quadratic	$y = 0.07 + 23.40x - 37.20x^2$	-0.057
PRE	Quadratic	$y = 1.20 + 375.000x -596.00x^2$	-0.057

Correlation coefficient values exceeding 0.51; 0.64 and 0.76 are significant at $p<0.05$), $p<0.01$ and $p<0.0001$ respectively.

Table 11: Prediction equations and correlation coefficients relating response criteria (y) with HCN (x) in raw and autoclaved cowpea varieties

Dependent variable	Model	Prediction equation	Correlation coefficient
Raw			
F1	Quadratic	$y = 111.00 - 41.10x + 6.82x^2$	-0.408
P1	Quadratic	$y = 12.31 - 4.48x + 0.75x^2$	-0.377
WG	Quadratic	$y = 9.11 - 0.83x + 0.15x^2$	-0.011
PER	Quadratic	$y = 0.12 + 0.86x - 0.14x^2$	0.206
C - PER	Quadratic	$y = 0.12 + 0.85x - 0.14x^2$	0.209
NPR	Quadratic	$y = 0.10x1.90x - 0.32x^2$	0.267
PRE	Quadratic	$y = 2.10 + 29.90x - 4.94x^2$	0.267
Autoclaved			
F1	Quadratic	$y = 56.30 + 33.\ 90x - 23.30x^2$	-0.419
P1	Quadratic	$y = 12.08 - 8.20x + 3.05x^2$	-0.425
WG	Quadratic	$y = 29.90 - 26.00x + 10.30x^2$	-0.446
PER	Quadratic	$y = 2.30 - 0.37x + 0.19x^2$	0.005
C - PER	Quadratic	$y = 2.25 - 0.34x + 0.18x^2$	0.010
NPR	Quadratic	$y = 2.44 + 1.49x - 0.54x^2$	0.135
PRE	Quadratic	$y = 39.\ 10 + 24.00x - 8.60x^2$	0.135

Table 12: Prediction equations and correlation coefficients relating response criteria (y) with Phytic acid (x) in raw and autoclaved cowpea varieties

Dependent variable	Model	Prediction equation	Correlation coefficient
Raw			
F1	Quadratic	$y = 624.00 - 2.44x + 0.003x^2$	-0.456
P1	Quadratic	$y = 66.10 - 0.26x + 0.0003x^2$	-0.342
WG	Quadratic	$y = -142.60 + 0.67x - 0.0007x^2$	0.081
PER	Quadratic	$y = -42.00 + 0.19x - 0.0002x^2$	0.248
C - PER	Quadratic	$y = -41.20 + 0.19x - 0.0002x^2$	0.250
NPR	Quadratic	$y = -57.20 + 0.26x - 0.0003x^2$	0.288
PRE	Quadratic	$y = -938.00 + 4.31x - 0.0047x^2$	0.298
Autoclaved			
F1	Quadratic	$y = 56.30 + 33.90x - 23.30x^2$	-0.351
P1	Quadratic	$y = 12.08 - 8.20x + 3.05x^2$	-0.035
WG	Quadratic	$y = 29.90 - 26.00x + 10.30x^2$	0.409
PER	Quadratic	$y = 2.30 - 0.37x + 0.19x^2$	0.345
C - PER	Quadratic	$y = 2.25 - 0.34x + 0.18x^2$	0.347
NPR	Quadratic	$y = 2.44 + 1.49x - 0.54x^2$	0.254
PRE	Quadratic	$y = 39.10 + 24.00x - 8.60x^2$	0.254

Correlation coefficient values exceeding 0.51, 0.64 and 0.76 are significant at $p<0.05$; $p<0.01$ and $p<0.001$ respectively

Table 13: Stepwise regression of antinutritional factors with response criteria in cowpea varieties

Dependent variable	CD due to Trypsin inhibitor	CD due to Hemagglutinin	CD due to Tannic acid	CD due to Hydrocyanic acid	CD due to Phytic acid
RAW					
F1	6.48	40.31	1.72	35.32	16.17
P1	3.64	42.89	1.40	39.66	12.40
WG	50.09	5.14	29.45	0.54	14.80
PER	38.99	13.20	15.03	11.01	21.77
C – PER	38.83	13.44	14.83	11.17	21.73
NPP	26.33	23.83	7.75	21.75	20.33
PRE	26.64	23.82	7.22	21.08	21.24
Autoclaved					
F1	-	-	40.38	35.18	24.44
P1	-	-	11.97	86.32	1.71
WG	-	-	44.25	24.30	31.45
PER	-	-	64.79	0.06	35.15
C – PER	-	-	64.69	0.06	35.25
NPP	-	-	64.51	4.17	31.17
PRE	-	-	64.64	4.18	31.17

CD = Coefficient of determination.

advanced for variations in feed intake will apply to protein intake except in autoclaved samples in which HCN accounted for 86.32% reduction in protein intake as HCN intake increased. Since protein was an integral part of the diet, the resultant anorexia due to inactivation of indopheno1 oxidase would tend to amplify reduction in protein intake.

Weight gain:

Weight gain varied from 6.53g to 9.76g in while raw cowpea diets. While in anticlaved samples, weight gain ranged from 11.14g and 17.35g.

Quadratic model regression analysis (**Tables 8 - 13**) revealed that, in raw samples, only tryspin inhibitor had significant (P<0.01) depressing effect on weight gain (r=0.72) while lectin, r=0.10, tannic acid (r= 0.39), HCN (r=0.01) and phytic acid (r=0.08) were not significant explanatory variables. As for the autoclaved cowpea diets, tannic acid (r=0.08, HCN (r= 0.45) and phytic acid (r=0.41) did not have any significant effect on growth. Stepwise regression analysis in the raw cowpea diets revealed that trypsin inhibitor, lectin, tannic acid, HCN and phytic acid accounted for the following respective variability in growth: 50.09%, 5.14%, 29.42%, 0.54% and 14.08% while in the autoclaved samples, tannic acid accounted for 44.25%, HCN accounted for 24.30% and phytic acid accounted for 31.45% variability in growth. Oke *et al.* (2004) found that significant varietal differences in growth as shown in the study may be due to different levels of anti nutritional factors as dictated by genetic make up.

Destruction of trypsin inhibitor and lectin and appreciable loss in HCN by heat application may explain the highly significant increase in weight gain.

The most logical explanation for the growth inhibition of trypsin inhibitors would be that they interfered with the digestion of proteins in the animal gut. Pancreatic hypertrophy observed was due to exogenous loss of protein as a result of repeated intake of trypsin inhibitor thus making the pancreas to become greater in size in order to produce more enzymes. This represents one of the primary physiological factors responsible for the poor growth response on a diet containing raw legumes. Growth response and pancreatic hypertrophy appeared to be highly closely associated. Loss of protein in form of trypsin which is rich in sulphur amino acid would further accentuate requirement for sulphur amino acids that are already deficient in legumes.

Although the weight of the pancreas was not monitored, the relationship established between weight gain and dietary trypsin inhibitor intake (r=0.72) gave attestation to the observation. It is known that the sulphur amino acids, among other essential amino acids, determine the quality of a protein. A good quality protein will however support growth. This view is further strengthen by the highly significant negative correlation between trypsin inhibitor and growth obtained in the research.

The inability of lectin to adversely affect weight gain may indicate its low dietary level since its contents in the raw cowpeas were further diluted by corn starch with a view to preparing a diet with 10%protein. Hence, the low negative effect of lectin on growth (r=0.10) is explanatory enough. Therefore, the effect of lectin to interfere with absorption of digested products non-specifically would be very low. Tannic acid was next to trypsin inhibitor in the raw samples to evoke the observed growth depressing effect. Weight gain was lower for high tannin than for low tannin diets establishing inverse relationship which could be explained that small amounts of phenolic compounds (tannins) when absorbed may be detoxified in a process which utilized methinone as a methyl donor which may increase methionine deficiency.

The relatively negligible growth- depressing effect of HCN in the raw samples could be due to the blanketing effect that trypsin inhibitor and tannic acid might have on it. The negligible growth-promoting effect observed with phytic acid could be ascribed to its non- involvement in nitrogen digestibility.

In the autoclaved cowpea diets, we found that variability in growth accounted for by tannic acid, HCN and phytic acid followed the same trend experienced in raw cowpeas diets except an improvement in this trend as a result of heat application that further decreased the dietary levels of these anti nutritional factors.

PER, C-PER, NPR AND PRE

They are indicators of protein quality based on weight gain and protein consumption (Table 7.1). They were significantly ($p<0.001$) influenced by variety and processing. In the raw samples, PER ranged from 1.06 to 1.91 while in the autoclaved samples, values ranged from 1.55 to 2.78. Similarly, values for C-PER ranged between 1.05and 1.89 in the raw samples. Autoclaved cowpea diets had C-PER values ranging from 1.53 to 2.74. For NPR, raw samples gave values that ranged from 2.44- 3.57. Autoclaved samples followed the same trend such that the values ranged from 2.72- 4.47 in the raw samples, PRE followed this trend with the lowest value of 39.01 and the highest value of 57.12. Autoclaved samples had PRE values ranging from 43.52 and 71.47.

In the raw and autoclaved cowpea diets, trypsin inhibitor, lectin and tannic acid were negatively correlated with PER, C-PER, NPR and PRE while HCN and phytic acid had positive relationship with these indicators of protein quality. All the correlation coefficient values were not significant except those relating trypsin inhibitor in raw samples to PER and C-PER. The inverse relations between TI and PER, C-PER, NPR and PER observed in this study ®= -0.62, -0.62, -0.50, and -0.50 respectively) were in conformity with the findings of numerous workers which could be due to the interference of TI with the digestion of proteins in the intestinal tract of animals.

Mr. Vice-Chancellor, Sir, hepatic hypertrophy represents one of the primary physiological factors responsible for the poor growth response on a diet that contained raw legume seeds. Since these indicators of protein quality depend on weight gain, poor growth would therefore undermine their values. The non specific interference of lectin with absorption of nutrients across the intestinal wall would be reflected in the extent to which the protein is digested. Hence the inverse relation between PER, C-PER, NPR and PRE and lectin in the raw samples.

Tannic acid similarly had inverse relations with PER and NPR in raw legumes. This could be due to the inhibition of trypsin and alpha- amylase thus leading to increased pancreatic secretion of digestive enzymes and their exogenous loss. The same sequence was recorded in the raw samples which served as a reflection of reduced tannic acid level. The observed non-significant direct relationship of HCN and phytic acid to PER, C- PER, NPR and PRE in raw and autoclaved samples could be due to detoxification of HCN when it entered the blood system and the non-involvement of phytic acid in nitrogen digestibility.

Determination of AD, TD, BV and NPU

The summary of the effect of autoclaving on the nutritive value of selected cowpea varieties is given in **Table 7.2**.

Values of feed intake, nitrogen intake, weight gain, feacal nitrogen, urinary nitrogen, AD, TD, BV and NPU are presented.

A critical look at the regression analysis results revealed that feed intake, protein intake, nitrogen intake and weight gain in the raw and autoclaved cowpea diets for all the antinutritional factors followed the same trend. Similarly, PER, C-PER, NPR, PRE, AD, TD, BV and NPU in the raw and autoclaved samples for trypsin inhibitor, lectin and tannic acid followed the same trend. However, differences were recorded for PER, C-PER, NPR, PRE, AD, TD, BV and NPU values in the raw and autoclaved samples with respect to HCN and phytic acid.

Feacal and urinary nitrogen

Nitrogen contents of feaces and urine produced by the rats during collection period are presented in **Table 7.2**. In the raw cowpea diets, feacal nitrogen ranged from 0.079g to 0.I25g while in the autoclaved samples, fecal nitrogen content ranged between 0.056g and 0.109g. Urinary nitrogen in the raw samples ranged from 0.164g to 0.25g. Autoclaved samples gave urinary nitrogen values that ranged from 0162g and 0.259g. There were significant ($p<0.001$) differences between varieties and processing. Generally, urinary nitrogen was higher than feacal nitrogen in the raw and autoclaved samples. Also, fecal Mr. Vice-Chancellor, Sir, Oke *et al*. (2004) found that Feacal nitrogen loss was confirmed by the significant ($P<0.01$) inverse relation between TI and weight gain. This was a manifestation of the fact that the nitrogen which could have been used in body building (growth) was lost in the feaces due to the inhibition of trypsin. More nitrogen was lost through the urine because of exogenous loss of protein by the pancreas due to its hypertrophy. It could also cause diversion of dietary sulphur amino acid from the synthesis of body tissue to the synthesis of pancreatic enzymes. This loss in sulphur amino acids thus serves to accentuate an already critical situation with respect to cystine and methionine content of cowpea protein.

Furthermore, Lectin was found to effect loss of more nitrogen through the feaces than through the urine. Prevention of the absorption of digestion products across the intestinal wall may account for this development. This assertion was confirmed by the fact that Lectin was responsible for the loss of the greatest amount of nitrogen through the feaces than any other anti nutritional factor. Tannic acid contributed more to feacal nitrogen than urinary nitrogen in raw samples and could form a complex with protein thereby rendering the latter resistant to action of proteolytic enzymes. Also, in the raw samples, HCN was responsible for higher urinary nirtrogen than feacal nitrogen due to the fact.
That HCN can be readily absorbed into the blood stream and its detoxification product excreted through the urine. Feacal nitrogen attributed to phytic acid in raw samples was higher than the urinary nitrogen. It serves as an attestation to previous observations in this study.

Since it also forms an indigestible complex with protein, the complex would then be eliminated through the feaces. Tannic acid in the autoclaved samples gave the same trend of events as in the raw samples but the contributions of HCN and phytic acids were reversed in the autoclaved samples. Among these three antinutritional factors, HCN contributed the highest feacal nitrogen level.

If this complex cannot be enzymatically degraded, it will be excreted as such in the feaces.
Phytic acid was found not to have effect on protein quality due to a high correlation between basic amino acid and the amounts of bound phytate. Outcome of the investigation showed that the protein moiety of the phytate- protein complex could be digested by the proteolytic enzymes to release its constituent amino acids, but the last amino acid, residue that remains bound to the phytate could be absorbed into the blood system. It may even be possible that part of the phosphate radicals of the phyphate could serve as a source of energy which may enhance active absorption of the degraded complex across the intestinal wall. If this degraded complex cannot be modified, it would be excreted as such, thus contributing to urinary nitrogen.

From the foregoing, it could be suggested that the nitrogen levels in the feaces and urine could serve as indicators or the extent to which a protein is digested as influenced by a particular anti metabolite.

This measurement could replace the rigorous exercise in measuring feed intake and probably weight gain of experimental animals except there is a strong desire to do so. In the unprocessed and autoclaved cowpea diets, AD, TD, BV and NPU were insignificantly inversely related to phytic acid (r=-0.34, -0.28, -0.04 and -0.15 respectively in raw samples and r= -0.31, -0.23, -0.01 and -0.06 respectively in autoclaved samples). Phytic acid had direct relations with PER, C-PER, NPR and PRE because it has no effect on protein digestibility and quality.
At low pH, that is, pH of the stomach, a strong charge effect has been shown to exist between phytic acid and protein. It was further shown that a strong electrostatic attraction exists between them.

This strong attraction may render the complex resistant to digestive enzymes thereby reducing protein digestibility. Therefore, phytic acid will have inverse relations with AD, TD, BV and NPU as observed in the investigation..

It should be noted however that impairment of protein digestibility by phytic acid as explained above would be minimal judging from the non-significant r values.

Table 14.1: Effect of Oligosaccharide contents (g/100g DM) on Flatus Production (cm^3) in Processed Cowpea.

Cowpea Variety	Autoclaving		Cooking		Germination		Soaking	
	Oligosac	Flatus	Oligosac	Flatus	Oligosac	Flatus	Oligosac	Flatus
IT84E-1-108	2.16	0.53	2.17	0.41	0.22	0.17	5.27	1.40
IT82D-889	1.92	0.42	1.56	0.43	0.18	0.17	4.47	1.06
IT81D-1137	3.13	0.55	2.63	0.47	0.37	0.28	5-9	1.67
T82E-16	2.20	0.46	2.73	0.50	0.40	0.26	5.27	1.19
Ife Brown	1.38	0.53	1.68	0.38	0.13	0.18	3.30	0.89
Mean	2.16a	0.46a	2.15a	0.44a	0.26b	0.21b	4.79c	1.24c
r	0.77		0.56		0.81		0.74	

a,b,c = Means followed by different letters are significantly different ($P < 0.001$).

Table 14.2 Varietal and processing effects on raffinose and stachyose contents of cowpeas (g/100g DM)

Cowpea varieties	PROCESSING					
	Auto-claving)	Cooking	Germination	Soaking	Raw	Mean
Raffinose						
IT84E-1-108	0.61	0.75	0.00	1.86	2.33	1.11a
IT82D-889	0.65	0.46	0.00	1.26	1.85	0.84c
IT8ID -1137	0.95	0.73	0.00	1.83	2.44	1.19a
IT82E – 16	0.74	0.68	0.00	1.40	2.00	0.96b
Ife Brown	0.58	0.63	0.00	0.93	1.25	0.68d
Mean ± SE	0.71 ± 0.04y	0.65 ± 0.03y	0.00z	1.46 ± 0.1[illegible]z	1.97 ± 0.[illegible]2v	0.96
Stachyose						
IT84E-1-108	1.55	1.42	0.22	3.41	3.88	2.10 c
IT82D-889	1.27	1.10	1.18	3.21	3.33	1.82 d
IT8ID -1137	2.18	1.90	0.37	3.76	4.35	2.51 a
IT82E – 16	1.46	2.05	0.40	3.87	4.05	2.37 b
Ife Brown	0.80	1.05	0.13	2.43	2.66	1.41 e
Mean ± SE	1.45 ± 0.13z	1.50 ± 0.12y	0.26 ± 0.03y	3.34 ± 0.13x	3.65 ± 0.[illegible]7v	2.04

Each value is a mean of three determinations a,b,c,d,e = varietal means followed by different letters are significantly different ($p<0.001$). u,v,x,y,z = Processing means followed by different by different letters are significantly different ($p<0.001$).

4.2.3 Influence of processing on flatus production

Flatulence, or the production of gases in the gut, is a common disturbance frequently associated with the consumption of legumes foods. Researches have been directed to this characteristic of legumes because it is widely consumed across all social strata and some individuals develop apathy for bean consumption as a result of gassing that ensues.

Oke *et al.* (1999) confirmed that oligosaccharide fraction of cowpea was responsible for flatus production by rats (Table 14.1). In an attempt to either reduce oligosaccharide content of cowpea to the bearest minimum or completely eliminate it , cowpea seeds were subjected to different processing which include autoclaving, cooking, germination and soaking. Since oligosaccharides are made up of raffinose and stachyose the effect of cowpea processing methods was determined by evaluating their concentration. Average value of raffinose in raw cowpeas was 1.97g/100g DM while average value for autoclaving , cooking, germination and soaking were 0.71, 0.65, 0.00 and 1.46g/100g DM respectively showing germination as the most effective method. As for stachyose, raw cowpea seeds had an average value of 3.65g/100g DM while the average values for autoclaving, cooking, germination and soaking were 1.45, 1.50, 0.26 and 3.34g/100g DM respectively . Germination was again found to be the most effective method. The effectiveness of germination in eliminating oligosaccharide was found to be due to the utilization of glucose and fructose, which are breakdown products of reffinose and stachyose , by germinating seeds. The enzyme alpha-galactosidase present in germinating seeds was responsible for the breakdown of raffinose and stachyose to their constituent units. Oke *at el* (1999) further found that intestinal micro floral in rat was responsible for flatus production which was related to the concentration of raffinose and stachyose after processing. Raw cowpea diet produced an average volume of 1.42 cm while average flatus production by rats fed autoclaved, cooked, germinated and soaked cowpea seeds were 0.46, 0.44, 0.21 and 1.24 cm respectively. Furthermore, taking the raw cowpea diet as the reference point for comparison purpose, average percent flatus produced by processing methods sequentially were 32.60, 31.43, 15.06 and 86.85 % confirming that germination as the most effective method of either appreciating reducing flatus production or eliminating it. The implication of these findings is that since monogastric animals and man do not possess enzymes that could hydrolyse the oligosaccharide, consumption of cowpea seeds would increase having subjected the seed into germination, a process that is adopted in the preparation of infant /baby foods. This would provide job for people by embarking on production of germinated fraction seeds on commercial as the process is simple. Good knowledge of what can pose danger in what is consumed by humans and animals would activate the world.

4.3 Contributions of Agro By-Products to Livestock Production

Mr Vice-Chancellor, Sir, the increasing competition between livestock and man for feedstuff and food resources stimulated the search for the alternative sources of energy, protein, fatty acids, mineral elements and vitamins. As a Nutritional Biochemist, the survival and healthy living of livestock and by extension, human beings calls for a serious concern. Hence, having gotten information on the nutritional potentials of feedstuff and food resources, feeding them to livestock to obtain optimal result was considered as the next step. The principle of " action and reaction are equal and opposite" cannot be jettisoned when it comes to livestock feeding. Whatever is given to the animal in the feed, the animal gives back in form of products.

Under this section it is therefore pertinent to highlight the contributions of agro by-products to livestock production. Feeding finisher diet containing dried poultry droppings meal (DLDM) supplemented with 0.50% methionine and lysine, the birds' performance and meat characteristics were enhanced. The investigation proved that broiler chickens could be fed successfully with DLDM inclusion at 25% supplemented with DL-methionine and lysine (Apata and Oke, 2012). Maggot meal at 50% level of inclusion was found to replace fish meal without deleterious effects on egg production in an experiment involving replacement of fishmeal with maggot meal in cassava - based layers diet (Agunbiade *et al.*, 2007). This investigation would reduce pressure on demands for fish meal which is always expensive to procure and can lead to high cost of poultry production if it is solely relied upon as animal protein source in commercial poultry feeding.

Feedwheat, a by-product of wheat production, was fed to broiler finishers to replace maize. Oke (2006) found that it can completely replace maize as energy source in order to reduce competition between man and livestock especially in broiler finisher diets without having any adverse effects on weight gain since this is the performance index that the farmer is interested in. Cashew nut shell liquid (CNSL) is a by–product of cashew nut processing industry which is normally discarded. Earlier investigation by Oke (1993) showed that CNSL can be included in broiler diet as a good source of unsaturated fatty acid. It was further investigated at higher level of inclusion and it was found to support carcass quality of broilers when neutralized (Oke, 2006). It had been observed (Oladeinde, 2000) that several million tons of corn cobs that had no immediate use to humans accumulate on farm processing units contributing to land and air pollution as sizeable percentage are burnt. Oke *et al.* (2007) fed fermented corn cob to broilers at graded levels and found that the birds can utilize the by – product up to 10% level of inclusion. Correlation coefficient values, r, (0.71 – 0.84) were established between performance indices and duration of fermentation.

In addition, subjecting the corn cobs to processing and fermented by rumen filtrate, they can replace maize at a 50% inclusion level in practical rabbit diets (Adeyemi *et al.*, 2008). That is a way to turn waste into wealth due to the knowledge of the nutrient content of corn cobs. As for sawdust, a timber industry by-product, it is considered an environmental menace which in most timber industries is burnt. Though it has been fed to ruminants in several researches, it is uncommon to include the by-product in monogastric animals' diets. The investigation conducted by Oke and Oke (2007) revealed that sawdust can be included in broiler practical diets to a level of 6 – 8% maize replacement without negatively affecting growth performance indices.

Mr. Vice – Chancellor, Sir, small ruminants' feeding were not left out in my contributions to research. West African Dwarf (WAD) sheep were chosen as experimental animals mainly because of ease of handling for being docile when compared to goats and the cheaper cost of procuring them when compared to cattle. Dry season ruminant feeding is an important factor that cannot be handled with levity and in an attempt to enlist the interest of many people in sheep production, the fear of such people should be allayed concerning feed availability.

Table 15: Proximate Composition of Ogea sawdust

Component	g/kg Dry matter
Dry matter	997.20
Ash	6.40
Crude protein (N x 6.25)	8.80
Crude fibre	676.10
Ether extract	14.70
Total carbohydrates	294.00

Feeding of sawdust to ruminant animals was made possible by elucidation of its nutrient content as shown in **Table 15.** Investigation revealed improved nutritive potential of mixture of sawdust, wheat offal and dried poultry droppings (at equal proportion) when fed with forage without any detrimental effect on growth attributes and nutrient digestivity (Onwa and Oke, 2018). Surprisingly, sheep fed diet containing 60% dried poultry droppings and forage was found to be superior to diet containing mixture of by-products taking into consideration the same performance indices (Onwa and Oke, 2018).. The same trend was observed (Uche and Oke, 2018) for the evaluation of blood parameters of WAD sheep fed the agro by-products. Apiakason and Oke (2018) did not observe any variation in the trend earlier mentioned when carcass quality of WAD sheep fed agro by – products was carried out. However, feeding the same animals with the agro by – products did not affect the sensory evaluation.

Mr. Vice – Chancellor, Sir, recent clashes between herdsmen and some communities in the country precipitated by consumption and destruction of crops by ruminant animals which has led to loss of lives and properties could be reduced or eradicated if agro by-products which are valueless to humans but can be effectively utilized by ruminants and converted to products that can improve the nutritional status of man would bring peace among different tribes, races, social classes and religions thereby activating the world.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Mr. Vice – Chancellor, Sir, from this presentation, it is obvious that with indepth knowledge of the nutritional contents of biological materials, the principle of complementarily would ensure maximum utilization of life-supporting nutrients which would enhance good health, animal and human productivity and global development. Solving the problem of food insecurity would ensure adequate man – hour which would more or less spontaneously increase GDP and thus lead to global economic buoyancy especially in underdeveloped and developing countries. This would bring global peace and consequently activating the world.

5.2: Recommendations

1. To have an uninhibited knowledge of the nutrient contents of feedstuffs and food resources, the concerted efforts of both the States and Federal Governments should be geared towards establishing centres where requisite equipment would be installed for indepth chemical and biochemical assays of feedstuffs and food resources.

2. Wastage should be discouraged in agriculture – based establishments and industries by ensuring optimal utilization of agro by – products with a view to reducing competition between man and animals for conventional food items so that the gap between poor and rich countries would be reduced.

3. Processes that would ensure adequate production and equitable distribution of food resources to increase human productivity through attainment of the globally acceptable man – hour, should be set into motion by further relaxing policies associated with granting of agricultural loan.

4. As human population dynamically increase especially in the under–developed and developing countries, the various governments should be directly involved in food production by providing the necessary incentives and production inputs to agriculture graduates on competition basis in order to produce food abundantly as a deliberate effort to eliminate the problem of food insecurity because a hungry man is an unproductive man. Action and reaction are equal and opposite.

5. There should be legislation by various national governments to limit the number of children that a couple should have in order to curb the disturbing population

explosion being witnessed in under – developed and developing countries.

6. In order to encourage uninterrupted animal protein production in form of eggs, meat and milk, governments should be ready to buy livestock and livestock products from livestock farmers and then sell to consumers at affordable prices. This would ensure raising future generations with high intelligent quotient and good health who would spontaneously contribute to the national GDP thereby activating the world because **"you are what you eat"**.

7. The three tiers of government in Nigeria should allocate at least 10-15% of their budgets to the Agricultural sector so that food, enough to feed the increasing population, would be available in order to make people healthy, ensure adherence to globally approved man –hour, increase GDP and thereby contributing to global development and activation. The disturbing and large number of unemployed youth could be radically reduced if increased budgetary allocation to the agricultural sector is guaranteed, because this sector is globally known as the largest employer of labour.

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