FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

DIETARY CALORIE: THE PILLAR THAT HOLDS NUTRITION IN MAN AND OTHER MONOGASTRICS

By

AYANWALE, BISI ALEX
B.Sc., M.Sc., MBA, PhD
Professor of Animal Production

INAUGURAL LECTURE SERIES 37

29TH OCTOBER, 2015

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

DIETARY CALORIE: THE PILLAR THAT HOLDS NUTRITION IN MAN AND OTHER MONOGASTRICS

By

AYANWALE, BISI ALEX

B.Sc., M.Sc., MBA, PhD

Professor of Animal Production

INAUGURAL LECTURE SERIES 37

29TH OCTOBER, 2015

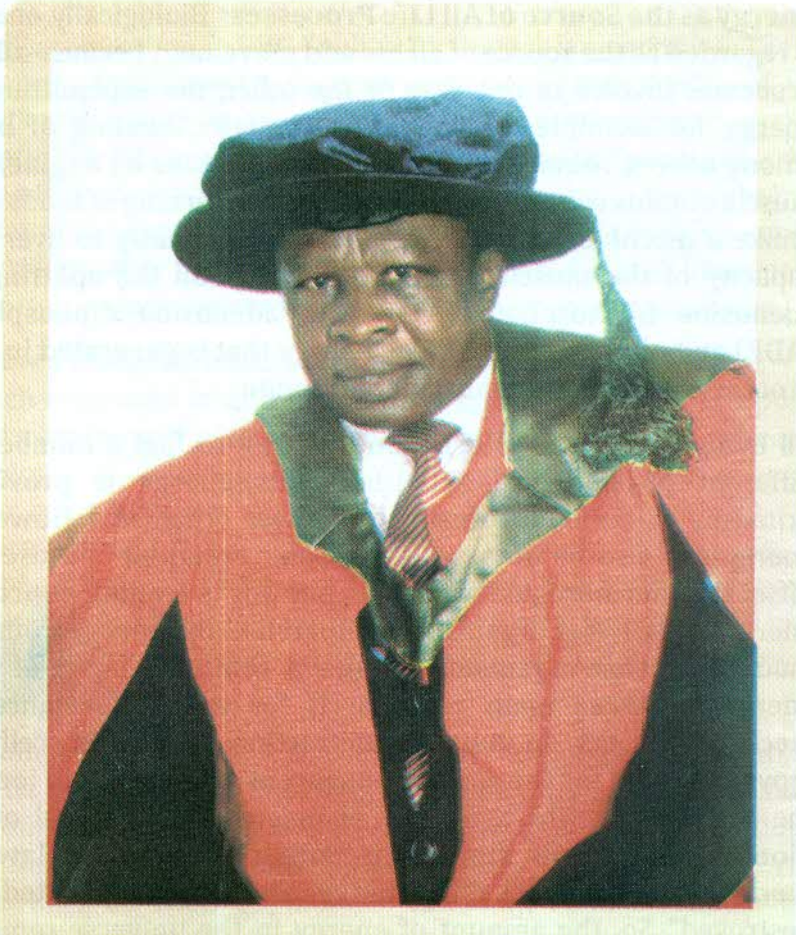
This 37th Inaugural Lecture was delivered under the Chairmanship of:

Professor M. A. Akanji, FNSMBM
Vice-Chancellor
Federal University of Technology, Minna

Published by:
University Seminar and Colloquium Committee,
Federal University of Technology, Minna.

29th October, 2015

Design + Print:
Global Links Communications, Nigeria
✆: 08056074844, 07036446818



AYANWALE, BISI ALEX

B.Sc., M.Sc., MBA, PhD

Professor of Animal Production

INTRODUCTION

Energy as the Source of All Life Processes: Biologically, energy is regarded as the source of all life and movement because all life processes involve in one way or the other, the expenditure of energy, for example, growth, tissue repairs, heating of body among others, require energy expenditure. Like an engine, the muscle obtains energy essentially from the burning of foods. But unlike a machine, animals need energy constantly to live. The capacity of the muscle for work depends on the splitting of adenosine triphosphate (ATP) into adenosine diphosphate (ADP) and phosphoric acid. The energy that is generated in this process is what powers muscle contraction.

All living things use calorie continuously to fuel a number of different physiological activities. This energy is provided primarily by the food consumed by these organisms. However, energy can also be obtained from solar radiation and used to offset the thermoregulation needs but this is a minor source of energy to the living organisms compared to the energy from the food. The living organisms require a continual input of free energy for three main reasons (i) for the performance of mechanical work in muscle contraction and other cellular movements.(ii) for the active transport of molecules and ions in the body.(iii) for the synthesis of macromolecules and other biomolecules from simple precursors. The first law of thermodynamics states that "energy can be neither created nor destroyed". So, the amount of energy in the universe remains constant. However, energy can be converted from one form to another (Jeremy *et al.*, 2002).

The continuous supply of energy that is used by the body is provided through the food consumption. In a short time the two sources of energy may not balance, as the food is eaten in a discontinuous manner. However, the process of digestion tends to even out the energy supply and demand over time. Since animals cannot match consumption with their immediate metabolic requirement there is the need for energy storage.

A pillar according to BBC English Dictionary is a narrow, tall solid structure that is used to support part of a building. A pillar of any particular group is an active and important member of that group. The Bible records that God went ahead the people of Israel in a pillar of cloud to guide them in the day and in the night by a pillar of fire to give them light (Exodus 13:21-22). In this context, the pillar either in form of cloud or fire was to guide or illuminate. The two main purposes which this lecture is set out to achieve.

Today's inaugural lecture centers on food energy, a topic that is so much neglected in nutritional discussions, seminars, symposia and even in most of the students' research studies. The principal objective of choosing this topic is to create awareness or bring into remembrance, for those that know, the significance of energy of food in our daily living. Erroneously, close to 95% of research output in animal production, in recent time, see protein as the sole purpose for conducting nutritional research. It is high time this trend is reversed or modified and food energy is given the required attention.

Attempt will be made in this lecture to restrict the discussion, as much as possible, to food energy or calorie. Food calorie is the amount of energy obtained from food, available through cellular respiration. It is expressed in kilojoules (kJ) or food calories (labeling: EU kcal, US/Canada, calories). Food calorie or the 'calorie' units used often in nutritional contexts, measures the amounts of energy1,000 times greater than the units, in scientific contexts, known as calories or gram calories ('cal'). Food calories are largely referred to, less ambiguously, in nutritional contexts, as kilocalories (kcal). One food calorie is equal to 4.184 kilojoules. The energy requirements of man and animals was originally measured and expressed in terms of "thermochemical kilocalories" until the change to SI (*Systeme Internationale*) units.

Thermochemical kilocalories is usually referred to loosely as kilocalories or 'calories'; and was originally defined as the quantity of heat required to raise the temperature of one gram of water from 14.5 °C to 15.5 °C . The physicists make use of two of such units, one a thousand times greater than the other and is written with capital C while the smaller one is written with small c (Wikipedia, the free encyclopedia).Within the European Union both kilocalorie (kcal) and kilojoules (kJ) appear on the nutrition labels. In many other countries only one of the units is displayed.

In theory, food energy can be measured in different ways, such as Gibbs free energy of combustion or the amount of adenosine triphosphate (ATP) generated by metabolizing the food. Conventional food energy measurement is based on heat of combustion in a bomb calorimeter and corrections that take into account the efficiency of digestion and absorption, urea production and other substances in the urine are made. It is possible to measure the amount of energy associated with any particular food by completely burning the dried food in a bomb calorimeter, a method known as direct calorimetry. Direct calorimetry gives a systematic over estimate of the amount of calorie that actually enters the blood through digestion. This is because it also burns the indigestible dietary fibre and does not account for faecal losses.

Most fundamental works were carried out on the calorie value of foods and feeds by Rubner in 1885 in Germany and by Atwater, 1901 in America. Rubner's analysis resulted in values 4.1 calories (per gram) for mixed proteins, 9.3 calories (per gram) for a variety of fats and 4.1 calories (per gram) for carbohydrates as heat of combustion. Atwater improving on the work of his master (Rubner) analysed the urine of 46 people and arrived at the figures 4.0, 9.0 and 4.0 as the values for calculating available energy values of individual foods. In spite of decades of discussions, interpretations and scrutiny, no significant modifications have been made to the 4, 9, 4 figures for proteins, fats and carbohydrates as the most accurate average figures for use in the calculation of human food values and nutritional needs.

SOURCES OF ENERGY:

The primary source of energy on earth is the electromagnetic radiation from the sun. This is the source of the energy required to sustain virtually all life processes on this planet, ranging from the simplest unicellular micro-organisms to the most complex animals including man, each depends on the combination of solar energy and photosynthetic activity of the plant cells. In the process of photosynthesis, green plants are capable of trapping 1.0 % of the solar energy, CO_2 is absorbed from atmosphere and O_2 is liberated. The radiant energy absorbed by the green plants is transformed into stable high potential chemical energy in a process described as photosynthesis, $6CO_2 + 6H_2O \rightarrow 6O_2 + C_6H_{12}O_6$. For the complete process, sunlight and chlorophyll are very essential. The stored energy of the plants is taken by animals since the animals cannot manufacture their own food due to lack of chlorophyll. When the carbohydrates are ingested and metabolized in the body, the process of photosynthesis is precisely reversed in respiration as follows:

$$C_6H_{12}O_6 + 6O_2 \rightarrow \text{Energy} + 6CO_2 + 6H_2O.$$

Chemotrophs, animals inclusive, obtain chemical energy through the oxidation of foodstuffs generated by phototrophs (Donald *et al.*, 2008). At any given time in cells, thousands of energy transformations are taking place simultaneously. These reactions that transform carbohydrates and fats into cellular energy are called catabolic reactions or catabolism.

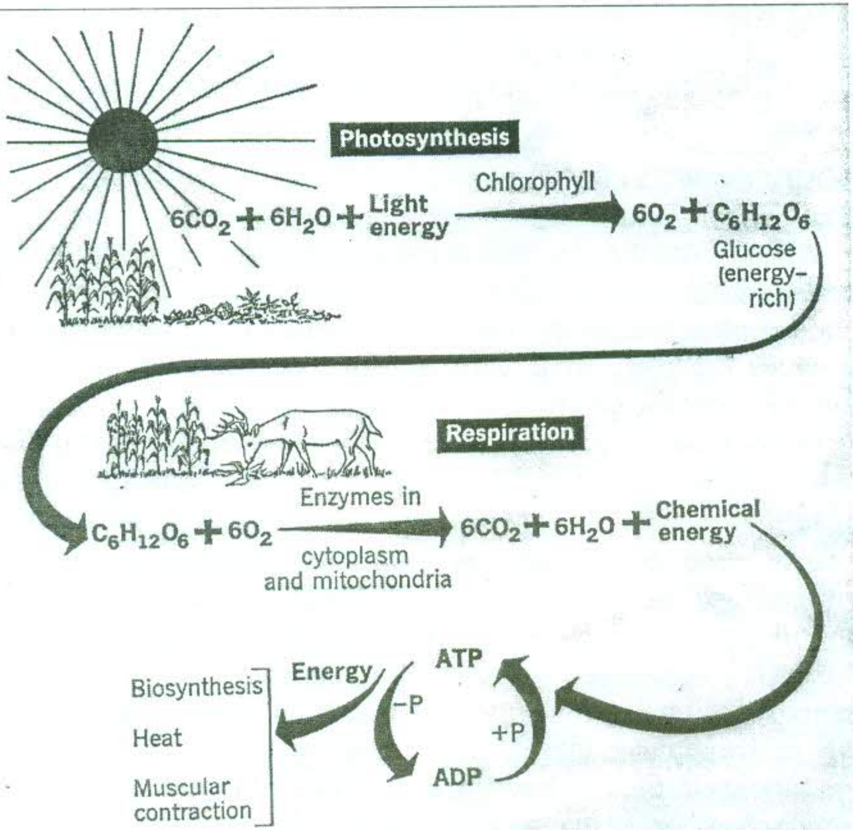


Figure 1: Energy Relationships in Life. Biological Science: An Inquiry into Life

Adopted from Anatomy and Physiology of Farm Animals by R. D. Frandson (1974)

The commerce of the cell metabolism is facilitated by what (Jeremy, *et al.*, 2002) called the energy currency, that is, adenosine triphosphate (ATP). Part of the free energy derived from the oxidation of the foodstuff and from light is transformed into this highly accessible molecule, which acts as the free energy donor in most energy requiring processes such as motion, active transport or biosynthesis. The active form of ATP is usually a complex of ATP with Mg^{2+} or Mn^{2+}. ATP is the primary cellular energy carrier, in which its triphosphate moiety is very important. In addition to this, two important electron carriers, NAD^+ and FAD are derivatives of ATP. ATP is an energy- rich molecule. The free energy liberated in the hydrolysis of ATP is harnessed to drive reactions that require an input of free energy, such as muscle contraction. ATP itself is formed from ADP and Pi, when fuel molecules are oxidized in chemotrophs or when light is trapped by phototrophs. Therefore, the fundamental mode of energy exchange in biological systems is the ATP-ADP cycle. The role of ATP in energy metabolism is therefore of paramount importance to the body.

Fats and Oils as Energy Sources: Fats serve as concentrated forms of energy. Of the three main energy-giving ingredients (carbohydrates, fats, proteins), fat provides the highest quantity of energy (about 2.25 times the energy of carbohydrates) on an equal weight basis. In addition, fats are carriers of fat soluble vitamins (A, D, E & K). Fats were reported to possess "extra caloric effect" (Jensen *et al.*, 1970) while Haroni and Sell (1977) indicated that fats possess "extra metabolic effect." The most plausible explanation for the effects of fats is that supplemental fats reduce rate of food passage through the gut, thereby facilitating more complete digestion and absorption (Mateos and Sell, 1981).

Energy Partitioning: In terms of animal utilization, energy is partitioned into various fractions which include gross energy (GE), metabolisable energy (ME), digestible energy (DE), net energy (NE) and heat increment (HI) (Church and Ponds, 1982). GE represents the amounts of heat released when a substance is completely oxidized in a bomb calorimeter and may not be a useful measure of utilizable energy by the animal. DE is the GE of the feed consumed minus faecal energy while ME is the difference of GE and energy contained in excreta (faecal and urinary energy). True ME (TME) requires the separation of GE of excreta of food origin from endogenous origin. TMEn is TME corrected for protein tissue growth or loss by adding to the excreta energy, the energy equivalent of the nitrogen retained or subtracting from it the energy equivalent of the nitrogen lost (NRC, 1994). NE is the proportion of energy utilized for maintenance and production purpose. NE is ME minus the energy lost as heat increment (HI) (NRC, 1994). HI is the energy cost on feed that may serve to warm the body. HI is the heat produced due to inefficiencies of digestion, nutrient fermentation in the gut and due to metabolic processes. Energy partitioning sketch is shown in figure 2.

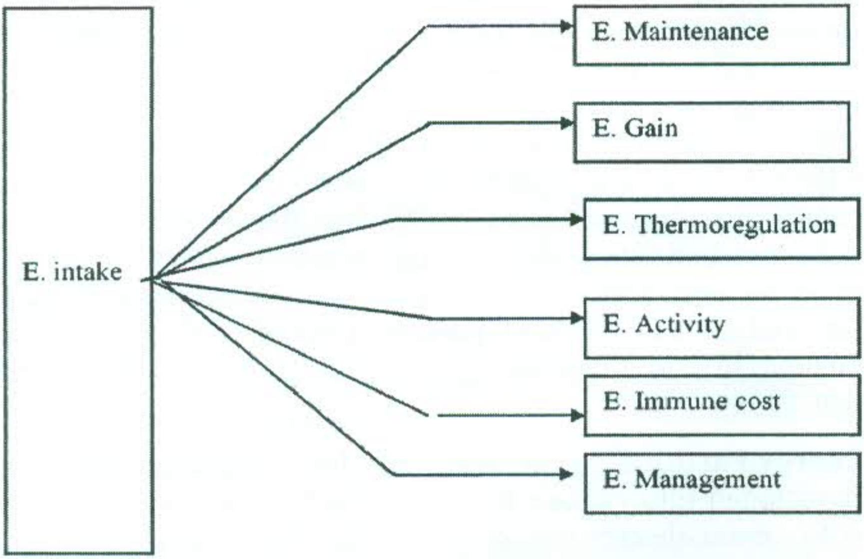


Figure 2: Energy Partitioning Scheme for Broilers

Adopted from Adnan Beker Yousuf (2006)

DIETARY CALORIE: THE MOST CRITICAL SINGULAR FACTOR IN MONOGASTRIC NUTRITION

The discovery that "animals eat primarily to satisfy their energy requirements" as stated by Hills and Dansky (1954) has in no small measure helped the nutritionists in formulating and compounding balanced diets that are adequate in energy, protein and other nutrients for various categories of animals. When fundamental principles of nutrition were put together and when foundations of feeds and feeding were being laid the nutritionists did not lose focus on the overbearing influence of calorie on nutritional requirements. Of all the major dietary nutrients (proteins, carbohydrates, lipids) calorie is considered as the most important factor since energy needs must be met even at the expense of the requirement for any other nutrient. The reasons for these are not farfetched as captured in the subsequent paragraphs.

Energy Consumption Governs the Intake of Other Nutrients: It is a known fact that the governor of food consumption is the calorie of the food. However, the governor of a state could change from time to time but dietary calorie's position as the governor of food intake remains constant and unchanged, just as it is written that neither the pillar of cloud by day nor the pillar of fire by night left its place in front of the people (Exodus, 13: 22). It is also an established fact that nutritional recommendations and allowances are made with reference to dietary energy. The import of this fact is that as you feed high energy diets the other nutrients must increase proportionally and vice-versa since animals eats primarily to satisfy their energy needs. Dietary calorie therefore becomes the yardstick for measuring the needs of animals for other nutrients. The Animal Scientists have discovered that the higher the energy density of the diets the lower the feed intake and vice versa. Excess calorie intake or too little intake is therefore, very detrimental to the health of the animal.

Unlike other nutrients energy is not a specific substance; rather numerous organic compounds can be used to generate energy in the body. Often, it has been suggested that the value of food, primarily depends on its usable energy content. Maynard *et al.,* (1979) emphasized the significant of calorie in nutrition by stating that "of the various nutrient needs for growth, the requirement for energy is far the largest and primarily governs the total food allowance". It is therefore, important to discuss this largest nutritional requirement of man and his monogasric animals.

Requirement for Energy Must First be Met Before that of Protein: It may be shocking to let you know that in spite of all the hues and cries about the protein intake and consequences of its inadequate consumption, the energy needs of the monogastric animals must first, be met before their protein needs. This is because when energy supply is inadequate the available protein will be deaminated to supply energy for the body system. In fact, the early physiologists were of the opinion that proteins were broken down to yield energy in the process of doing a mechanical work by man or animals. This assumption was predicated on the fact that muscle is built by protein and to do work muscle must be broken for energy supply. The assumption was spearheaded by Liebigs. However, Kellener, in 1879 was able to prove that as long as food supply was constant, protein catabolism did not increase by increasing work. The breaking of protein is more complex because the amino acids from protein digestion must be deaminated or transaminated (NH_2 groups removed or exchanged) before further conversions can occur. So, the energetic efficiency of using protein to supply energy is very poor compared to the use of carbohydrates. This means that protein is metabolized less economically for calorie supply, as a dietary constituent, in the presence of fats or carbohydrates. Consequently, when a ration is deficient in calorie, protein has to be 'shunted' into the energy yielding metabolic pathways to make for the required energy. In this process, amino acids can go to pyruvic acid and then form carbohydrates, such are referred to as glycogenic amino acids, others that can form aceto-acetic acid and acetyl –COA are called ketogenic amino acids. The glycogenic amino acids enter glycolysis scheme and back to glucose (gluconeogenesis) and glycogen. The ketogenic amino acids similarly enter the citric acid cycle to yield energy. It is important to note that the reverse reaction does not occur, when an animal suffers from inadequate protein intake, dietary calorie is never used to supply the needed protein, rather there will be over consumption of the diet to meet the calorie needs of the animal. As far back as 1957, Rosenberg and Baldini, reported results obtained with isocaloric diets of different protein levels and indicated that the energy content of the diets governed the methionine (an essential amino) requirement. The three stages of energy extraction from energy substances are shown in figure 2.

Energy Extraction from Foodstuffs: Han Krebs identify 3 stages in the generation of energy from the oxidation of foodstuffs. In stage one, Han, reported that large molecules of food are broken down into smaller units. Proteins are hydrolysed into 20 kinds of constituent amino acids, polysaccharides to simple sugars such as glucose; and fats to glycerol and fatty acids. Stage 2, involves the degradation of the numerous small molecules to a few simple units that play a central role in metabolism. The sugars, fatty acids, glycerol and several amino acids are converted to acetyl unit of the acetyl-coenzyme A (acetyl-COA). Only small amounts of ATP is generated at this stage while in stage 3 ATP is produced from the complete oxidation of the acetyl unit of acetyl-COA. This stage comprises of citric acid cycle and oxidative phosphorylation, which are the final common pathways in the oxidation of fuel molecules. Acetyl-COA brings acetyl units to citric acid cycle (tricarboxylic cycle, or Krebs cycle) where they are completely oxidized to CO_2.

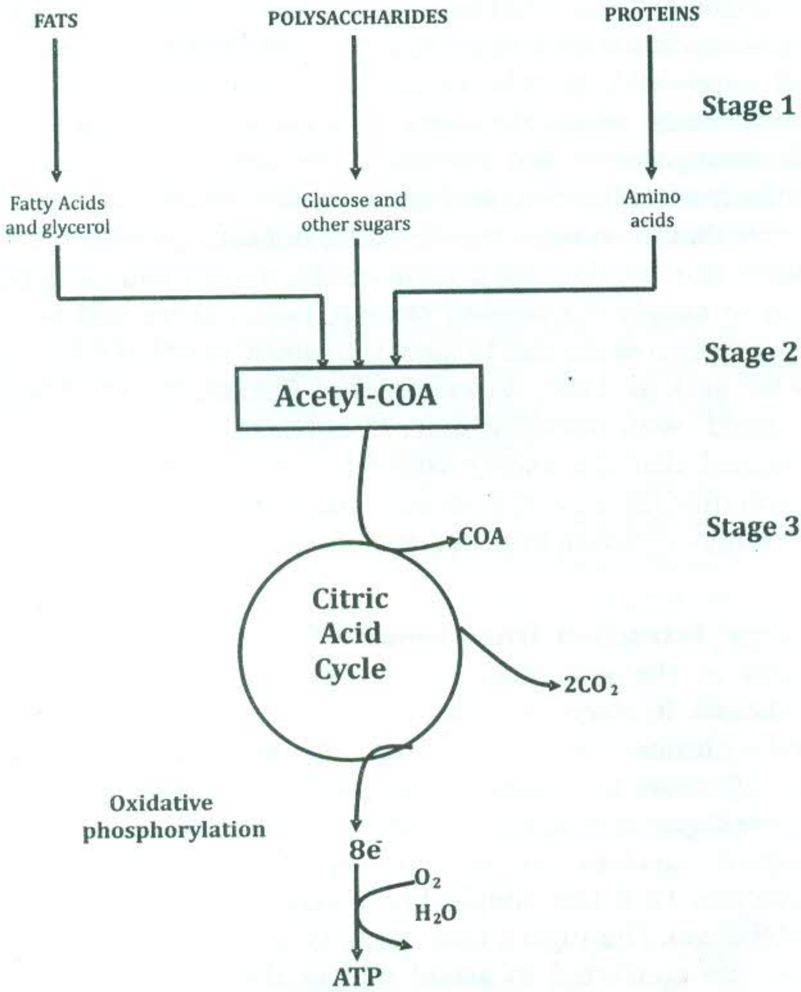


Figure 3: Stages of Catabolism. The extraction of Energy from fuels in three stages:

Source: Jeremy et al. (2002)

The TCA is a central pathway for recovering energy from several metabolic fuels, including carbohydrates, fatty acids, and amino acids that are broken down to acetyl-COA for oxidation. In 1976, Lindsay pointed to the glucogenic nature of amino acids. Since then, it has been shown that a restriction in energy value of the diet can be associated with an increased catabolism of labile proteins in an effort of the animal to correct the caloric deficiency.

Conversely, increase in feed calorie value permits improved utilization of feed nitrogen for synthesis and conservation of body protein. The energy that activates the process of glycolysis comes from ATP which reacts with glucose to form glucose 6-phosphate and ADP. Glycogenesis makes it possible to reverse the formation of pyruvic acid and instead form lactic acid. Fats are hydrolysed to glycerol and fatty acids. The glycerol is transformed to triose phosphate then to phosphoglyceric acid and finally to pyruvic acid, which then enters the TCA cycle. The fatty acids are broken down, 2-carbon atom at a time, in a reaction known as β-oxidation, and form acetyl- COA which is used at the initial step of the Krebs cycle.

The Ideal Balance Diets: The idea that every nutrient must increase or decrease in proportion to the energy density of the diets gave rise to the idea of balanced diets. This means diets that contain energy, proteins, lipids, vitamins and minerals in the right proportions; and in relation to the age, sex, body size and activities of the man or animals.

Dangers of Grossly Excessive and Grossly Deficient Calorie Consumption: Either grossly excessive or grossly deficient calorie consumption are damaging to health. There are available evidences to support the co-existence of calorie- protein malnutrition and mental development of children. But more terrifying to any nation are the long time effects of the child-hood calorie-protein malnutrition. In fact, calorie-protein malnutrition in early life may permanently impair physical efficiency and endurance in life. Therefore, an environment that favours calorie malnutrition often favours poor mental development, because where food is poor, mental stimulation and opportunities for learning may also be poor.

Dietary Calorie for National and International Planning: Dietary calorie is an important standard in terms of National and International Planning. It is needed to estimate physiological and nutritional needs of a population. It can as well be used to set nutritional targets and assess the nutritional needs of any population. It is therefore not out of place to consider food calorie as the most critical factor in nutrition since every action, function, process and even biochemical reactions of monogastric animals and man requires energy supply and expenditure. In view of its importance as enumerated, dietary sources of energy and its consumption should occupy a central position in any nutritional scheme.

Interrelationship of Energy with Other Nutrients: There are numerous interrelationships of food calorie with other nutrients. The interdependence of the utilization of food calorie with premixes (vitamins and mineral combinations) has been well documented (Sibbald *et al.*, 1962a, b; Ayanwale, 1988, 1992). The interdependence of calorie and micronutrients becomes more apparent when intake of one or another is below or above the requirements. Although, vitamins and minerals are not sources of energy their functions are often associated with energy metabolism, since they function as co-enzymes and co-factors of the enzymes systems. Evidences are accumulating which demonstrate that metabolisable energy (ME) of poultry feed ingredients vary according to the nature of materials with which they combine. Sibbald *et al.* (1961; 1962a) demonstrated that calcium, phosphorus, antibiotics and vitamin levels exerted small and variable influences on energy available to the chicks.

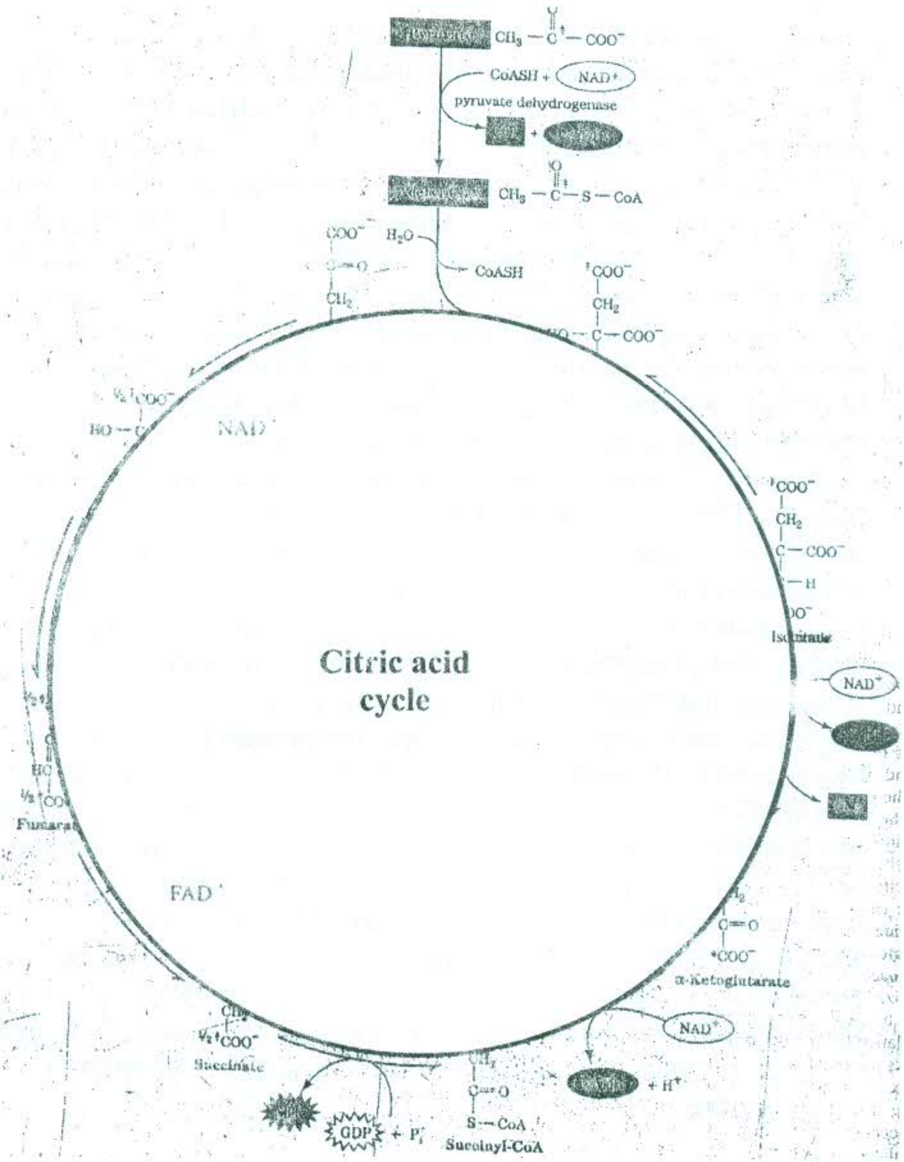


Figure 4: Citric acid cycle. *Adopted from Donald et al, (2008)*

Calorie - Minerals Interrelationship: Sibbald *et al.* (1961) demonstrated that changes in dietary Ca levels affected M.E. values of diets in the presence of chlortetracycline (antibiotic).Calcium serves as a co-factor in several enzyme systems such as, pancreatic lipase, which helps in the hydrolysis of tripalmitin. Lipase, in the pancreatic juice is also the most important fat splitting enzyme of the GIT. Calcium equally activates acid phosphatase that catalyses the hydrolysis of glucose 6-phosphate to glucose and Pi. The various enzymes that are activated by Ca include myosin adenosine triphosphatase (ATPase), succinic dehydrogenase, cholineacetylase just to mention a few. Leach *et al.* (1959) observed increased need for potassium (K) by chicks when a high energy and high protein diet was fed. They noted that K requirement was related to energy content of the diet rather than fat content *per se.* The percent K^{2+} ion requirement was found to be in close agreement with increase in energy content of the diets. Gardiner (1971) found energy and phosphorus interaction to be important in three trials, which support the conclusion that in heavy breeds, at least, the higher the energy level of the diet, the greater the phosphorus requirement. Phosphorus, like calcium, functions in several metabolic pathways. Phosphorus functions in energy metabolism as a component of adenosine monophosphate (AMP), adenosine diphosphate (ADP) and adenosine triphosphate (ATP) which are vital to all life processes (Church and Pond, 1982). Equally, phosphorus is needed in carbohydrate metabolism because the utilization of carbohydrates occurs in the form of sugar phosphate. ADP and creatine phosphate are compounds that are important for utilization of energy of carbohydrates.

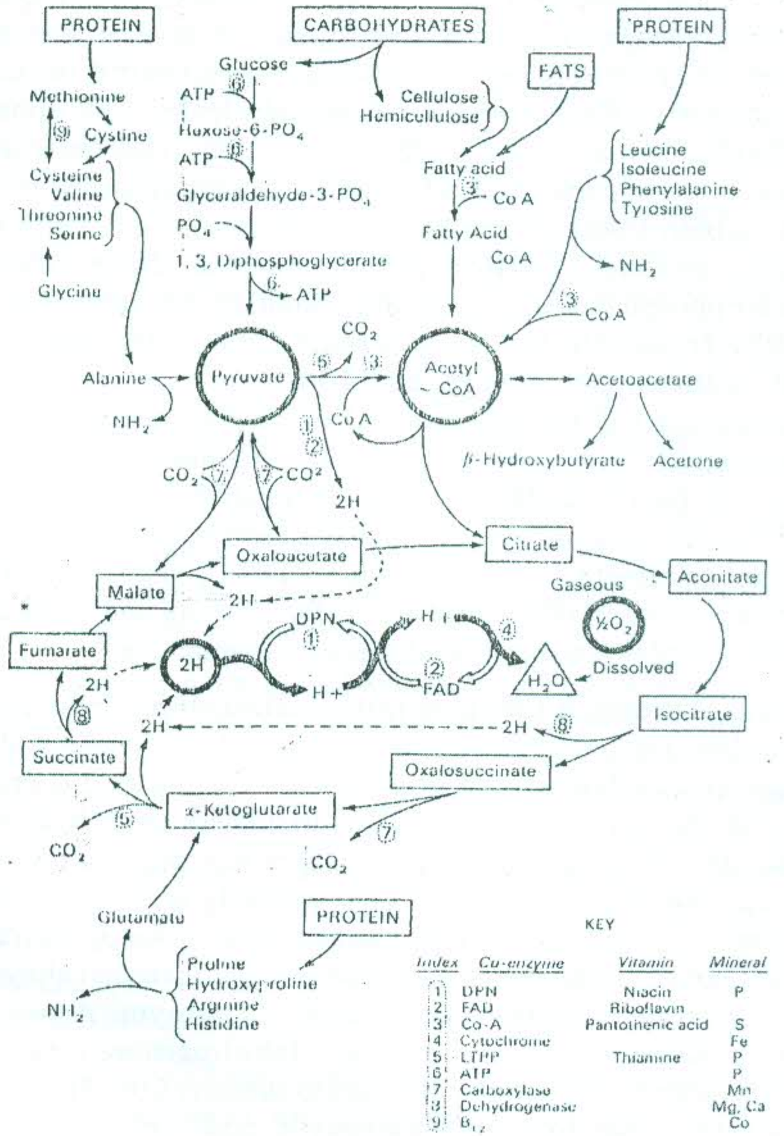


Figure 5. Some Important Pathways of Energy Metabolism
Source: Adopted from Crampton and Harris (1969)

ATP and ADP belong to a group of phosphorus compounds that are the most prominent high–energy compounds in biological systems. Phosphorus, as a constituent of several enzyme systems, is involved in several metabolic processes that include, co-carboxylase, flavo–proteins, nucleotide adenine diphosphate (NADP) (Church and Pond, 1982). Lloyd (1978) reported works in which Magnesium (Mg) activated those enzymes concerned with carbohydrate metabolism. The enzymes include mutases, kinases, enolases, isocitric dehydrogenases, cholinestrases, alkaline phosphatases and arginases. Similarly, phosphorylation of ADP is favoured by Mg^{2+} because the chelation of Mg^{2+} ions with ADP reduces the energy required for ATP formation. Subsequently, Mg^{2+}ion deficiency increased plasma triglyceralde and cholesterol levels. In the heart, Mg^{2+} and phosphate ions are taken up by the metabolizing mitochondria. The uptake is facilitated by Zn^{2+} ions. This Zn stimulated process is propelled by ATP or tetramethyl phenyldiamine (TMPD) ascorbate. The involvement of TMPD ascorbate in the process indicates the regulatory roles of ascorbic acid in energy metabolism.

Calorie - Vitamin B-Complex Interrelationship: Church and Pond (1982) stated that, because pyruvic acid is a key metabolite in energy metabolism and utilization in the citric acid cycle, vitamin B_1 deficiency seriously disturbed carbohydrates metabolism. Physiologically, thiamine acts as a coenzyme known as thiamine pyrophosphate (TPP), which is required by the enzymes pyruvate dehydrogenase and α-ketoglutarate dehydrogenase. The enzyme pyruvate dehyrogenase catalyses the conversion of pyruvic acid to acetyl – Coenzyme A (acetyl-COA or ACOA) while α-ketoglutarate dehydrogenase catalyses the conversion of α- ketoglutaric acid to succinyl-COA. The ACOA is further metabolized in tricarboxylic acid cycle to release energy. The TPP is equally needed in Pentose Phosphate Pathway (PPP) where it serves as a coenzyme for transketolase. In the PPP the hexosephosphate formed are made to release energy when the hexoses from them undergo oxidative degradation. Also, a by-product of PPP is the reduced nicotinamide adeninie dinucleotide phosphate (NADPH) which is used for fatty acid synthesis. Hence, Scott *et al.* (1966) concluded that diets rich in carbohydrates must contain relatively more thiamine. Bro-Rasmussen (1958) studied riboflavin requirement of some animals and found optimum riboflavin requirement to be independent of age or pregnancy provided, the requirement is expressed relative to energy. The influence of increasing dietary energy on the riboflavin requirements of young turkeys was studied by Chu *et al.* (1964). They found growth rate to be related to milligrams of riboflavin per 1000 kcal M.E. than to milligram per pound of ration. Riboflavin functions in the co-enzyme flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN) which occur in a large number of enzyme systems. Both FAD and FMN are related closely in several reactions with niacin enzymes and cytochrome systems especially in tricaborcylic acid (TCA) cycle (Church and Pond, 1982).

Calorie and Growth: Available evidences from researches have shown that diets high in energy content promote more rapid growth and better feed conversion efficiency in chickens than diets of lower energy content. Sunde (1956) showed that rations high in protein but low in energy reduced growth and feed efficiency. Similarly, Farrell (1974) reported that as M.E. concentration of diets increased birds grew faster and required less feed both in total weight and total energy consumption. Llyod *et al.* (1978) asserted that, energy needs of a growing body increases for one or more of these three reasons, viz:

(i) The process of tissue building, food digestion and putting together of different bits of digested food into appropriate molecules which require energy, among other things.

(ii) The synthesis of body lipids require energy and that fat is always formed and deposited as reserve energy to carry the animals in between the feedings.

(iii) As the young animals grow activities normally increase, which in turn, demand extra energy because it requires a speed up of metabolism.

Observations have shown that severe retardations or growth arrest due to failure of glandular secretions is comparatively rare in animals fed adequate dietary calorie. But much more common are the lesser retardations due to under nutrition, either in calorie or in some specific essential nutrients (Maynard *et al.,* 1979). The nature and the extent of the effect on growth are dependent on the character and severity of the deficiency and upon the period involved.

Calorie and Carcass Evaluation: Farrell (1974) demonstrated that body composition of broilers was influenced by both dietary energy concentration and sex. The work showed that yield, energy and fat contents of the carcass generally increased with increasing dietary energy concentrations. A good number of researchers, among them (Sonaiya, 1985) reported works in which diets with more energy gave higher abdominal fat proportions when birds were fed on higher energy diets. Sonaiya particularly reported higher abdominal fat pad in males than in female birds on lower energy diets. In another carcass analysis, some excess calories fed to rats were stored as fat but greater parts were dissipated, presumably by diet-induced thermogenesis. In the group of animals restricted to 50% of *ad-libitum* intake, energy rather than protein appears to be the factor limiting growth (Lunnand Austin, 1983) causing changes in body composition.

Calorie Storage: The energy balance concept means that energy expended will be equal to energy consumed, thereby maintaining the weight at a stable level. Consequently, hard trainings require significant increases in carbohydrate intake to supply energy. Excess energy consumption can be stored in the body, particularly in the form of fat. Sibbald *et al.* (1962a) demonstrated a remarkable difference in the energy storage of Na-supplemented and non-Na-supplemented diets for rats. The average weight gain was 3.5 % and 7.5 % for the sodium supplemented and non-sodium supplemented diets respectively. But more important is the character of energy storage in the form of fat, which was larger with sodium supplemented diets than with Na-deficient diets. Excess energy is stored as fat and not as carbohydrate, because it is more efficient to store energy as fat. The body stores energy in lipid molecules because it is a more stable molecule but proteins are not known for their energy storing ability. Glucose is quickly and easily used in a pinch, so it cannot be properly stored. When the body stores energy as glycogen in the liver or muscles, the stores are one of the first sources of chemical energy when the body has no enough energy. The process of glycogenolysis will then convert stored carbohydrates back into glucose for energy use. The energy

Table 1: The Effect of Energy Restriction on Weight Gain of Rats Receiving a Constant Level of Protein

Group	Protein intake	Energy intake	Protein - Energy	Weight	Mean
Number	g/kgrat/day	kJ/kgrat/day	Total Energy	g/day	SE
1	4.10	2108	0.0300	0.74	0.13
2	4.10	1897	0.0333	0.73	0.22
3	4.10	1686	0.0375	0.65	0.09
4	4.10	1475	0.0429	0.62	0.04
5	4.10	1264	0.0500	0.46	0.07
6	4.10	1054	0.0600	0.19	0.31*
Control	23.40	1953	0.2000	5.43	0.90

Mean values significantly ($P< 0.05$) different from group 1 value.
Source: Lunn and Austin, 1983

An increase in the proportion of body fat was observed in the rats of groups 1-4 which could, in part, be due to excess energy consumption.

Nutritional stunting is a reduced growth rate in human development. It is a primary manifestation of under nutrition. Caloric deficiency can lead to childhood stunting. Stunted growth is defined as, height for age below the fifth percentile on a reference growth curve, meaning to stop, slow down, or hinder the growth in human development. UNICEF in 2013, reported that stunting is the result of having either too few calories, too little variety of food or both of them. In the same 2013, Federal Ministry of Health, Nigeria making reference to the result of the survey stated that 41 % of Nigerians were stunted, 14 % suffer wasting while 23 % were underweight due to malnutrition.

Studies that looked at the ranking of the underlying determinants of stunting in children in order of their potency found dietary energy intake from non-staples to have one of the greatest impacts along with per capita energy supply (Smith and Haddad, 2014), among other factors. Wikipedia, the free encyclopedia, identifies three major causes of stunting to be (i) feeding practices, in which pure lack of caloric intake and other vital nutrients are the causes of stunting. (ii) Poor maternal nutrition during pregnancy which may lead to maternal underweight or anemia and gives rise to stunted children and may perpetuate the intergenerational transmission of stunting. According to United Nations Children Fund (2013) more than 90 % of World's stunted children live in Africa and Asia where 36 % and 56 % of children are affected. Nutrition Landscape Information System (2014) stated that about 162 million children under 5 years of age were stunted in 2012. The most tragic aspect of stunting is the fact that stunted children may never regain the height lost as a result of stunting and most of them will never gain the corresponding body weight. In which case, stunting and its effect become permanent. Very worrisome is the fact that stunted growth can even be passed to the next generation, a situation called "intergenerational cycle of malnutrition" (Nutrition Landscape Information System, 2014).

Bulkiness and Cost of Feed Ingredients: It is no exaggeration to say that the energy giving ingredients form the greatest bulk of the formulated and compounded feeds given to the animals under confinement. My survey shows that energy giving ingredients forms about 50.0 to 80.0% in some of the finished feeds. Considering the song of Animal Nutritionists in Nigeria that feed cost occupies about 70.0 to 75.0 % of the total cost of animal production in Nigeria; one can then understand the magnitude of the critical role the food calorie is playing in our quest for adequate protein supply and consumption. As long as the costs of energy giving ingredients are high and are on the increase, and the ingredients are scarce and expensive, the cost per kilogram of meat cannot come down, more people will suffer protein deprivation in their diets and more children will suffer from marassmus and kwashiorkor due, largely to scarcity and prohibitive costs of energy giving ingredients and poor understanding of calorie as the pillar of nutrition in all monogastric diets. This existing gap was what led to the following series of investigation on calorie.

MY CONTRIBUTIONS

I have been able to make a modest contribution to knowledge in the areas of research, training and community services.

RESEARCH: The title of my first study, starting in 1984, was "Energy Content of Meat and Meals from Six Secondary Schools at Six Locations in Ibadan" (Ayanwale, 1985). This title incidentally is the pivotal title for this inaugural lecture today. It actually opened my eyes to the short comings encountered in the course of our feedings. It provided answers to some questions that have long agitated my mind concerning growth inequalities in animals and man in my early days in life. The study bailed me out of certain nutritional ignorance. Two locations, indigenous and none-indigenous areas in Ibadan were considered for the study. Three schools were chosen from each of these two locations. The schools chosen from each of the locations comprised of one boys only, one girls only and a Boys and Girls Secondary School. A survey carried out before data collection indicated that an average of 50 kobo food was purchased per student per meal in each of the schools. This information formed the basis for the quantity of food used in the study. The study was conducted for five months, December, January, February, April and May. Gross energy in kilocalorie per kilogram was determined by completely combusting a known quantity of the meat and meal in Ballistic Atomic Bomb Calorimeter on weekly basis for the five months of the experiment.

At the end of the work, the results obtained indicated that there were variations in energy intake by the students from different meals at different schools in different locations but with no definite trend. That the locations, school types and months of the year had real influences on the energy consumption in the study areas (figures 6-11). That the intake of energy from meat and meals was below the recommended levels in the types of school considered. It was observed then that the problem of inadequate energy intake was aggravated by the strongly biting economic measures of that time. The problem was compounded by the simple reason that some students preferred buying non-food materials, such as, table tennis eggs, chewing gums, cleaners and pencils and other writing material with part of their money for food. Painfully, it was realized that some of the students did not know the health hazards or damages that could result from poor energy consumption. The study then recommended a system of food subsidies, if not outright free feeding for school meals in each type of schools in the different locations; to be provided by the government of that time.

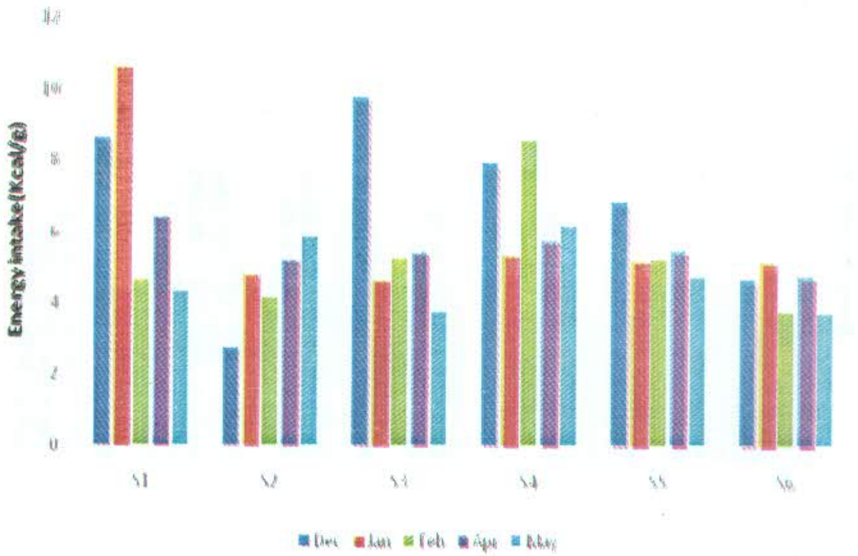


Figure 6: Energy from Porridge Meat as Percentage of Daily Recommended Energy

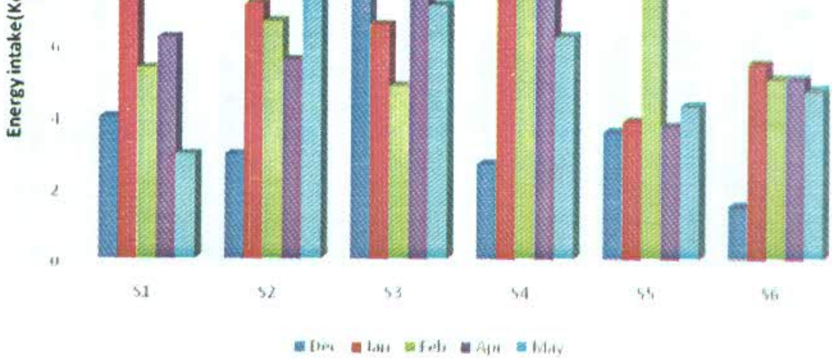


Figure 7: Energy from Rice Meat as Percentage of Daily Recommended Energy

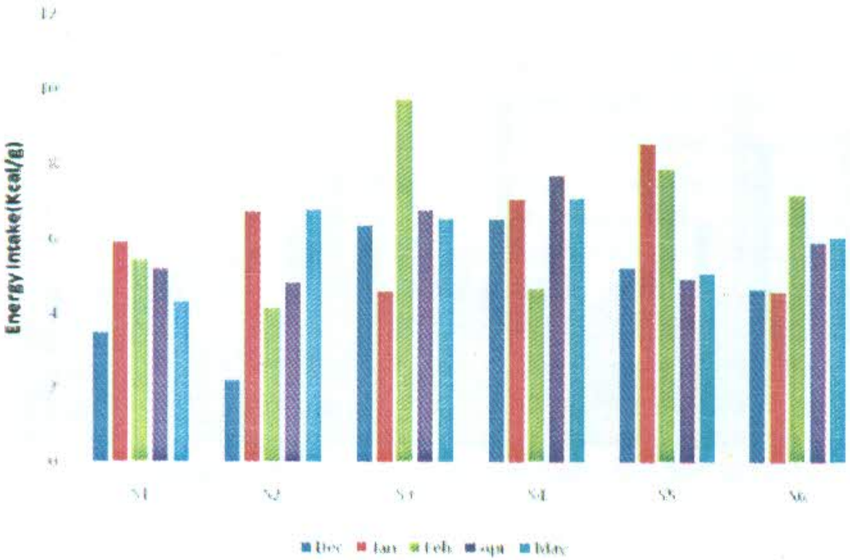


Figure 8: Energy from Bean Meat as Percentage of Daily Recommended Energy

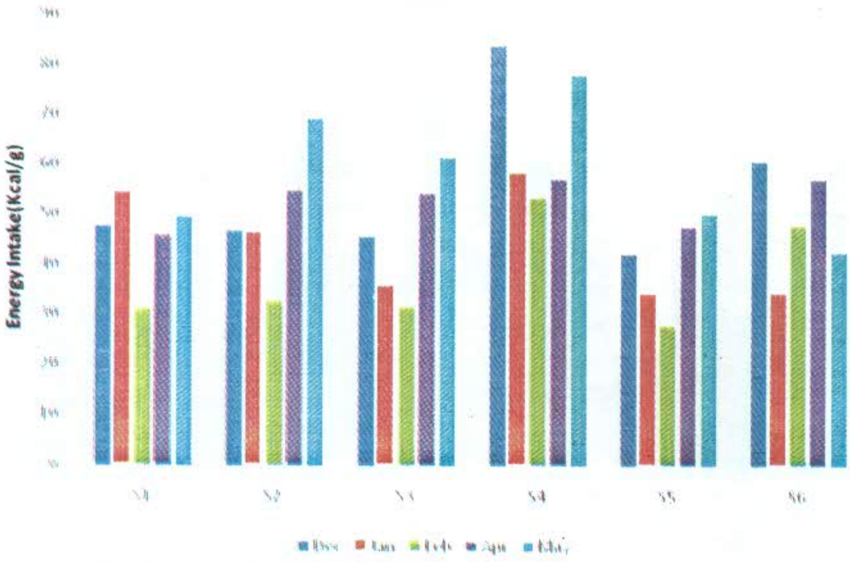


Figure 9: Energy from Porridge as Percentage of Daily Recommended Energy

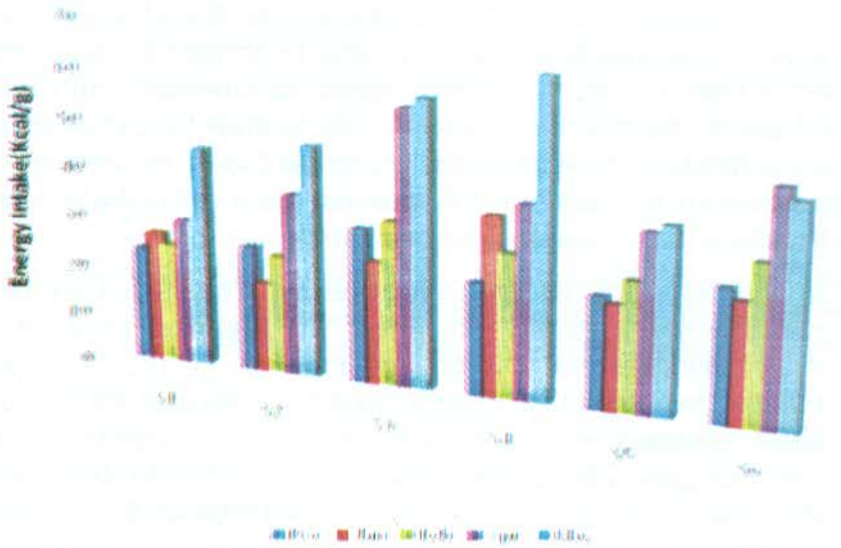


Figure 10: Energy from Rice as Percentage of Daily Recommended Energy

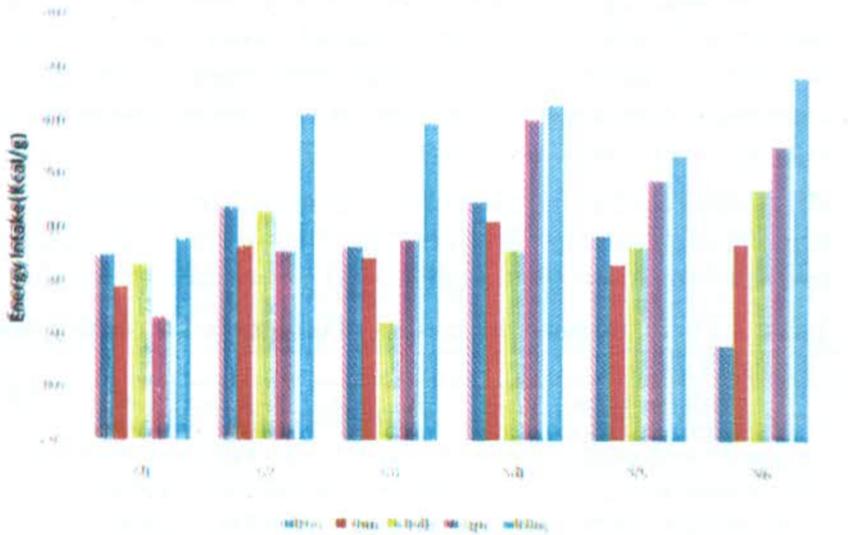


Figure 11: Energy from Beans as Percentage of Daily Recommended Energy

It was equally recommended that students should be guided on how to purchase foods that will give them optimal nutritional advantage. A clarion call was made for adequate nutritional education, for no greater favour could be done for a child than to train him/her to realize, the essential foods, to inculcate by practice a proper attitude towards foods that will make for a good health and happiness in later years of life.

In another study, energy utilization by Broilers fed on Three Premixes was critically examined. The premixes used for the study had different vitamin and mineral compositions, with some of them replete in vitamins and minerals that are known to affect energy metabolism while others are deplete in such combinations. The vitamins that were identified to significantly affect energy metabolism were thiamine (Vitamin B_1), riboflavin (vitamin B_2), pantothenic acid and niacin (known as nicotinic acid); and formerly called vitamin G. Many minerals are of great importance in the process of energy metabolism. They include calcium, phosphorus, potassium, magnesium, sodium, iron, copper and zinc. However, some of them are supplied in monogastric animal diets through other supplements such as bone meal, oyster shell, limestone, among others. Some of them are not usually included in the dietary premixes.

Three diets containing each of the premixes were formulated for starting and finishing broilers. The diets were made isocaloric and isonitrogenous (Ayanwale, 1988). The results are as follows:

Table 2: Performance Parameters of boilers fed three premixes

PREMIXES				
Parameters	**A**	**B**	**C**	**SEM**
Initial body weight(g)	33.0	34.0	34.0	-
Final body weight (g)	1450	1423.0	1410.0	0.80
Total feed intake (g)	5094.0^{a}	4187.0^{ab}	3996.5^{b}	3.60
Live weight gains (g)	1418.0	1389.0	1376	0.51
Feed/gain ratio	3.59^{b}	3.0^{a}	2.90^{a}	0.18

a, b Mean values with different superscripts in the same row differ significantly ($P<0.05$)

The results clearly demonstrated that the three premixes with the different inclusion levels of vitamins and minerals differently affected energy utilization by the broilers. It was noticed that premix A-fed broilers had higher body weight, consumed significantly ($P<0.05$) higher feed but with poorer feed efficiency than others (Table 2). Broilers fed premixes with adequate supply of vitamin B components had better results than the one with lower Vitamin B values. The results obtained were then attributed to the ability of the premix to supply sufficient quantities of vitamins-combinations for carbohydrate metabolism.

A more detailed work on this important topic of energy utilization by broilers fed different premixes was published by Ayanwale (1997) titled "Energy utilization by broilers fed different micronutrient mixtures". In the study, three commercial micronutrient mixtures designated, A, B and C was evaluated in terms of broiler performance, and energy efficiency. The study was conducted using randomized complete block design. The diets were isocaloric and isonitrogenous for the starter and finisher diets. Each of the diets contained one of the three micronutrient mixtures. The diets were formulated to conform to Oluyemi and Roberts (1979) standards for broilers raised in warm wet climate. A total of 180 brown hypeco broilers were randomly allotted to three treatment groups in three replicates. The micronutrients being supplied by each of the mixtures were carefully compared with NRC (1977) recommendations. The micronutrient mixtures were chosen in a manner that, macronutrient mixture A contained micronutrients that were above NRC (1977) recommendations, B contained micronutrient mixtures that compared well with the recommendations while C contained micronutrient mixtures that were below the NRC (1977) as shown in Table 3. The recommendations per 100 g of diets were, 0.81, 0.36, 0.30, 2.70, and 4.0 mg for thiamine (vitamin B_1), riboflavin (Vitamin B_2), niacin (Vitamin B_3), pyridoxine (Vitamin B_6) and zinc respectively. The results showed that mixture B fortified with better vitamin- mineral combinations in the diet produced broilers with significantly ($P<0.05$) higher body weight than others which is more noticeable at the finisher phase (Tables 4 & 5). In a similar work, Lockhart *et al.* (1966 a, b) while feeding different vitamins reported that accentuated deficiency of each of thiamine, pyridoxine, riboflavin, pantothenic acid and niacin either by deprivation or depletion caused a reduction in the amount of metabolisable energy obtained from the basal diets by poultry birds. Their reports are in consonance with the results of this study.

The effect of feeding three commercial premixes on energy efficiency at two developmental stages of broiler rearing was studied (Ayanwale and Ogunmodede, 1999). In the work, three different brands of commercial premixes containing different vitamin and mineral compositions were included in different diets of broilers and fed at starter and finisher stages in two replicates in a completely randomized experiment. The work was designed to proffer solutions to the peculiar problem of the feed industry at the time, due to the ban on some of the agricultural inputs in which case a farmer could start raising broiler with a brand of premix and end up with another.

This work was then designed to take cognizance of this situation and examine the effects, using a split plot design experiment, as shown in figure 12.

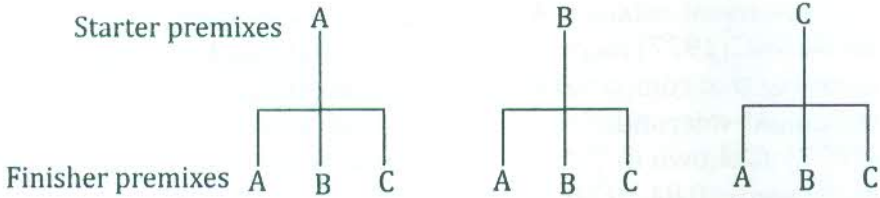


Figure 12: Allocation of premixes and experimental design

Table 3: Micronutrients that Affect Energy Utilization Contained in 100 grams of the Diets

Micronutrients	Mixture A Starter & Finisher	Mixture B Starter & Finisher	Mixture C Starter & Finisher	
Thiamine	-	-	0.15mg	-
Thiamine as NRC %		83%	-	
Vitamin K	-	-	0.20mg	0.30mg
Vitamin K as NRC %	-	-	400%	566%
Riboflavin	1.20mg	1.00mg	0.60mg	0.25mg
Riboflavin as NRC %	333%	277%	166%	69%
Pyridoxine	2.80mg	2.00mg	0.35mg	0.03mg
Pyridoxine as NRC %	933%	666%	166%	10%
Niacin	4.40mg	4.00mg	3.50mg	0.08mg
Niacin as NRC %	163%	148%	130%	30%
Pantothenate	1.0mg	-	-	-
Capantothenate	1.0mg	-	-	100
Zinc	-	-	112	11
Copper	0.4mg	250	250	50
Iron	8.0mg	87	87	62

Source: Calculated from National Research Council (1977)

Table 4: Performance parameters of the experimental broilers

Parameters	Starter Phase				Finisher Phase			
	A	B	C	SEM	A	B	C	SEM
Mean body weight (g/bird)	195.20^{a}	199.3^{a}	177.5^{a}	4.34	856.90^{b}	888.98^{a}	823.70^{c}	5.43
Mean feed intake (g/bird)	235a	251.19a	255.26^{b}	11.72	754.08^{b}	766.31^{a}	729.16^{c}	10.14
Mean weight gain (g/bird)	98.20	101.5	88.30	4.14	157.7	170.70	159.70	4.08
Feed efficiency	2.45	2.45	2.66	0.13	4.73	4.51	4.55	0.10

a, b Means in the same row with the different superscripts differ significantly ($P<0.05$).

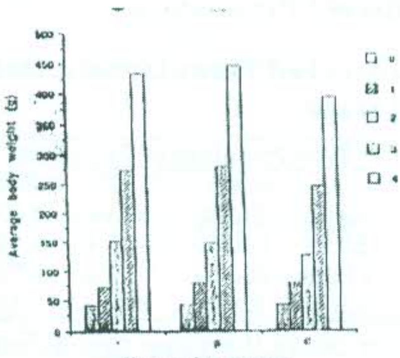
Table 5: Energy Efficiency of Broilers Fed Different Micronutrient Mixtures

	Starter Phase				Finisher Phase		
Parameters	**A**	**B**	**C**	**SEM**	**A**	**B**	**C**
Mean daily feed intake(g)	46.70a	68.26a	62.26b	1.10	117.41a	118.84a	114.47±0.76a
Mean daily energy intake(kcal/g)	194.10a	204.79a	187.18b	3.31	340.49a	342.66a	332.82±4.20b
Mean daily weight gain(g/bird)	22.93b	24.93a	21.51c	0.45	26.56b	28.70b	26.31b±0.51b
Energy efficiency	8.46b	8.21c	8.70a	0.05	12.81a	12.01b	12.02±b

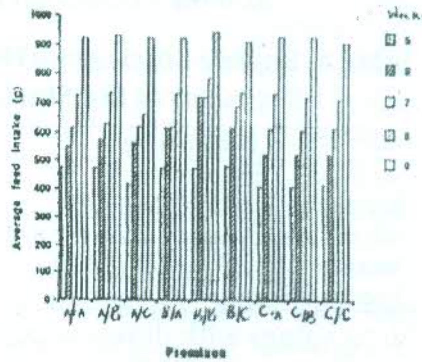
a, b Mean values with different superscripts in the same row differ significantly ($P<0.05$).

The work evaluated growth rate, feed and energy consumption and body weight gain within the period of feeding trial along with energy efficiency of the feeds. The findings pointed to the fact that broilers fed the diets containing premix B at the two developmental stages had better weight gain (20.59g/day), consumed more dry matter(56g/day) and energy (168 kcal/day) with better energy efficiency (Table 6) than broilers in the other treatment groups. It was also discovered that energy efficiency was improved when broilers were finished with the premix containing higher vitamin- B supplements irrespective of their starting premix (Table 7). The poorer performance of broilers fed diets containing premix A or C was attributed mainly to their deficiency of thiamine and marginal deficiencies of other energy related micronutrients leading to nutrient imbalance. The pattern of growth is as indicated in figures 13 for the two developmental stages of starter and the finisher.

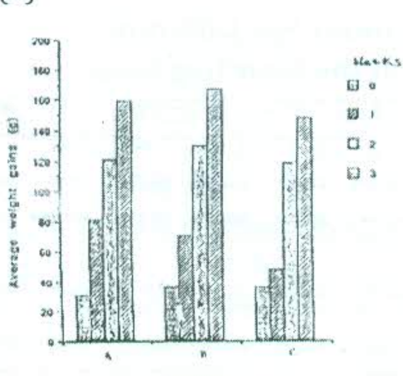
The pattern of growth as shown by the results (figure 13) for the starting and the finishing stages indicated that broilers fed the B premix containing adequate levels of the B-vitamins had higher body weights, gave better feed efficiency and energy utilization compared to birds in the other groups. This is an indication that the feed was better utilized for growth due to better efficiency of energy utilization based on vitamin and mineral composition of the diets (Table 6).A close look at the composition of the tested premixes pointed to the deficiency of thiamine (Vitamin B_1) in premixes A and C. Vitamin B_1 is a major co-enzyme in the metabolism of pyruvic acid, which is the main metabolite, in energy utilization in TCA cycle. Physiologically, thiamine pyrophosphate (TPP) is required by pyruvate dehydrogenase and α - ketoglutarate as co-enzymes (Church and Ponds, 1982; Lehninger, 1987).



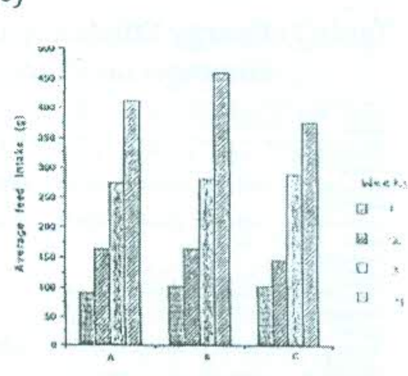
(a)



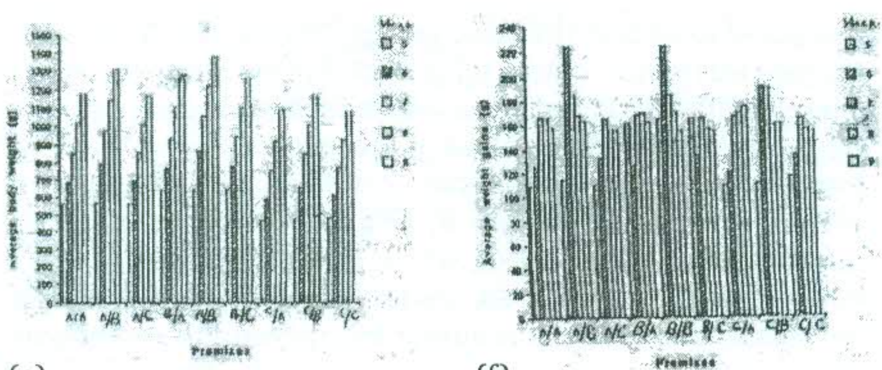
(c)



(b)



(d)



(e) (f)

Figure 13: Bar Charts Showing the Effects of Changing the Starter Premix on Different Parameters

Table 6: Energy Efficiency of Broilers Fed Three Commercial Premixes at the Starting Stage

Parameters	Type Premixes of Premixes			
	A	B	C	SEM
Dry matter intake(g/day)	53.05	56.00	53.40	1.83
Metabolisabe energy intake (kcal/day)	59.15	168.00	160.5.49	5.49
Mean body weight gain (g/day)	19.00a	20.50a	18.75a	0.51
Energy efficiency	8.39a	8.16b	8.54a	0.17

Mean values with different superscripts in the same row differ significantly ($p<0.05$).

Table 7: Energy Efficiency of Broilers Fed Different Commercial Premixes at the Finishing Stage

Premixe fed at starter	A	A	A	B	B	B	C	C	C	SEM
Premixe fed at finisher	A	B	C	A	B	C	A	B	C	
Dry matter feed intake (g/day)	103.32^{d}	101.56^{b}	107.12^{b}	110.9^{a}	104.61^{dc}	111.42^{a}	103.53^{d}	104.03^{de}	111.96^{a}	0.90
Metabolisable energy intake/day (kcal)	299.63^{d}	294.52^{d}	310.64^{b}	321.62^{a}	303.38^{c}	323.12^{a}	300.25^{d}	310.7^{d}	323.23^{a}	2.60
Mean body weight gain (g/day)	23.64^{dc}	23.95^{c}	26.46^{a}	23.61^{dc}	26.02^{a}	26.34^{a}	23.33^{c}	23.06^{dc}	24.52^{b}	0.31
Energy efficiency	12.73^{c}	12.29^{d}	13.16^{ab}	12.15^{d}	11.63^{a}	12.26^{d}	13.02^{ab}	12.93^{ab}	13.15^{a}	0.12

Values denoted by different alphabets in the same row differ significantly ($p<0.05$). SEM is the standard error of mean

Lockhart *et al.* (!966a, b) had earlier reported a similar condition in which accentuated deficiency of each of thiamine, pyridoxine, riboflavin, pantothenic acid and niacin either by deprivation or depletion had caused a reduction in the amounts of metabolisable energy obtained from the basal diets by the poultry birds. In addition to lack of thiamine in premixes A and C, they were equally marginally deficient in Vitamins B_3 and B_6 against NRC (1984) recommendations. It should be borne in mind that premix C is over loaded with vitamins A and K, which are of less importance as far as energy metabolism is concerned. This overloading can result in hypervitaminosis A thereby engender nutrient imbalance with adverse effects on efficiency of energy utilization for growth. It was equally observed that changing from premix A or C to B at the finishing stage of broiler rearing improved energy availability but not *vice versa*. In the recommendations, farmers, feed millers and premix users were advised to always seek for premixes replete with adequate amounts of the required vitamins before purchase and use for poultry diets.

The effect of alkaline treated soyabean meal on the performance, protein and energy utilization of starter broilers

In the study, soyabean seeds were divided into 4 batches. Soyabean seeds in batch 1, were autoclaved at 100 °C (control), the other batches were soaked in aqueous solutions of 3% concentrations of Sodium Chloride, Trona or Sodium Sesquicarbonate ($Na_2CO_4NaHCO_3.2H_2O$) and Alum ($Al_{2(}SO_4)2.24H_2O$) and designated as T1, T2, T3 and T4 respectively, for 24 hours, brought out, air-dried and milled. These soyabean preparations were used in formulating four isocaloric and isonitrogenous diets for this study. All birds were raised on deep litter system. Feed and water were supplied *ad-libitum* as recommended by Oluyemi and Roberts (1979) for birds raised in warm wet climate. These results (Table 8) indicated superior energy efficiency by the birds fed the alkaline treated soyabean diets. This was attributed to the release of some mineral elements such as Mg^{2+} and Na^{+} ions, some of which serve as co-enzymes and co-factors of the enzyme systems when available and are involved in both energy and protein metabolism (Llyod *et al.*, 1978; Church and Pond, 1982); and their levels in the diets affect feed energy utilization.

These results agreed with the findings of Laurena *et al.* (1969) and Nelson *et al.* (1976) that soaking legumes in alkaline salts lowered the effects of endogenous anti-nutritional substances found in them.

Table 8: Energy and Protein Efficiency of Starter Broilers Fed on Soyabeans Treated with Different Alkaline Salts

Parameters	T1	T2	T3	T4	SEM
Dry matter intake (g/day)	32.85	31.28	32.63	31.31	1.22
Energy intake (Kcal/day)	116.12	90.40	96.42	94.89	4.3
Weight gain(g/bird/day)	16.85a	13.84b	16.44a	16.21a	0.32
Energy efficiency	7.00a	6.46ab	5.86b	5.85b	0.17
Nitrogen retention (%)	66.28	66.67	66.49	66.49	1.54
Protein efficiency ratio	2.12^{a}	1.83^{b}	2.09^{ab}	2.14^{a}	0.12

a, b, Mean values with different superscripts in the same row differ significantly ($P<0.05$)

It was concluded that for better energy efficiency starter broilers should be fed on soyabeans treated with the appropriate concentrations of alkaline salts.

Effect of Feeding Sodium Sesquicarbonate Treated Soyabeans on Energy Utilization and Performance of Broiler Chickens

The idea of this study was first muted at the University of Ibadan as part of my PhD proposal to provide an easy method of calculating energy efficiency. The study also observed that the potential value of soyabeans in animal nutrition is on the increase but that raw soyabeans must be processed to remove the anti-nutrients including polyphenols and trypsin inhibitors. The common methods of soyabean processing traditionally known include soaking and boiling but they have their limitations. Boiling uses fuel or fired woods which are scarce and expensive (Omueti *et al.*, 1992). Heat treatment may not be of any advantage since when heat processing is applied below or above a required level protein availability and solubility were adversely affected. Singh (1988) demonstrated that addition of alkaline salts such as sodium bicarbonate was effective in reducing soaking and cooking time for many legumes. But processing of soyabeans with a strong alkaline like phosphate resulted in decreased protein quality, loss of amino acids and reduction in lysine (an essential amino acid for poultry) availability (Friedman *et al.*, 1976). Sodium sesquicarbonate (trona) is a cheap alkaline salt, commonly used as a flavouring agent and as a tenderizer in cooking legumes and vegetables (Buchanan, 1969). The enhancement of nutritional and organoleptic properties of cowpeas by alkaline salts was demonstrated by Uzogara *et al.*, 1988; 1991). It was however, feared that alkaline processing of soyabeans could have undesirable nutritional and toxicological consequences as expressed by Friedman (1976).

Preparation of Sodium Sesquicarbonate Solutions: Aqueous solutions of Sodium Sesquicarbonate ($Na_2CO_3NAHCO_3.2H_2O$) were prepared by adding 0.0, 5.0, and 10.0 g of powdered Sodium Sesquicarbonate to 1,000.00 milliliters of water at room temperature to obtain 0.0, 0.5, and 1.0 % solutions respectively. Raw local variety of soyabean seeds were divided into 4 parts. Each part was then soaked in each of the prepared solutions for a period of 24 hours. After, the soyabeans were brought out of the solutions, drained and air-dried. The soyabean seeds after proper drying were ground and used in the formulation of 4 isocaloric and isonitrogenous diets containing about 3000 (kcal/kg) M. E. and 22.0 % protein.

Feeding Trial: Total of 120 Avian broiler chickens were randomly allotted to the diets at the rate of 30 broiler chicks per diet in 3 replicates. Starter diets were fed for 35 days while finisher diets were given from 36 to 63 days. Feed and water were supplied *ad-libitum* to the birds. The birds were raised in conformity with Oluyemi and Roberts (1979) methods. Weekly data collections were on mean body weight, feed consumption and body weight gain and feed to gain ratio were obtained by calculation. The graphs of body weight, feed intake and weight gain of the birds are presented in figures 14 - 16; the performance results are shown in Table 9 while carcass evaluation results are indicated in Table 10. The energy efficiency results are shown in Table 11.

When I started my study on energy utilization by broilers, I was seriously disturbed by inability to lay my hands on a simple methodology for calculating energy efficiency. After many days and months of rigorous thinking (meditation) an idea occurred to me which I borrowed from the determination of protein efficiency ratio method. It is simply like this, that protein efficiency ratio (PER) is calculated as:

Protein efficiency ratio (PER) = $\frac{\text{Protein intake (g)}}{\text{Weight gain (g)}}$ (Maynard *et al.*, 1979).

Where protein intake is, dietary protein content (dry matter basis) grams × percentage protein content of the diets.

The PER equation has been widely used as one of the equations for calculating protein quality in animal nutrition. In the course of my research and with the dire need for me to calculate energy efficiency, after a thorough search of the literature, I decided to use a similar method to obtain energy efficiency; to avoid the complex mathematical calculations which has been the crux of energy efficiency determination.

Energy efficiency was then calculated as,

$$\text{Energy efficiency (EE)} = \frac{\text{Energy intake (kcal/g)}}{\text{Weight gain (g)}}$$

Where energy intake is, feed intake (dry matter basis) grams× metabolisable energy (kcal/g) (M.E) of the diets.

This equation was used to present my proposal at my ph. D defense and was accepted. Therefore, I decided to put it forward more explicitly in one of my publications and it was equally accepted as Ayanwale (2003).

Carcass Evaluation: At the end of the feeding trial, two birds were randomly selected per replicate and fasted for 12 hours (overnight). Their feathers were removed by scalding. They were cut open at the abdominal region with a sharp knife. Each of the internal organs (livers, kidneys, lungs, hearts and gizzards) was removed weighed, labeled and expressed as percent of their live weights. Other parameters measured were average weekly feed consumption, body weight and weight gains. Energy efficiency was calculated over a period of 28 days (Ayanwale, 2003).

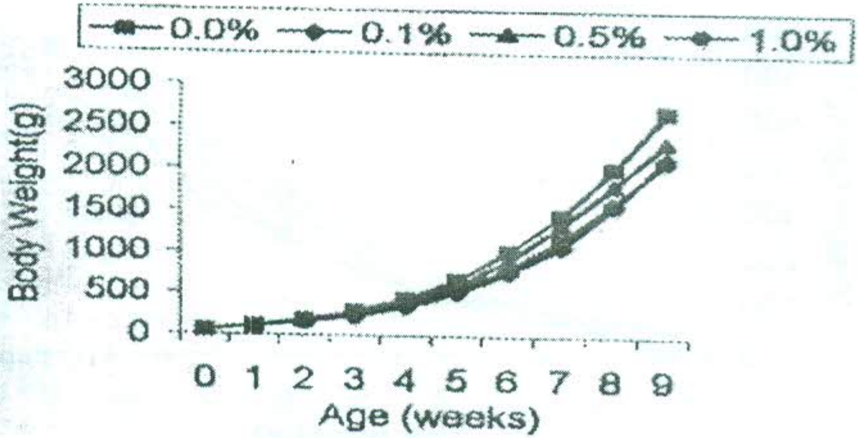


Figure 14: Mean weekly body weight of broilers fed soyabean treated diets

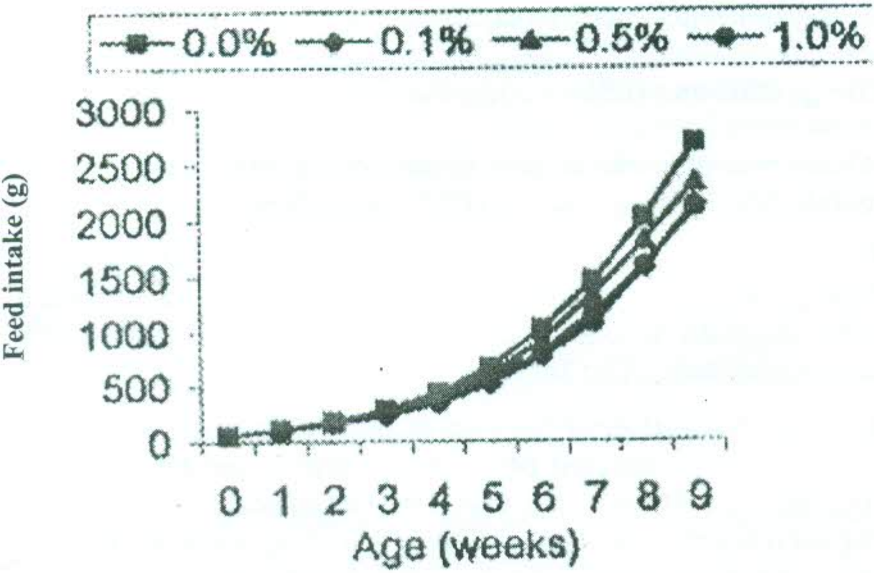


Figure 15: Mean weekly feed intake of broilers fed soyabean treated diets

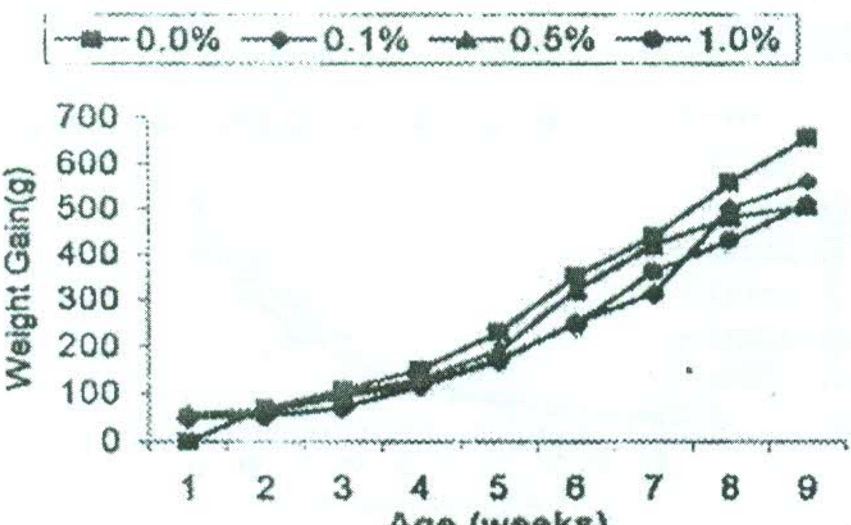


Figure 16: Mean weekly weight gain of broilers fed soyabean treated diets

The different concentrations of Na-sesquicarbonate did not have significant effect on broilers performance. Figure 14 - 16 illustrate the pattern of growth, feed consumption and weight gain of the birds fed the experimental diets with no adverse effects on body weight changes, feed consumption and weight gain as body weight increased progressively with age and feed consumption.

Table 9: Performance of broilers fed sodium sesquicarbonate processed soyabean

	Dietary Treatments (%)					
	0.0	0.1	0.5	1.0	SEM	
Initial live weight (g/bird)	55.62	55.60	55.61	55.60		
Final live weight (kg/bird)	2.68	2.14	2.33	2.32	2.03	NS
Total feed intake (kg/bird)	5.60	5.47	5.60	5.50	1.26	NS
Live weight gain (kg/bird)	2.62	2.08	2.27	2.26	2.11	NS
Feed gain ratio	2.14	2.63	2.47	2.43	1.05	NS

NS means no significant difference (P>0.05).

Table 10: Carcass value of Broilers feed Sodium Sesquicarbonate Processed Soyabean

Parameters (%)	Concentrations (%)				
	0.0	0.1	0.5	1.0	SEM
Live weight (%)	100.00	100.00	100.00	100.00	-
Head	2.32^{a}	2.49^{ab}	2.88^{ab}	3.12^{b}	0.21
Drumsticks	8.42^{a}	9.32^{ab}	9.67^{ab}	11.52^{b}	0.68
Liver	2.08	1.94	2.21	2.20	0.07
Gizzard	2.96	3.18	3.49	2.77	0.18
Heart	0.61	0.50	0.69	0.56	0.05
Abdominal fat	3.38^{a}	2.18^{b}	2.26^{b}	2.28^{b}	0.92

Values denoted by different letters in the same row are significantly different (P < 0.05)

Table 11: Energy Efficiency of Broilers Fed Sodium Sesquicarbonate Treated Soyabean Seeds

Starter Phase	Concentration (%)				
0-35 days	0.00	0.10	0.50	1.00	SEM
Feed intake day-1 (g)	56.50	56.00	55.90	55.68	0.22
M.E. intake (day-1) (kcal/kg)	168.00	164.59	163.85	164.74	2.34
Body weight gain (day-1)(g)	19.84	20.10	20.42	21.94	1.44
Energy efficiency (0-35days)	8.46a	8.19ab	8.02ab	7.74b	0.17
FINISHER PHASE					
Feed intake (day-1) (g)	111.32	103.53	104.03	104.61	2.15
M.E. intake (day-1) (kcal/kg)	323.65	300.25	301.70	303.38	2.18
Body weight gain (day-1)(g)	24.54	23.33	23.06	26.02	1.07
Energy efficiency (36-63 days)	13.18a	13.02ab	12.99ab	11.63b	0.12

Values denoted by the same alphabet in the same row differ significantly ($P<0.05$).

Table 11 shows that energy efficiency of the birds improved as the concentration of the Sodium Sesquicarbonate increased in the diets. The poor utilization of the energy in the control diet was attributed to deficiency of Na^{+} ions and marginal supply of Ca^{2+} and Mg^{2+} ions by the diet. Sodium functions as the exra-cellular component through an energy dependent sodium 'pump' Sodium ions promote glucose absorption against a concentration gradient which requires adenosine triphosphate (ATP). This sodium ion gradient is considered the primary driving force in the active transport of sugar through the intestinal wall. Therefore, the deficiency of Ca^{2+} and Mg^{2+} ions of the control diet could be the main factors for the poor energy efficiency of the diet. Lloyd *et al.* (1978) supported the claim of Kleiber 1941 that Mg^{2+} ions deficiency decreased energy efficiency and that Mg^{2+} activated certain enzymes (kinases, mutases and enolase) which are involved in energy metabolism.

The high abdominal fat pad shown in the control bird-fed birds (Table 10) is an indication of poor utilization of the diet which was used for fat deposition instead of lean tissue. The high values of the head and drumsticks conformed to the reports of Rand *et al.* (1957) and Sonaiya (1985) in which diets with more energy gave higher abdominal fat. However, Hood and Thorton (1979) reported body composition of animals to be related to body weight.

Table 12 shows the mineral composition of the soyabean seeds processed with the different concentrations of Sodium Sesquicarbonate.

Table 12: Mineral Composition of Soyabean Seeds Processed with Different Concentrations of Sodium

	Concentrations (%)			
Minerals (%)	0.00	0.10	0.50	1.00
Ca	0.30	0.31	0.33	0.32
Mg	0.20	0.20	0.19	0.16
Na	0.06	0.09	0.15	0.24
K	0.90	0.78	0.80	0.90
P	0.60	0.39	0.40	0.45

Table 13 indicates the growth and energy efficiency of the broilers fed shea butter oil at starter and finisher phases. The results showed that inclusion of shea butter oil in the diets significantly ($P<0.05$) improved energy efficiency and decreased feed consumption at levels above 6 %.

Table 13: Growth and energy performance of broilers fed shea butter oil at both starter and finisher phase

Parameters	0.0	3.0	6.0	9.0	SEM
Broiler starter					
Initial body weight (g/bird)	35.00	35.00	35.00	35.00	0.00NS
Average feed intake (g/bird/day)	26.96	28.99	27.08	26.54	1.58NS
Final body weight (g/bird)	548.43^{ab}	625.60^{a}	606.18^{a}	480.22^{b}	21.14*
Average body weight gain (g/bird/day)	73.35^{ab}	84.37^{a}	81.60^{a}	63.60^{b}	3.20*
Energy intake (g/bird)	106.70^{b}	130.69^{a}	123.42^{a}	117.41^{ab}	3.37*
Energy efficiency	0.17^{b}	0.11^{a}	0.15^{ab}	0.12^{a}	0.01*
Feed conversion ratio	1.87^{ab}	1.72^{b}	1.66^{b}	2.08^{a}	0.65*

a, b Means denoted by different superscripts in the same row differ significantly ($P<0.05$)

TRAINING: I have been able to make significant contributions to the training of undergraduate, and Postgraduate Programs both within Federal University of Technology, Minna and outside this University.

While I acknowledge and appreciate the efforts of pioneer staff members of the Department of Animal Production, I must say, like the common adage says that honour must be given to who it is due. I must say that the credit of commencing Postgraduate studies in the Department of Animal Production, FUT, Minna, goes principally, to Professor O. O. A. Fasanya as the then Head of Department. He was a dogged man. But as it is always said, "a tree cannot make a forest" I joined him at that crucial moment. Together, we forged ahead with the program in the department. I was involved in the teaching of all the Biochemistry and Nutrition courses at the Postgraduate level. Together, we produced the first set of M. Tech. graduates of the Department of Animal Production, FUT, Minna. Building on this pedestal, we went ahead to initiate the PhD program, produced the first batch of PhD graduates from this same department. To God be the glory. My work experience has also taken me to Ahmadu Bello University, Zaria on a number of occasions. I will not want to bore the audience down with the listings of my training outputs, but suffice it to say that, the graduates of this institution that I personally supervised are creating waves in several higher institutions and other human endeavours.

In spite of time limitations, I would like to inform this audience that I served as a resource person to Niger State Agricultural Development Project (NSADP) for a period of eleven years (1995 - 2006). I fully participated in most of their Monthly Technology Review Meetings (MTRM), Pre-season trainings and some other programmes of that time.

CONCLUSION: This paper has clearly shown that nutritional knowledge and awareness are grossly inadequate in our society.

Consequently, dietary calorie as the pillar and the main factor for which the man and other monogasric eat is not given the required attention. Therefore, the common saying "that my people perish for lack of knowledge is very much applicable." Placing a ban on Animal Production inputs without adequate preparation for local production and supply will only aggravate the already precarious condition. This paper is presented to arouse the societal's interest in dietary calorie intake. As failure to address the glaring inadequacies, in dietary calorie knowledge, consumption and awareness may negatively and permanently affect both mental and physical development of the younger generation. However, all hope is not lost as these observed conditions are reversible. In my candid opinion, the way forward is for the society to adopt the option of using dietary calorie as the pillar of the nutritional education. Just as it happened in the Israelite days in the wilderness, when the pillar of cloud guided them in the days and pillar of fire guided them in night. The people then kept the statutes and the decrees that it gave them. So, it is written that neither the pillar of cloud by day nor the pillar of fire by night left its place in front of the people.

RECOMMENDATION: I wish therefore to recommend that our society should be guided, in the area of nutrition, by adequate dietary calorie knowledge and as a pillar to guide our dietary intake and as fire to kindle the societal's interest in this very important subject matter. I would also like to recommend that governments at various levels (Federal, State, Local governments) should put in place the required policies and enabling environment that will engender adequate nutritional understanding, as no greater favour could be done to any child than to train him/her to realize, the essential foods to consume and to inculcate in the child, by practice, a proper attitude towards foods that will make for a good health and happiness in later years of life. It is also recommended that for optimal maximization of profit in monogastric animal production, farmers should be encouraged to acquire basic educational knowledge on balanced diets formulated on the principles of dietary calorie as the pillar. Finally, I would like to suggest that dietary calorie as the pillar of nutrition for all monogastrics and man should no longer be put at the back seat but rather should be at the front seat in all our nutritional considerations.

APPRECIATION

I am highly grateful to God Almighty for His divine protection, guidance, provisions and abundance grace;+ and for paving the way for me to stand before you this afternoon. I would like to borrow the following prophetic expression from Hannah (1 Samuel 2:8) "He raise up the poor out of the dust and lifted up the beggar from the dunghill, to set them among princes, and to make them inherit the throne of glory: for the pillars of the earth are the Lord's".

I am greatly indebted to my late parents, Chief Ayanwale Samuel and Princess Abigail Ayanwale (nee Adeniyi), who through relentless efforts made schooling a reality for me, in spite of their lowly backgrounds. The contributions of my elder brothers, Chief Magistrate Stephen Osho Ayanwale (rtd) and late Elder Olatunji Alabi Ayanwale, to my educational career cannot be over emphasized. As time will not permit me to enumerate their individual contributions, it suffice it, to say that 'I am deeply grateful to both of them' from the bottom of my heart.

To the Vice-Chancellor, Federal University of Technology, Minna and the entire Principal Officers of the University I am very grateful. The Vice-Chancellor has left a very deep indelible mark in our hearts in the family. We are sincerely grateful to you sir. I cannot in any way, forget the honour done to me by Professor M. S. Audu, the former Vice-Chancellor for finding me worthy to be appointed Chairman, Anti-Corruption and Transparent Monitoring Unit of this great University. Thank you very much sir.

Of immense importance in my life is my Academic Supervisor, Professor Bankole Kayode Ogunmodede (Baba) who combined several attributes into one. He was a supervisor, a role model, an adviser, a designer, a father outside the home and a crucial and selfless helper at the time of need. I can never forget his fatherly role in my life.

There are no words or dictionary adjectives sufficient to describe my appreciation to the wife of my youth, Dr. (Mrs.) Ayanwale, Victoria Adesola, who is a "divine favour" from God to me; as it is written that, he who finds a wife find what is good and receives favour from Lord (Proverbs 18:22). I want to thank God for making me to find you, and I want to let you know today that I have no reason to regret the ten years I spent in pursuing you before the marriage. Before I met you, you were a lady of good testimony and up till now you are still the same. My ever young looking wife, i love you dearly. You will ever remain my better half.

To my lovely children, I am grateful to you all for being good children and behaving yourselves well even in my absence. Thank you for your understanding on many occasions when I have to be away from home.

I sincerely appreciate all my students, particularly those that I supervised their projects. I know you all have one factor in common, "weeping and sobbing but surprisingly, but to always ask for more." Thank you that you gladly accept to graduate under me.

I am sincerely grateful to all members of the School Board, School of Agriculture and Agricultural Technology and members of Animal Production Department in particular.

Words are not enough to express my heartfelt appreciations to the pastors, Board members and the entire congregation of ECWA Goodnews Church, Minna for your fervent prayer support. You have all seen the manifestations of the answered prayers.

I am sincerely grateful to members of Yoruba Community Forum for your care and support.

My people and friends who have travelled from different places to grace this occasion, time and space will not allow me to mention you one by one but be assured that i appreciate you all.

National Institute of Animal Science, I appreciate you for the Fellowship Award and I say more powers to your elbow.

To the energetic farm workers, particularly Mallam Hussaini (late), Ibrahim and Danjuma (retired) I am grateful for your co-operation and support. I am glad that the sweat you shed while working on the farm with me has not been in vain.

To members of Anti-corruption and Transparent Monitoring Unit, FUT, Minna, I am very grateful to you all for the support and co-operation I enjoyed from you while it lasted. I am equally indebted to the Servicom Unit for recognizing our modest contributions to fighting corruption in this system and subsequently gave the award. Thank you for this recognition. I appreciate members of Search FM for your contributions. The Security Unit, you are warmly appreciated.

I cannot forget the Seminar and Colloquium Committee. Your constant reminder is well noted. Thank you for making today a reality. I will remain grateful to the students and the mistress (Mrs. Adebayo) from FUT Staff School for your melodious and encouraging songs.

I am indeed very sorry that time and space will not permit me to mention the names of all the individuals and groups who have contributed to make this occasion a success, please note that your contributions are well engraved in my heart. I believe God will certainly reward you more than I or anyone else can do.

REFERENCES

Adnan, B. Y. (2006). Effective Caloric Value of Nutritional and Non-Nutritional Components of Broiler Nutrition. A PhD Thesis submitted to the Faculty of the Graduate College of the Oklahoma State University.

Ayanwale, B. A. (1997). Energy utilization by broilers fed different micro-nutrient mixtures. Agrosearch. *A Journal of Agriculture, Food and Development,* 3 (1&2): 63:72.

Ayanwale, B. A. (1985). Energy contents of meat and meals from secondary schools at six locations in Ibadan. B.Sc. Project submitted to the Department of Animal Science, University of Ibadan, Ibadan Nigeria.

Ayanwale, B. A. (1988). Energy utilization by broilers fed three different premixes. M.Sc. Thesis submitted to the Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

Ayanwale, B. A. (1992). Energy utilization by broilers fed on commercial premixes and three levels of dietary oil. PhD Thesis submitted to the Postgraduate School University of Ibadan, Ibadan, Nigeria.

Ayanwale, B. A. (2003). The effect of feeding sodium sesquicarbonate treated soyabeans on energy utilization by and performance of broiler chickens. *Pertanika Journal of Tropical Agric Science,* 2 (1): 7-13.

Ayanwale, B. A. (2005). Effect of alkaline treated soyabeans on the performance, protein and energy utilization of starter broilers. *Animal Production Research Advances,* 1(2): 64-69. *Tapas Institute of Scientific Research and Development.*

Ayanwale, B. A. and B. K. Ogunmodede (1999). Growth and energy efficiency of broilers fed different commercial premixes at two developmental stages. *Nigerian Journal of Animal Production,* 46: 43-47.

Bros-Rasmusser, F. (1958). The riboflavin requirement of animals and man and associated metabolic relations. Part II. Relation of requirement to the metabolism of protein and energy. *Nutrition Abstract and Reviews,* 28: 369-386.

Chu, A. B., L. M. Potter, B. K. Applegate, and A. T. Leighton (1964). Influence of increasing dietary energy on the riboflavin requirement of young turkeys. Poultry Science, 431: 1307.

Church, D. C. and W. G. Pond (1982). *Basic Animal Nutrition and Feeding,* 2nd edn., John Wiley and Sons, U. S. A.

Crampton, E. W. and L. E. Harris (1969). Applied Animal Nutrition: The use of foodstuffs in the formulation of livestock rations. Freeman and Coy San Francisco.

Donald, Voet Judith, G. Voet, Charlotte, W. Pratt (2008). *Fundamentals of Biochemistry,* 3rd edn. Life at molecular level. John Wiley and Sons, U.S.A.

Farrell, D. J. (1974). Effect of Dietary energy concentration on utilization of energy by broiler chickens and on body composition determined by carcass analysis and predicted using tritium. *British Poultry Science,* 15:25-41.

Frandson, R. D. (1974). *Anatomy and physiology of farm animals,* 2nd edn., Lea and Febiger, Philadelphia.

Friedman, M., M. R. Gumbmann, and P. Masters (1984). Protein-alkali interactions: chemistry, toxicology and nutritional consequences. *In* nutritional and toxicological aspects of food safety. Advances in Experimental Medicine and Biology, 177: 356-412. New York Plenum Press.

Gardiner, E. E. and C. C. Whitehead (1976). Effect of dietary palmitic acid on broiler chicks fed on various concentrations of calcium. *British Poultry Science,* 17: 241-244.

Haroni, F. and J. L. Sell (1977). The modifying effect of calorie-protein ratio on laying hen performance and on 'extra-metabolic effect' of added fat. *Poultry Science* 56: 1981-1988.

Hill, F. W and L. M. Dansky (1954). Study on energy requirement of chickens, the effect of dietary energy on growth and feed consumption. *Poultry Science* 33.112-119.

Hood, R. L. and R. F. Thornton (1979). Cellularity of ovine adipose tissue. *Austr. Journal of Agric. Research,* 30 (1): 153-161.

Jensen, L. S., G. W. Schumaier and J. D. Latshaw (1970). Extra-caloric effect of dietary fat for developing turkeys as influenced by C: P ratio. *Poultry Science,* 49: 1697-1704.

Jeremy, M. Berg John, L. Tymozko Lubert and L. Stryer (2002). *Transducing and storing energy. Basic concepts and design.* International edition, Freeman and Coy, New York.

Jiya, E. Z.; B. A. Ayanwale, O. S. Eniola, S. Ayano, A. O. Taiwo and Y. U. Usman (2014). Performance and energy efficiency of broiler chickens fed graded levels of Shea butter oil *(Vitelleria Paradoxa),* Paper presented at 16th AAA Conference of Animal Production Congress 10th - 14th October, Indonesia.

Kleiber, M. M., D. D. Boeiter and D. M. Greenberg (1941).Fasting catabolism and food utilization of magnesium deficient rats. *Journal of Nutrition,*21: 363- 373.

Laurena, A. C. O., Gracia, V. V., and Mendoza, E. M. T. (1969). Effect of soaking in aqueous acid solutions on removal of polyphenols and *in-vitro* digestibility of cowpea. *Qual. Plant Foods and Human Nutrition,* 36: 107-118.

Leach, R. N. (1956). Soft phosphate in poultry rations. *In* published M. Sc. Thesis Purdue University cited by Gardiner, E. E. 1971.

Lloyd, L. E., B. E. McDonald and E. W. Crampton (1978). *Fundamentals of Nutrition,* 2nd edn. Freeman and Coy, San Francisco.

Lockhart, W. C., R. L. Bryant and D. W. Bolin (1966b).The effect of B-vitamins deficiency on the efficiency of metabolisable energy and protein utilization. *Poultry Science,* 45: 939-945.

Lockhart, W. C., R. L. Bryant, and D. W., Bolin (1966a). The effect of B-vitamins deprivation on subsequent energy metabolism. *Poultry Science,* 45: 520.

Lunn, P. G. and S. Austin (1983). Excess energy intake promotes the development of hypoalbuminaemia in rats fed on low protein diets. *British Journal of Nutrition,* 49: 9.

Mateos, G. G., and Sell, J. L. (1981). Metabolisable energy of supplemental fat as related to dietary fat level and methods of estimation. *Poultry Science,* 1509: 1515.

Maynard, L. A., T. K. Loosli and R. G. Warner (1979). *Animal Nutrition.* 7th edn.Tata McGraw-Hill publishing Coy Ltd, New Dehli India.

National Research Council (NRC) (1984). National Academy of Science. (NAS). Nutrient requirement of Domestic Animals, No. 1. Nutrient requirement of poultry, 8th edn. Washington, D.C.

National Research Council (NRC) (1977). National Academy of Science (NAS). Nutrient requirement of Domestic Animals, No. 1. Nutrient requirement of poultry, 7th edn., Washington, D.C.

Nelson, A. I., M. P. Steiberg and L. S. Weis (1976). Illinois process for preparation of soya milk. *Journal of Food Science*, 41: 57-61.

Nutrition Landscape Information System (NLiS) WHO - Retrieved 12 Nov. 2014.

Oluyemi, J. A. and F. A. Roberts (1979). *Poultry Production in Warm Wet Climate.* Hong Kong. The Macmillan Press.

Patrick, H. P. and J. Schaible (1980). *Poultry Feeds and Nutrition,* AVI Publishing Coy Westport Connecticut.

Scott, M. L. (1966). Factors modifying the practical vitamin requirement of poultry. *Proceeding 1966 Cornell Nutrition Conference,* p. 30.

Sibbald, I. R. S., J. Slinger and G. C. Ashton (1961). Factors affecting Metabolisable energy content of poultry feeds: The influence of Ca, P, antibiotics and pantothenic acids. *Poultry Science,* 40: 945-951.

Sibbald, R. I, S., S. Pepper, J. Slinger (1962a). Sodium chloride in the feed and drinking water of chicks. *Poultry Science*, 41: 541-545.

Sibbald, R. I. S., S. Slinger and J. Pepper (1962b). Interrelationships of riboflavin, niacin, vitamin B12 and methionine measured in terms of chicks weight gain and Metabolisable Energy Values. *Poultry Science,* 41: 135-142.

Singh, K. B., W. Erskine, L. D. Roberts, H. Nakkoul and P. C. Williams (1988). Influence of pretreatment on cooking quality parameters of dry food legumes. *Journal of Food and Agriculture,* 44: 135-142.

Smith, L. and L. Haddad (2014). Reducing Child Undernutrition:

Past Drivers and Priorities for the Post-MD Era, IDS Working Papers 441, IDS (Institute for Development Studies), U.K.

Sonaiya, E. B. (1985). Abdominal fat weight and thickness in prediction of total body fat in broilers. *British Poultry Science,* 26: 453-458.

UNICEF (2013). Improving Child Nutrition: the achievable imperative for global progress, United Nations Children's Fund (UNICEF), New York, USA. ISBN 978-92-806-4686-3.

United Nation's Children's Fund, World Health Organization, The World Bank. UNICEF - World Bank Joint Child Malnutrition Estimates. (http//data.unicef.org/resources/2013/webapps/nutrition)

Uzogara, S. G., I. D. Morton, and J. W. Daniel (1988). Quality changes and mineral content of cowpea seeds processed with "kanwa" alkaline salt. *Food Chemistry,* 30: 1-18.

Uzogara, S. G., I. D. Morton, J. W. Daniel, and P. W. Emery (1991).Effect of "Kanwa" treatment of cowpea seed flour on protein quality measured by growth rate in rats. *Ecol. Food Nutrition,* 25:79-91.

PROFILE OF INAUGURAL LECTURER

Prof. Ayanwale, Bisi Alex was born on 25th October, 1961; at Obinn-Aiyetoro, Ifelodun, Local Government Area, Kwara State, Nigeria.

Marital information: He is married to Dr. (Mrs.) Victoria Adesola Ayanwale and have 4 children, namely Oluwatosin Grace, Olubunmi Eunice, Olufunmilayo Joy and Emmanuel Adebisi.

Education and certificates obtained: He obtained his 1st School Leaving Certificate in 1972, at Local Education Authority (L.E.A) Primary School Owode; West African School Certificate (WASC) at G.S.S., Dekina in 1978. He attended Kwara State School of Basic Studies (at the then Kwara Tech.) and obtained Advanced level Certificate in Mathematics, Chemistry and Biology in 1980. In 1981, he proceeded to the premier university, University of Ibadan and obtained a B.Sc. degree in Agriculture (Animal Science) in (1985); M.Sc. degree (Animal Science) (1988) and PhD degree (Animal Science) (1992). In the same year he enrolled at University of Ilorin for Masters in Business Administration (MBA) and finished in 1995. Professor Ayanwale, has a very high appetite for knowledge as he proceeded to acquire more and more certificates to his credit, which include the following (i) Certificate in DNA Recombinant Technology, A.B.U., Zaria (2007) (ii) Certificate in Computer Science, A.B.U., Zaria (2008) and (iii) Certificate in Data Analysis using Excel and SPSS, A.B.U., Zaria (2015).

Work experience: He joined the services of FUT, Minna in January 1994 as a Lecturer II and has remained in the services of FUT till date.

Publications: Prof. Ayanwale is a prolific writer. He has to his credit more than **104** articles in reputable Journals, Books and

Books of Proceedings. He has attended and presented papers in many workshops.

Student supervision: He has successfully supervised and graduated a total of 10 PhD degree holders, 27 M.Tech. degree graduates, 12 postgraduate Diploma degrees and several B. Tech. degree holders.

He has served as a Course Developer for National Open University of Nigeria.

He is a Fellow of Nigerian Institute of Animal Science (NIAS) Post Graduate School.

External Examiner: Served as External Examiner to many universities including, (1) Abubakar Tafawa Balewa, Bauchi (2) Ahmadu Bello University, Zaria (3) Ibrahim Babangida University, Lapai (4) University of Abuja. (5) Michael Okpara University of Agriculture, Umudike (6) Federal University of Agriculture, Abeokuta. (7) Nassarawa State University, Keffi, Lafia Campus. (8) Ladoke Akintola University of Technology, Ogbomosho (9) Kogi State University, Ayingba.

Assessor: He has assessed many candidates for promotion to Professorial ranks at many universities including (1) University of Agriculture, Makurdi (2) Usman Dan Fodio University, Sokoto (3) Ahmadu Bello University, Zaria (4) Osun State University (5) Ladoke Akintola University of Technology, Ogbomosho.

Community Services: He has served FUT, Minna meritoriously in various capacities, which include, (a)Head of Department Animal Production (2002-2006) (b) Member University Senate (c) Editor–in–Chief, Journal of Agriculture and Agricultural Technology. (d) Chairman, Anti-Corruption and Transparency

Monitoring Unit (e) University Desk Officer for National Network and Development Solution (f) President, ASUU Golden Trust and Multipurpose Co-operative Society (g) Member, University Development and Planning Committee. (h) Chairman, Examination Misconduct Investigation Committee for SAAT (i) Member, University Committee on Investigation of Admission Racketeering Committee. (j) Member, University Committee on Issuance of Fake Receipts. (k) Member, LOC for the 5th Nigerian Universities and Research and Development, 2012.

Niger State: (1) Resource Person at several Niger State Agricultural Development Project (ADP) Monthly Technology Review Meeting and Pre-season Training between 1995 and 2006.(2) Member, ADP/ NCRI Badeggi Field Monitoring and Evaluation Team, 1998. (3) Member, Niger State Diagnostic and Pest Survey of Roots and Tuber Based Farming Systems (Livestock), 2004. Member, Niger State Fadama Beneficiary Evaluation/Assessment Team.

National: Member, FAO/Federal Ministry of Agriculture and National Data Contributor to the Preparation of the 1st Report on the State of the World's Animal Genetic Resources (2003-2004) He served as a resource person in many workshops. Prof. Ayanwale is a devout Christian, who has served in various capacities and committees in his church.

AWARDS AND DISTINCTIONS

The best year 1, 2, 3, & 4 students of G.S.S., Dekina (1973 to 1977).

Kwara State Scholarship award (1980-1985).

Listed in the profile of New York Academy of Science (1998).

Individual award in Agricultural Research at the 5th Nigerian

Universities Research and Development Fair (NURESDEF) 2012.

He has won 6 Research Grants from FUT Minna University Board of Research.

He was conferred 'Member, Nigerian Society for Animal Production (1999)' and 'Member, Animal Science Association of Nigeria (2003)'. He is a Registered Animal Scientist (RAS).

Conferred with the honour 'Fellow of the Institute of Animal Science Post Graduate School (2015).

Servicom Award 2014.

Professors, B. A. Ayanwale (FUT, Minna) and Yusuf L. Henuk (University of Nusa Cendana, Kupang, Indonesia)