NUTRIENT COMPOSITION, PEST AND MICROBIAL STATUS AND EFFECTS OF DISCARDED BISCUITS ON THE GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND ECONOMIC PROFILES OF GROWING-FINISHING PIGS

By

Frank Manu

A Thesis submitted to the Department of Animal Science,

Kwame Nkrumah University of Science and Technology, Kumasi

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

(Animal Nutrition)

Faculty of Agriculture

College of Agriculture and Natural Resources

November, 2013

DECLARATION

I, **Frank Manu**, hereby declare that this submission is my own work towards the award of a Master of Science (MSc.) degree in Animal Nutrition and that no previous submission has been made here or elsewhere for the award of any other degree. However, all references made herein are fully and respectfully acknowledged in the text.

Frank Manu (PG 4237910)	....	....
(Student's Name and ID)	Signature	Date

Certified by:

Prof. D.B. Okai	....	....
(Project Supervisor)	Signature	Date

Dr. (Mrs.) Victoria Attoh-Kotoku	....	....
(Head of Department)	Signature	Date

DEDICATION

This work is dedicated to the Trinity God, my wife, Mrs Patricia Assuah Manu, and our children.

ACKNOWLEDGEMENT

My appreciation goes to the Head of Department and all the Lecturers of the Department of Animal Science, KNUST, for their care, support, constructive criticisms and encouragement.

My greatest thanks go to Professor D.B. Okai, my able supervisor, for his guidance, constructive criticisms, technical and fatherly advice in the design and successful execution of this project. Prof., may the Good Lord grant you more years to continue your good works at KNUST. I would be most ungrateful if special mention is not made of Dr. Michael Boateng, my Lecturer and brother as well who never refused to heed to my call no matter the time, for his assistance in all areas of need. Doctor, may you live to realise all your dreams. For service to mankind, they say, is service to God. To the supporting staff of the Livestock Section and the Meat Processing Unit, I say God bless you for assisting me throughout the study period. My special thanks go to Mr. Nixon Faakye for his practical brain, hard work and encouragement. I am also grateful to Dr. Stephen Bonna of Veterinary Service, MoFA, Ejisu, Ashanti for his role in the acquisition of the Discarded Biscuits from Accra. Doctor, your effort is much appreciated.I cannot also forget Mr. Effah Baah of Rakeb Farms & Co. Ltd., Kumasi who provided me all the other ingredients on credit. Daddy, your kindness is much acknowledged. I applaud the efforts of my colleagues Messrs Kwabena Owusu Ansah, Yaw Oppong Frimpong and Solomon Osarumwense Okungbowa in assisting me throughout the trial. I also acknowledge the efforts of Messrs J.A. Bentil (Animal Nutrition Laboratory), Mr. L. Gariba (Hospital Laboratory, KNUST) and Mr. Malik Borigu and Mrs. Josephine Mends (both of Pathology Laboratory, Crop and Soil Science Department, KNUST) for their assistance with the proximate, blood, microbial and pest analyses. My appreciation will not be complete if I fail to express my indebtedness to my family, particularly my wife, for her financial support and encouragement.

ABSTRACT

An experiment was conducted to evaluate Discarded Biscuits (DB) as an alternative to maize in pig diets. Proximate composition, pest and microbial status of the DB and the effects on growth performance, carcass characteristics, blood and other economic profiles of growing-finishing pigs were determined. Prior to the trial, samples of the DB were examined for the proximate composition, pest and microbial status. The proximate composition of the DB was 17% moisture, 9.90% crude protein, 0.63% crude fibre, 11.00% ether extract, 0.50% ash and 60.97% nitrogen- free- extract. The DB was infested with *Tribolium species*, with both live and dead insects present. The microbes contained in the DB samples were three fungi species namely, *Penicillium spp.*, *Aspergillus niger* and *Aspergillus versicolor* with *Penicillium spp.* being the most predominant. A total of twenty Large White starter pigs aged 9-10 weeks with an average initial weight of 16.6kg were used for the trial. The pigs were allotted to five groups with four replicates in a Complete Randomized Block Design. They were fed *ad-libitum* with isonitrogenous diets containing 0%, 10%, 20% and 30% levels of DB replacing similar amounts of maize and representing treatments T1, T2, T3 and T4 respectively. Feed intake, weight gain and feed conversion efficiency were determined weekly and at the end of the feeding trial. Blood samples were collected via the ear vein for haematological and serum biochemical assay when a pig attained a liveweight of62$\pm$ 0.5kg weight but before being slaughtered for the determination of carcass characteristics. There were no significant (P>0.05) differences in Average daily feed intake (ADFI), Average total feed intake (ATFI), Average daily weight gain (ADWG), Average total weight gain (ATWG) and Feed conversion efficiency (FCE) values for the four dietary treatments. There was a linear decrease in feed cost as the level of DB increased in the diet, and the cost of gain followed a similar trend. The haematological and serum biochemical studies did not (P>0.05) indicate any dietary influence. Carcass characteristics were similar (P>0.05). It was concluded that DB could constitute as much as 30% of the diet and replace about 60% of the maize in the diet of growing pig without any adverse effect on growth performance and carcass characteristics thereby reducing the competition for maize between humans and livestock.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATIONS

ADFI	Average daily feed intake
ADWG	Average daily weight gain
AFW	Average final weight
AIW	Average initial weight
ATFI	Average total feed intake
ATWG	Average total weight gain
AOAC	Association of Official Analytical Chemists
ANF	Anti-nutritional Factor
ANOVA	Analysis of variance
ALBP	African Locust Bean Pulp
BWM	Biscuit waste meal
Ca	Calcium
CBS	Cocoa bean shell
CC	Copra cake
CF	Crude fibre
CP	Crude protein
CPH	Cocoa pod husk
CRBD	Completely Randomized Block Design
CSC	Cotton seek cake
DB	Discarded Biscuits
DBWP	Dried Bakery Waste Products
DE	Digestible Energy
DM	Dry Matter
EE	Ether extract
EDTA	Ethylene diamine tetra acetate
FCE	Feed conversion efficiency
FCR	Feed conversion ratio
g	gramme
GE	Gross energy
G-F	Growing-finishing pigs

GHC	Ghana cedis
GIT	Gastro-intestinal tract
GNC	Groundnut cake
Hb	Haemoglobin
HCT	Haematocrit
HDL	High-density lipoprotein
IMF	Intramuscular fat
Kg	kilogramme
KNUST	Kwame Nkrumah University of Science and Technology
Kcal	Kilocalories
LSD	Least significant difference
LDL	Low-density lipoprotein
MJ	Mega joule
ME	Metabolizable energy
MCH	Mean cell haemoglobin
MCHC	Mean cell haemoglobin concentration
MCV	Mean cell volume
NRC	National Research Council
PKC	Palm kernel cake
QPM	Quality Protein Maize
RBC	Red blood cell
SBM	Soyabean meal
SNC	Sheanut cake
TDN	Total digestible nutrients
TFI	Total feed intake
TWG	Total weight gain
WBC	White blood cells

CHAPTER ONE

1.0 INTRODUCTION

The importance of the pig industry in helping to increase the animal protein intake of Ghanaians cannot be overemphasized (Okai, 2005). The industry aims at supplying consumers with reasonably priced meat and meat products (Okai *et al.*, 2000) but more often than not, the generally high costs of feed inputs has defeated this objective in developing countries. This situation is partly the result of competition between man and animals for feed ingredients particularly energy sources such as cereal grains leading to high prices of these ingredients at certain times of the year (Okai and Aboagye, 1990). In Ghana, feed cost represents between 70 and 80% of the total cost of pig production (Cameron, 1970) and the bulk of the commercial feed may consists of high-energy cereal grains such as maize (Andah, 1974). Among all the nutrients required for effective performance of monogastric animals, carbohydrates (energy) remains dominant in a balanced diet, constituting between 45-60% of finished feeds (Nestle, 1975; Machin, 1992).

Maize has for a long time been a traditional and indispensable cereal grain in the commercial diets of monogastric animals in Ghana and typically forms anywhere from 50-60% of such diets (Okai *et al*., 2003). However, the competition between humans and livestock has brought about a high demand for maize resulting in an escalating price of maize and consequently the cost of feeding pigs and poultry in Ghana (Okai *et al*., 2001a). Currently, in Ghana, the price of maize is between GH¢0.90p and GH¢1.00 per kg (Personal market survey). The solution to this problem of escalation in prices of maize and animal products may be in the use of alternative feed resources that are cheaper (Addo-Quaye *et al*., 1993) and not competed for by man (Okai and Aboagye, 1990).

There is therefore, the need for research into locally available materials to find alternate sources of feedstuffs to replace some or all of the conventional feed sources such as maize and fishmeal to lower feed cost and to reduce, if not stop completely, the competition between man and farm animals. In an effort to find alternate sources of feedstuffs, several studies have been conducted to determine the suitability of some agro-industrial by-products as feed ingredients in the diets of pigs and poultry. Okai (1998) revealed that Ghana abounds in a wide variety of agro-industrial by-products and crop residues that can be used as alternative feed resources for pigs to help reduce the competition between man and some livestock species and poultry for the same ingredients such as maize and fish. Even though no accurate figures are yet available, the few biscuit factories in Ghana produce substantial quantities of various by-products, which are usually discarded (Okai and Bonsi, 1989). These discarded biscuits are not used as human food on aesthetic and health grounds (Okai-Amankwa, 1986). Tibiru (1980) and Heloo (1984) included the same levels of a dried bakery waste product (DBWP) and discarded biscuits (DB) in the diets of growing pigs to replace maize and found non-significant ($P>0.05$) differences in the feed intake, mean daily gain and feed conversion efficiency. Economically, they recorded significant reduction in feed cost since the prices of the DBWP and DB were lower than maize. Okai-Amankwa (1986) also recommended DB as a potential source of energy for non-ruminant animals when she included up to 45% DB in the diets of rats. She also recorded a significant reduction in feed cost as the level of DB increased. Analysis of DB showed that it had 11%CP, O.73%CF, 14.7%EE and 70.33%NFE (Atakora, 1982) and also 10.6% CP, 0.7% CF, 4.0% EE, 72.3% ASH (Okai and Bonsi, 1989). Longe (1986) has suggested that DB has no anti-nutritional factor.

The above suggests that DB could readily and economically be utilized as good replacement for maize and other energy sources as ingredient in the diets of pigs. However, none of the earlier studies considered carcass characteristics and pests and microbial status of DB. These other considerations are important since it is basically a waste or by-product and could easily contain contaminants and other extraneous materials. Furthermore, the durations of these earlier experiments were short-term spanning from four to eight weeks. Data collected within such short periods may not be sufficient enough for drawing justifiable scientific conclusions. Again, the causes of many diarrhoea cases reported in the earlier experiments were left undetermined. This might have resulted from the presence of certain pathogenic organisms in the DB, which is a mixture of broken biscuits and other foreign materials. Given these shortcomings, there is the need for a long-term and more detailed research that will provide more information and probably useful data that would help to finally establish the role of DB in the nutrition of non-ruminant livestock especially pigs. The main objective of this study, therefore, was to determine the effects of feeding growing pigs with diets containing DB as substitute for maize. The specific objectives were:

- To determine the nutrient composition of DB.
- To determine pest and microbial status of DB.
- To evaluate the effects of varying levels of DB:

- on the growth performance of G-F pigs

- on the carcass characteristics of G-F pigs.

- To determine the optimum inclusion level of DB for growing pigs.
- To evaluate the economic performance of pigs fed the DB containing diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. GROWTH AND DEVELOPMENT OF PIGS

Growth according to Brody (1945) is "the constructive or assimilatory synthesis of one substance at the expense of another (nutrient) which undergoes dissimilation". It relates to gain in weight brought about by cell multiplication, cell enlargement and the direct incorporation of materials in cells (Whittemore, 1987). In practical terms, growth is measured as the increase in body weight with time and this largely depends on the amount of feed intake or total nutrient intake (Holness, 2005). In animal production, the term growth is often considered synonymous with increase in body weight of the animal from conception to maturity. In practical pig production, the most meaningful and useful measure of growth is increase in body weight gain. Growth can be expressed as absolute gain in a given period of time or as relative gain. The growth rate of individual parts of the pig is unequal (Pond and Maner, 1974). Dissection and carcass studies by McMeekan (1940) as cited by Pond and Maner (1974) showed that the head and shoulders reach mature size before the posterior part of the body. This indicates that early in life, the head and shoulder represent a higher proportion of the total body weight than they do later. Similarly, individual organs, tissues and cell types within a single organ grow at different rates.

Growth in pigs occurs in two phases. These are hyperplasia (increase in number of cells) and hypertrophy (increase in size of cells) with most growth occurring immediately after conception being hyperplasia. During late prenatal and early postnatal life, both hyperplasia and hypertrophy occur concurrently. Finally, at some point in postnatal life, cell division ceases and growth occurs only by hypertrophy

(Pond and Maner, 1974). In pigs, growth occurs during prenatal and postnatal periods. The postnatal period is in three phases, based on live weight change namely, weaner (starter) phase from 5-20kg, grower phase from 20–45 kg and finisher phase from 45 – 90kg live weight (Frobish *et al.,* 1969; Meade *et al.,* 1969; Robinson *et al.,* 1965). Daily live weight gain varies at the various stages. Serres (1992) has suggested growth rates of 400g following weaning, 500g for 30kg live weight, 600g for up to 40 kg live weight and 700g between 60 and 70kg after which they fall progressively. Okai *et al*. (2001a) reported average daily live weight gain of 0.50kg for starter (8-20kg), 0.64kg for grower (20-50kg) and 0.52kg for finisher (50-70kg).

2.2 NUTRIENT REQUIREMENT OF PIGS

The pig requires a supply of essential nutrients if it is to survive, maintain itself, grow and reproduce (Holness, 2005). A nutrient, according to Pond and Maner (1974) is any chemical entity required by the animal to meet metabolic needs. Gillespie (1992) also defined nutrient as an element or a compound that aids or supports life. It can be supplied by feeding or in some cases, by parenteral administration (Pond and Maner, 1974). Feed cost represents 55 to 85% of the total cost of commercial pig production. For this reason, it is highly important that economical as well as nutritionally balanced diets be provided during all phases of the life cycle (Pond and Maner, 1974; Gillespie, 1992). The major nutrients generally required by pigs are water, fats and oils (fatty acids), vitamins, proteins (amino acids), inorganic elements and carbohydrates (energy) (Pond and Maner, 1974; Okai and Bonsi, 1994). The body of a pig adult or young contains an average of 16% protein, 16% lipid, 3% mineral (ash) and 65% water (Whittemore, 1993).

Pigs require different rations at different stages of life (Table 1). As they grow older, protein, mineral and vitamin requirements decrease (Payne, 1990).

Table 1: Nutrient concentration of diets for different classes of pigs.

Class of pig	**DE Density (MJ/kg)**	**CP Density (g/kg)**	**CP (g/MJDE)**
Starter	15.5	250	16
Grower	15.0	225	15
Finisher	14.0	200	13
Pregnant breeder	12.5	150	12.2
Lactating breeder	13.5	165	12.5
Male grower	15.0	225	15

Source: Whittemore, (1993).

2.2.1. Energy

The ability of a feed to supply energy is of great importance in determining its nutritive value (McDonald *et al.*, 2002). Energy constitutes by far the largest component of pig diets (Pond and Maner, 1974). Apart from water, sources of energy are the most important feed requirements of the pig and will most rapidly influence its survival if withdrawn (Holness, 2005). The energy value in feeds is expressed as Gross Energy (GE), Metabilizable energy (ME), Digestible Energy (DE) and Net Energy (NE). The DE and ME are commonly used, but occasionally, NE is used (Kellems and Church, 2002). Energy concentration of pig diets ranges from as low as 11MJDE/kg for diets containing grass meal and other roughages to more than 15MJDE/kg for high-energy ingredient diets (Whittemore, 1993). Payne, (1990) gave recommended digestible energy levels for pigs as follows: pregnant pig; 12.5MJ/kg, lactating sow; 12.5MJ/kg and piglets between 13.7-14.3MJ/kg. Excessive energy intake of above 40MJDE daily (3kg of cereal-based diet) is likely to be detrimental in early pregnancy (Whittemore, 1993). Non-ruminants like pigs, within certain limits consume the same amount of energy irrespective of the energy content of the diet offered (Cole *et al*., 1967; Andah, 1974). They consume more when a low energy ration is offered. The energy content of the diet generally controls the amount of feed consumed *ad libitum* daily and pigs will compensate for low energy diet by increasing feed intake and high-energy diet by decreasing intake (Cole, 1984). Voluntary feed intake decreases with high-energy feed but results in a better feed-to-gain ratio, that is, less feed is required per unit of gain. Okai and Bonsi (1994) recommended DE levels of 3,500kcal/kg for starter pigs and 3,300kcal/kg for grower and finisher pigs.

2.2.1.1 Carbohydrates

The main-energy nutrients found in animal rations are carbohydrates. They are made up of sugars, starches, cellulose and lignin and are chemically composed of carbon, hydrogen and oxygen (Gillespie, 1992). They are major constituent of vegetable food materials on DM basis and by far the biggest constituent of the food of domestic animals. Very little of it is found in the animal body (Williamson and Payne, 1964). Carbohydrate is the most abundant form of energy in plant materials and, as such, is the most widely available source of energy for feeding pig (Pond and Maner, 1974). According to Blakely and Bade (1994) the carbohydrate content of a ration makes up the largest, although not all the energy requirements. Some energy is derived from fats and oils in some instances from protein. All carbohydrates have about the same gross energy content of about 17.5 MJ/Kg DM (McDonald *et al.,* 2002). The foods richest in starch and sugars (carbohydrate sources) are the tubers and roots (e.g. cassava) and cereals (e.g. maize, sorghum, and millet). Peeled cassava root contains more than 92% carbohydrates, yam about 88%, sweet potato about 90%, rice grains 85% and none of these contains much fibre (Williamson and Payne, 1964).

2.2.1.2 Fats and oils

The pig has not been shown to require fat except as a source of possible essential fatty acids and as a vehicle for absorption fat-soluble vitamins (Pond and Maner, 1974). Although practical pig rations are always thought to contain adequate fat, it is generally accepted that a level of 1.0 to 1.5% fat or oil in the diet will ensure adequate essential fatty acids. Adding fats up to 20% has increased growth rate but often produces a fatty carcass or "soft pork". The demand is now for lean pork so the fat in the ration seldom exceeds 5% (Blakely and Bade, 1994). Fats and oils from plants and animals are the most concentrated form of energy available, and this is about 2.25 times the energy value of carbohydrates (Pond and Maner, 1974). They are easily digested by animals and provide body heat.

Animal fats including tallow, lard, lamb fat and fish oils as well as fats and oils from such plants as coconut, soybeans, cotton, maize and others, are by-products of other food and industrial uses and are available for swine feeding (Pond and Maner, 1974). Fat deficiency is not likely when diets contain appreciable amounts of maize or the cereal grains. However, when roots and tubers or processed carbohydrates make up a major part of the energy source, there is potential danger of skin lesions related to fat or a fatty acid deficiency (Pond and Maner, 1974)

2.2.2. Protein

All living cells of the body except fat cells are composed of protein. Each cell is continually undergoing degeneration and disintegration and therefore a constant supply of protein with its amino acids is required for the reconstruction of cells (Table 2). Every animal must have a constant supply of a certain amount of protein if it is to maintain health and not lose weight (Williamson and Payne, 1964). Proteins should be provided in terms of both quality and quantity. Protein quality refers to the amino acid content (Blakely and Bade, 1994). The body protein consists of twenty-two (22) amino acids which are found in the digestive tract, muscle tissues, blood and hair. Small amounts are present in enzymes and hormones (Gillespie, 1992). Ten (10) of these amino acids called essential amino acids which include arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine cannot be synthesized in sufficient quantities by pigs and therefore must be provided in their rations. The other twelve (12) amino acids called non-essential amino acids are needed by animals, but can be synthesized in sufficient quantities in the body of pigs (Gillespie, 1992,). The ligaments, hairs, hooves, horns, skin, internal organs and muscles of the animal (pig) body are partially formed from proteins. Protein is also essential for fetal development in pregnant animals (Gillespie, 1992). Proteins makes up about 15-20% of the total body weight of the pig (Holness, 2005).

The concentration of protein required in the diet depends on the total amino acids (Table 2) needed for lean tissue growth or milk production in comparison to energy needed for body fueling (Whittemore, 1993). The amino acid requirements usually expressed as a percentage of the diet decreases as the pig grows older (Kellems and Church, 2002). Pig diets are formulated based on crude protein (Adesehinwa, 2008). The protein levels are establishshed for the various weight classes of pig. Theoretically, the pig requires the following diets: starter ration of 18%CP, creep feed of 19-20%CP, grower ration of 16% CP, fattening ration of 14%CP, gestation gilt of 16%CP, gestation sow of 14%CP, lactating sow of 16%CP, young boar of 16%CP and older boar of 14%CP (Payne, 1990). Whittemore (1993) divided pig diet into three (3) broad classes according to their protein: energy ratio and stated that diets with 13g CP/MJ DE or less are appropriate for pregnant adults and growers above 80kg liveweight while a diet with 13-14kg CP/MJ DE is appropriate for pigs of less than 30kg liveweight.

Table 2: Amount of amino acids in the 'ideal' protein for growing pigs.

Essential amino acid	**Ideal requirement for growing pigs (g/kg protein)**
Lysine	70
Methionine	35
Threonine	42
Tryptophan	10
Isoleucine	38
Leucine	70
Histidine	23
Phenylalanine & tyrosine	67
Valine	49

Source: Agricultural Research Council, UK (1981).

2.2.3. Energy: Protein Ratio

Efficient utilization of protein depends on the amount of energy available. Thus, the amount of protein per unit of DE is more important than the absolute concentration of protein (Holness, 2005). Good diet formulation requires a balance between the percentage crude protein and the number of energy units in the diet (Longe, 1988). The optimum ratio depends on the age of the pig and genotype. The optimum protein to energy ratio changes steadily as the pig grows, being highest in the young animal and lower in the older pig, when protein requirements per kg live weight are less. Exotic pigs need a higher protein to energy ratio than unimproved and indigenous pigs because they have a higher lean to fat ratio in their bodies (Holness, 2005). Cooke *et al*. (1972) observed a decline in lean percentage and an increase in fat percentage with increasing dietary energy level when they fed varying levels of dietary crude protein of 15, 18, 21 and 24% at four energy levels of 2830, 3700, 3375 and 3585 kcal/kg DE. They also observed an increase in growth rate and an improvement in FCE as the dietary protein level increased from 15 to 18%, but recorded depressed growth rate and FCE from 21 to 24% protein levels. Earlier, Robinson and Lewis (1964) also fed varying protein levels of 11, 13, 16 and 19% at two different DE levels of 3340 and 2950 kcal/kg and recorded a significant increase in the lean percentage of the carcass as the dietary protein level increased.

2.2.4. Minerals

Minerals are of vital importance in the diet of the pig. The growth and efficiency that should result from expensive inputs of protein and energy can be negated by small inbalances in or shortages of essential minerals (Holness, 2005). Minerals are the inorganic components of the diet. They are solid, crystalline elements of the diet that cannot be decomposed or synthesized by chemical reaction (Kellems and Church, 2002). An intake of certain amount of minerals is as essential to the life of an animal as is consumption of water; an adequate amount being essential for its perfect health and maximum production. Nevertheless, the amount found in the animal is but a small proportion of its total body weight. The growth of the young animal as well as the continuous renewal of the mature cells of the body call for a constant supply of minerals (Williamson and Payne, 1964). About 5% of the total body weight of the pig consists of mineral elements. Minerals are vital for most of the basic metabolic reactions in the body. They are needed for digestion, metabolism of protein, fats and carbohydrates; and the structure of chromosomes, enzymes, nerves, blood, skeleton, hair and milk. Minerals are also important in reproduction, growth and resistance to diseases and parasites in pigs (NRC, 1998).

Four (4) major or essential minerals and six (6) trace or non-essential minerals are frequently added to pig rations. The major minerals are calcium, phosphorus, sodium and chlorine. The trace minerals are zinc, iron, copper, selenium, manganese and iodine (Gillespie, 1992). Sodium and chlorine are commonly added to rations in the form of common salt, NaCl (Holness, 2005). Common salt contains about 40% sodium and 60% chlorine (NRC, 1988). Almost all feedstuffs for pig are deficient in sodium and chlorine; therefore, common salt is routinely added to virtually all mixed diets for swine (Pond and Maner, 1974). The level commonly added is 0.5% of the diet (Pond and Maner, 1974; Gillespie, 1992). NRC (1998) gave the recommended level of salt as 0.25% for a grain-soybean meal diet for growing and finishing pigs, 0.40-0.50% in starter diets and 0.50% in sow diets. A level of salt intake equivalent to 2% of the diet is enough to cause acute toxicity and death if access to water is not freely available (Pond and Maner, 1974; Holness, 2005).

Calcium and phosphorus requirements are closely tied together because of the importance of an optimum dietary ratio, i.e. approximately 1.2 part of calcium to 1.0 part of phosphorus for bone formation and other metabolic functions (Pond and Maner, 1974). It has been shown that calcium and phosphorus play important roles in the development and maintenance of the skeletal system, blood clotting, muscle contraction and some physiological functions (NRC, 1998). It is important to maintain the right calcium to phosphorus ratio in the diet, which should not exceed 1.7:1 for pigs up to 20kg liveweight; 2.0:1 for 20-55kg pigs and 2.4:1 for pigs over 55kg (Holness, 2005). The most common calcium source is ground limestone and the ration should contain 0.5-0.7% calcium. Also, dicalcium phosphate in grain soyabean meal diet supplies both calcium and phosphorus in the ratio of 1.0-1.5 Ca to 1.0 total phosphous (Gillespie, 1992). Trace minerals are often found in commercial protein supplement mixes. Iron and copper help to prevent anaemia and are especially important in piglet rations. In addition to iron supplied in the ration, piglets should always be given iron when they are two or four days old. Zinc is required to prevent parakeratosis and excess minerals in pig ration slow the rate of gain. Minerals should not be added to a ration containing commercial protein supplements unless the feed tag indicates that they are required. A mineral mix can be fed free choice since pigs will not over eat minerals if they are receiving enough in the ration (Gillespie, 1992).

2.2.5. Vitamins

Vitamins are organic compounds that function in small amounts and are essential to the normal functioning of the body. They cannot be synthesized in adequate amounts by body tissues and when lacking, they can provoke deficiency diseases (Holness, 2005). Many of the vitamins required by pigs are already present in the feeds used in pig rations (Gillespie, 1992). Fourteen (14) vitamins are normally required in the diet of pigs, of which four (4) are fat-soluble and ten (10) are water-soluble (Holness, 2005). The fat-soluble vitamins are vitamins A, D, E, K and the water-soluble vitamins include thiamin, riboflavin, niacin, vitamin B6, pantothenic acid, biotin, folic acid, vitamin B12 and choline (Gillespie, 1992; Holness, 2005). Many feedstuffs commonly used as energy and protein sources for swine contain appreciable amounts of fat-soluble and water-soluble vitamins (Pond and Maner, 1974). Vitamins may be added to the ration as vitamin premixes (Gillespie, 1992).

In general, animal products, including milk, liver and muscle, and green forages are rich sources of most of the vitamins. In practice, riboflavin, choline, pantothenic acid, niacin, vitamin B12, vitamin A, vitamin E and vitamin D are most likely to be in limited supply in natural diets (Pond and Maner, 1974). Vitamin K and biotin are synthesized in adequate amounts by microflora to overcome dietary deficiencies under most conditions. However, recent field reports have indicated the possibility of clinical signs of vitamin K and biotin deficiency among growing pigs raised on slated floors (Pond and Maner, 1974).

2.2.6. Water

Water is one of the most important nutrients in pig ration (Gillespie, 1992). With the exception of oxygen, water is the most important ingredient for the maintenance of life (Holness, 2005). About two-thirds of the weight of the growing animal is water. It is vital to every cell in the living body and the main constituent of all liquids of the body without which mastication, deglutition, digestion, absorption and distribution of food throughout the tissue becomes impossible, as does the deleterious products of metabolism. The amount needed naturally varies with the physiological requirements of the body and the amount drained from the body on accounts of one activity or another. From the practical point of view, the relative need of immature animals is very much more than that of adults. At birth, the water content of the body is as much as 80% of the total body weight and drops to about 60% as the animal reaches maturity (Williamson and Payne, 1964).

Pigs require clean fresh water at all times to keep up feed intake and utilization (Gopalakrishnan and Lal, 1996). The water content of the body of a pig varies with age from 50-80% (Whittemore, 1993) or from 500g/kg to 750-800g/kg (McDonald *et al.,* 2002) in newborn and the matured fat adults respectively. In general, young pigs will need more water per kilogram of body weight than adult ones. The ratio of water to dry matter ranges from 5:1 for piglets using sow's milk as a guide; growing pigs: 2:1; pregnant sows 3:1; lactating sow 5:1 as absolute minimum requirement. Dry feeding system may waste 5-10% of feed supplied while wet feed waste is normally 2-4% (Whittemore, 1993). Pigs can be watered two or three times daily (Gopalakrishnan and Lal, 1996) but the water should not be colder than 7^oC (McDonald *et al*., 2002) since highly chilled water is harmful to pigs

(Gopalakrishnan and Lal, 1996). Water is of particular importance in the tropics and hotter and drier parts of the World, where it is often in short supply and where the pig requires more water to enable it maintain body temperature. Lack of water very quickly leads to a rise in body temperature and death. Equally important is that sub-optimal amounts of water will have a major effect on feed intake and performance and this applies irrespective of the system of production (Holness, 2005). However, the feeding of succulent materials reduces water requirements of pigs (Gopalakrishnan and Lal, 1996). It is essential in the tropical climates that pigs have access to a supply of clean fresh water at all times (Holness, 2005).

2.3. SOME PROTEIN SOURCES FOR PIGS

2.3.1. Soyabean Meal (SBM)

Soyabean meal (SBM) is one of the most widely used protein sources for pigs and it possesses the highest biological value of all the vegetable proteins (Holness, 2005). The use of SBM in pig rations has been under investigation for more than 40 years. Studies have related primarily to the influence of different processing methods on feeding quality of the meal and to the specific nutrient requirements of growing pigs when SBM is used as a portion or all of one supplemental portion (Pond and Maner, 1974). It is one of the best and most widely used protein supplements in animal feeding but is highly priced in most tropical and sub-tropical countries, probably only slightly cheaper than groundnut cake (GNC). Soybean protein contains all the essential amino acids but the amounts of cysteine and methionine are sub-optimal and a number of toxic stimulatory and inhibitory substances including allergic, goitrogenic and anticoagulant factors may also be found (McDonald *et al*., 1992). Properly processed SBM contains a protein of excellent quality. Depending on completeness of oil extraction and degree of hull removal, soyabean meal contains between 43 and 51% CP and has an excellent content of amino acids. Soyabean protein has a good balance of amino acids essential for growing pigs. The distribution of amino acids is similar to that of animal protein (Pond and Maner, 1974).

According to Pond *et al.* (1991), SBM contains about 44% CP, 7.30% CF, 7.84% EE, 3.3% cellulose and 3.48% hemicellulose on DM basis. Relative to the requirement of the pig, most amino acids are quantitatively in excess when SBM is used to supply all of the dietary protein. However, in practice, SBM is seldom used as the only source of protein but is used as a supplemental protein in combination with other feed ingredients, such as maize, sorghum, cassava meal, banana meal and by-product feeds (Pond *et al.*, 1991).

A combination of maize and SBM provides an excellent diet for pigs of all ages if the proper proportions of maize and SBM are used to supply an adequate balance of amino acids (Pond and Maner, 1974). O' Doherty and Keady (2000) and McKeon and O' Deherty (2001) reported that SBM can be used at levels of 10% and 20% in grower and finisher pig diets respectively without affecting performance. However, SBM is a poor source of B-vitamins, which must be supplied either as a supplement or in the form of animal protein such as fishmeal (Banerjee, 1988). It is a good source of potassium, magnesium and fair amount of trace elements (Ralph, 1987). Soyabean meal has very high protein and energy digestibility and is considered good source of supplemental protein in diets of pigs (Dunsford *et al.*, 1989).

2.3.2. Groundnut Skin Meal (GSM)

Groundnut meal is another wisely used source of protein for pig feeding in the tropics. Although high in protein, the biological value is relatively low (Holness, 2005). Ghanaian animal nutritionists have been studying in some detail, a by-product of the local processing of groundnuts namely groundnut skin meal (GSM). It consists mainly of the skin or testa and varying quantities of broken kernels and germs (Okai, 1998). The GSM is obtained after roasting the seed and removing the skin. It contains 18.8% CP, 24.8% EE and 4.4% Ash (Okai *et al*., 1994). Owing to the susceptibility of groundnuts to infection with moulds, the meal often contains aflatoxins, which can seriously depress the growth rate of pigs (Holness, 2005). It must therefore be stored well to prevent the material from going rancid (Okai *et al*., 1994). Some few experiments on GSM by Okai *et al. (*1994*)* suggest that it has some potential. Both rat and pig experiments by Okai (1998) have shown that GSM can be a satisfactory feed ingredient providing both protein and energy. Unfortunately, GSM contains tannins and therefore there may be poor CP digestibility (Okai, 1998).

2.3.3. Groundnut Cake (GNC)

Groundnuts are among the legume crops cultivated in Ghana. Groundnut cake (GNC) and groundnut skin meal (GSM) are by-products of groundnuts. Currently, only limited amounts of groundnut cake (GNC) are produced in Ghana for the feed industry but the bulk of the nation's requirement is imported from Europe and / or neighbouring countries. In spite of its limited production but huge importation to Ghana, GNC can help to reduce the cost of feeding pigs and poultry by reducing the demand for the major protein sources (Okai, 1998). Groundnut cake has a moderate cellulose content of 5 to 7%. Residual oil contents are variable depending on the method of preparation: 4-8% for the expellers and 1% for the extraction cakes. The CP contents are high with average of 45% and 50% for expellers and extraction cakes (Say, 1987). According to Ranjhan (1999), GNC may be decorticated or undecorticated with the undecorticated GNC having higher fiber content. The decorticated GNC is normally fed to monogastrics. It has low fiber content of 6-10% and a CP level of 40-48%. However, GNC is deficient in lysine and methionine (Say, 1987; Ranjhan, 1999). Adequate supplementation with animal protein is necessary when GNC is used in high cereal diets since its CP has sub-optimal amounts of cysteine and methionine (McDonald *et al.*, 1992).

2.3.4. Palm Kernel Meal (PKM)

The oil industry in Ghana has several by-products that could be considered as alternative feed resources for pigs (Okai, 1998). Palm kernel meal (PKM) is obtained after the extraction of oil from palm kernel. The cake (PKC) is often used as a vegetable protein supplement in animal rations but it is not as popular as groundnut cake or cotton seed cake. The PKM is abundant in the tropical areas of the world (Abu *et al.*, 1984). Analysis at the Nutrition Laboratory of KNUST indicated that sun dried PKM contains 91.04% dry matter, 19.02% crude protein, 23.25% oil and 5.68% ash. This shows that it could be a good source of protein and energy for animals. The results also showed that diets containing 20% PKM could be fed economically to growing pigs (Okai *et al*., 1994). In detailed studies including chemical assays, Fetuga *et al*. (1977) described PKM as a good source of methionine and cysteine but marginal in lysine. Fresh PKM could easily go moudy or rancid if it is not fed within a short time (about one week) because of the high moisture and fat content (Okai *et al.*, 1994). Palm kernel cake (PKC) is produced in large quantities in a number of tropical countries and is available at competitive prices (Kim *et al*., 2001; FAO, 2002). It contains about 14-21% CP and 10-20% CF with methionine being the first limiting amino acid (McDonald *et al*., 1995; Okeudo *et al.*, 2005). Okai and Opoku Mensah (1988) included 0, 10 and 20% of locally produced PKC at the expense of some of the maize, SBM and wheat bran in the control diet of growing pigs for 28 days. While all growth performance criteria with the exception of feed intake (higher for the PKC diets) were found to be similar for the treatments, the PKC-containing diets were cheaper. However, the carcass back fat content was higher ($P < 0.05$) for the pigs fed the PKC-containing diets.

2.3.5. Sheanut Cake (SNC)

About 30,000 metric tonnes of sheanuts were collected in 2000. Even though, most of this was exported directly, local processing to extract the shea butter from the nut is quite common. The SNC which is made available after this extraction is material that has attracted the attention of scientists and animal nutritionists in Ghana. There is evidence that SNC contains 14% CP, 4.3% ash, 5.8% CF and 49.8% NFE suggesting that it could be a useful energy/protein source in livestock and poultry diets (Okai *et al*., 1994). Unfortunately, studies with both pigs and rats have shown that despite the fact that SNC-containing diets are cheaper, its reasonably good CP and EE contents of 14 and 12% respectively may not support good growth performance if more than 10% is included in monogastric diets. It is believed that tannins and perhaps other anti nutritional factors (ANFS) may be responsible for this (Okai and Bonsi, 1989). Okai *et al*. (1994) suggested that in view of the presence of tannins, saponins and other ANFS, not more than 5% of SNC should be fed to pigs. Simple processing techniques such as soaking and boiling have been done to determine whether such "processed "forms are valuable (Okai, 1998). Okai *et al*. (1995) observed that the soaked or boiled SNC gave a better growth performance in rats than the unprocessed form due to an improved diet digestibility because of the removal of some of the tannins.

2.3.6. Cotton Seed Cake (CSC)

Cotton seed cake (CSC) is the main by-product of interest in animal feeding that can be obtained from the cotton plant. Relative to groundnut cake, CSC is cheaper as a standard protein supplement (McDonald *et al*., 1988). Banerjee *et al.* (1988) indicated that CSC contains protein of high quality but has low cysteine, lysine and methionine contents. According to McDonald *et al*. (1995) lysine is the first limiting amino acid in CSC and has high phosphorus to calcium ratio of 6:1. For optimum performance in monogastric animals, CSC should be supplemented with animal proteins (McDonald *et al*., 1988). The material contains variable (0.3-20g / kg DM) amounts of a toxic compound, gossypol, and a polyphenolic substance. For poultry and pigs, it is generally accepted that the level of free gossypol should not exceed 50-100kg / tonne (McDonald *et al*., 1995). According to Banerjee (1988) a level of 0.03% free gossypol should not be exceeded in pig ration. McDonald *et al.* (1988) suggested that because of its gossypol content (0.03 to 0.2%) which has toxic effect on monogastrics, CSC should not form more than 10% of monogastric diets. For swine, a percentage exceeding 9% will lead to mortality of the growing pigs (McDonald *et al*, 1995). In laying chickens, it should not exceed 5% to avoid undisarable effects on the storage quality of eggs such as discolouration of the yolk (Atuahene *et al*., 1987; McDonald *et al.,* 1995). Banerjee *et al.* (1988) and

McDonald *et al*. (1995) suggested that the use of ferrous sulphate and iron salts may render the gossypol inactive.

2.3.7. Copra Cake (CC)

Copra cake is the main by-product obtained after the extraction of coconut oil and used in poultry and pig feed as protein source (McDonald *et al.,* 1992). Copra cake (CC) is produced in large quantities in a number of tropical countries and has been widely used in pig diets (FAO, 2002). It is a vegetable protein supplement of mediocre quality and less popular than other vegetable protein supplements (McDonald *et al*., 1992). Copra cake contains about 19.09% CP, 5.48%EE, 16.25% CF and 89.70% dry matter (Okai *et al*., 1994). It is low in lysine and histidine. Incorporation of CC in diets for monogastrics requires further supplementation with animal proteins (McDonald *et al*., 1992) Grower-finisher pigs have been fed diets containing CC at inclusion level of 5 and 10% respectively without any adverse effect on performance (Lekule *et al*., 1986). Panigrahi (1991) and McDonald *et al.* (1995) reported that feed intake of pigs decreased linearly with increasing level of copra cake from 20 to 30%. Some disadvantages of its utilisation are susceptibility to rancidity, low level of lysine, histidine and high crude fibre content, all of which limit its use by simple-stomached animals (McDonalds *et al*., 1992). However, an increase in the energy content of the diet by addition of maize oil improves efficiency of food utilization, feed intake and growth rate (Panigrahi, 1991). According to McDonald *et al.* (1988) the maximum inclusion level of CC in the grower- finisher diets of pigs should be less than 20%. However, Kim *et al.* (2001) suggested that 10% CC in the diet of pigs is satisfactory.

2.3.8 Fish Meal (FM)

Fish meal is the main source of protein of fish origin with crude protein (CP) content of about 60% (Okai and Bonsi, 1989). It is the most important fish product used in pig feeding (Pond and Maner, 1974). Fish meals are among the most valuable feed ingredients when they are of high quality, and are among the most costly and disappointing when they are of poor quality (Pond and Maner, 1974). According to Ousterhout (1968) as cited by Pond and Maner (1974) fish meals are basically of two types: those made from waste from human food fishery and those made from whole fish. In order to make a fish meal that will be reasonably stable under normal storage conditions, the moisture content must be reduced to around 10% (Cole, 1968 as cited by Pond and Maner, 1974).

In many tropical countries, two types of fish meals are on the market; sun-dried and artificial dried (Payne, 1990). Sun-dried meal usually has lower protein and higher oil contents and may be dangerously contaminated with bacteria (Payne, 1990). Fish meal is rich in lysine and other essential amino acids placing it among the best protein feeds available with Calcium content of 5% or higher (Serres, 1992). Locally produced fish meal can be obtained. Some are very valuable with CP levels reaching 60% (Serres, 1992).

2.4. ENERGY SOURCES FOR PIGS

Energy is generally supplied from cereal grains and by-products, root crops, fats and oils, sugar by- products or various fruits (Holness, 2005). According to Okai *et al.* (1994) in Ghana, energy for pigs can be obtained from maize, cassava, maize bran, sorghum, yam peels, pito mash, rice bran, “koko”chaff, cassava peels, cassava foliage or leaf meals, oil palm slurry, dried bakery waste products, dried coffee pulp, cocoa pod-husk, dried cashew pulp, oil seeds and ripe plantain peels.

2.4.1 Maize as a Major Energy Ingredient for Pigs

Maize is a major cereal crop for both human and livestock nutrition with high carbohydrates, low fats and mineral contents (Prasanna *et al*., 2001). It is the major grain used as food in most parts of the world, and it constitutes the main bulk of the daily diets and account for about 15-56% of the total daily calories in Africa and Latin America (NRC, 1988). It is a vital staple, particularly for the rural poor in most of the developing World (NRC, 1988). In Africa, maize is an important cereal crop serving as a source of food and industrial raw materials (Olakojo *et al*., 2007).

The world- wide spread of maize has made it the number one feedstuff used as animal feed (NRC, 1988). In the developed countries like USA, maize is mostly used as animal feed. Maize is the most common grain used for feeding pigs and the basic energy feed used in pig rations (Pond and Maner, 1974; Gillespie, 1992) accounting for 40-60% of the whole diet (Payne, 2000). Because of its abundance, maize constitutes about 60% of a typical commercial swine and chicken diet (Maner *et al*., 1971; Burgoon *et al*., 1992). However, the competition for maize between livestock and humans has brought about high demand for it resulting in an escalating price of maize and consequently the high cost of feeding pigs and poultry (Okai *et al.*, 2001b).

2.4.2 Nutritive Value of Maize

Maize is the basic energy feed used in pig rations. It is high in digestible carbohydrates, low in fibre and palatable (Gillespie, 1992; Ranjhan, 2001). The energy value of maize is generally used as a standard with which other energy sources are compared (Pond and Maner, 1974, Gillespie, 1992). The NRC (1968) gave a detailed composition of maize (Table 3). White and yellow maize are of similar composition except that yellow maize is high in carotene, a vitamin A precursor. Both are fair sources of vitamin E, but low in vitamin D and in the B vitamins (Pond and Maner, 1974). Although maize is commonly used for swine feeding, it should never be fed as the sole source of protein in swine ration because of its relatively low protein content and poor balance of essential amino acid.

Furthermore, its phosphorus and nicotinic acid contents are partially unavailable (Pond and Maner, 1974; Payne 1990). It can be used at a rate of 85% of the ration for growing pigs and somewhat lower rates for pregnant pigs (Payne, 1990). The protein content varies from 8–12% (Ranjhan, 2001).

Extraction of the protein fractions with a copper reagent at different pH has shown that the protein of the endosperm and germ can be divided into four fractions: the zein, glutelin, acid soluble and residual fractions. The zein contributes as much as 50% of the total protein of the kernel in most varieties but contains very low levels of both lysine and tryptophan (Pond and Maner, 1974), the two amino acids that are not found in large amounts in maize (Gillespie, 1992). In a recent study of the meal,

Table 3: Nutrient composition of maize.

Nutrient	**Amount**
Dry matter	89.0%
Ash	1.1%
Crude fibre	2.0%
Ether extract	3.9%
Nitrogen free extract	73.1%
Protein (nitrogen x 6.25)	8.9%
Energy gross	3,918 kcal/kg
Energy	3,610 kcal/kg
TDN	82%
Calcium	0.02%
Phosphorus	0.31%
Vitamin A	3,000 iu/kg
Pantothenic acid	3.9mg/kg
Riboflavin	1.3mg/kg
Niacin	26.3mg/kg
Thiamin	3.6mg/kg

Source: National Research Council, (1968)

the starch, NDF and oil contents were in the range of 435-570, 220-572 and 35-175g/kgDM respectively (McDonald *et al.,* 2002). Maize contains about 730g starch/ kgDM, low in fibre and high in ME value (McDonald and Low, 1994). The oil content varies from 40-60glkg DM and high in linoleic acid (McDonald *et al*., 2002).

2.5. ALTERNATIVE ENERGY SOURCES FOR PIGS

The most common energy source used in commercial pig and poultry diets in Ghana is maize. Unfortunately, it is also a common staple in human diets (Okai, 1998). The consequent high demand by both humans and some domestic livestock species coupled with both official and unofficial exports have led to situations where prices become very high necessitating the use of alternate energy feed ingredients (Ngou and Mafeni, 1983; Okai, 1998). Alternative or non-conventional feed resources are those feeds that are not been used traditionally to feed animals or are not used in commercially produced rations for animals (Devendra, 1992). They are potential feed ingredients that are not frequently used in pig diets mainly because there is a limited research data on their chemical composition, suitable levels of incorporation in pig diets and lack of simple processing methods. Their importance cannot be over-emphasized since their utilization could reduce feed cost, reduce competition between humans and pigs for some feed or food ingredients such as maize and in some instances help recycle potential environmental pollutants (Okai *et al*., 1989). Examples include sorghum, cassava, wheat bran, rice bran, maize bran, bananas and plantains, bakery wastes including discarded biscuits, brewers spent grains, cocoa pod husk, dried coffee pulp, garbage or swill (kitchen waste) etc.

2.5.1 Sorghum (Guinea corn)

Sorghum is a hardy plant, able to grow and produce under a wide range of environmental conditions, particularly in warmer temperatures and tropical regions of the World (Pond and Maner, 1974). Sorghum tolerates drought better than maize. Trials in Zimbabwe indicated that it has approximately 95% of the feeding value of maize (Holness, 2005). Sorghum grain, like maize, is an excellent feed for swine when it is adequately supplemented and properly fed (Pond and Maner, 1974). Some of the original varieties tested were very unpalatable to swine due to their high content of tannins, which lowers the palatability and protein digestibility of the grain (Pond and Maner, 1974; Holness, 2005).

The embryo of sorghum is rich in lipids, protein, minerals and Vitamin B2. However, the removal of the outer pericarp by processing proportionately decreases the protein, cellulose, lipid and mineral contents. In mature seeds, the proportion of protein nitrogen in the endosperm increases, the composition of the endosperm storage protein changes, glutamic acid and proline levels increase while lysine, methionine and other basic amino acid levels decrease in proportion to the total nitrogen (Hulse *et al.*, 1980). Lysine is the limiting amino acid in sorghum. Digestibility of normal sorghum protein is varied. Sorghum, if solely fed to pigs lead to high excretion of nitrogen, calcium and phosphorus. The nutritional quality can however, be improved if supplemented with synthetic lysine or supplementary ingredients such as rice meal, legume, flours or animal proteins are added (Hulse *et al.*, 1980). Sorghum or guinea Corn is readily available in Ghana but usually its price does not encourage its use as an alternative feedstuff by livestock farmers. One major reason for its high price is the huge demand for the brewing of the local beer, pito (Okai, 1998).

2.5.2 Cassava and its By-Products

One feed source with a great-unrealized potential in many tropical areas is cassava (Pond and Maner, 1974). The production of cassava is widespread throughout Latin America and parts of Africa, mainly on small farms as a staple human food. The dry cassava is high in energy but low in protein, a factor that must be taken into consideration when cassava is used as a substitute for cereals in pig diets (Holness, 2005). The root contains an average of 65% moisture and 35% DM (Pond and Maner, 1974) and can be fed fresh, forming a particularly useful source of energy for dry sows (Holness, 2005). The pulp, or internal portion of the root contains 37.8% DM representing approximately 86.8% of the total root with the remainder of 13.2% being made up of the peeling (Pond and Maner, 1974). Cassava root provides carbohydrates (energy) for human and animal diet. An average of 30.84% of the fresh root is NFE. The NFE fraction of the whole root contains approximately 80% starch and 20% sugars (Vogt, 1966). Cassava contains 1.45% fibre, 0.20% EE, 1.15% ash, 0.12% calcium, 0.16% phosphorus, 0.06% sodium, 0.37% magnesium and 0.86% potassiuim (Pond and Maner, 1974).

The levels of various amino acids such as lysine and tryptophan are promising and constitute more of the protein than those of opaque-2 maize (Pond and Maner, 1974). However, the levels of both methionine and cystine are extremely low and appear to be first limiting-factor (Pond and Maner, 1974). The presence of a toxic factor in cassava presents some problems in its utilization as a livestock feed. The toxicity of the cassava is due to the presence of hydrocyanic acid (HCN) or prussic acid (Holness, 2005). Various processing methods can be used to reduce the HCN toxicity of cassava. According to Pond and Maner (1974) drying in a forced-air oven at moderate temperatures (70 to 80º C), boiling in water and sun drying are some of the methods used.

Large quantities of cassava peels obtained during the processing of cassava are regularly collected by pig farmers, cooked and fed to pigs after the addition of some vitamins, minerals and protein supplements. Dried cassava is regarded as very good alternative to maize because of its high carbohydrate and energy content. However, it is relatively low in protein content, less than 3% CP (Okai, 1998). Cassava leaves and foliage have a CP content ranging from 21-26% and a good amino acid balance and can be used as a protein source to help reduce the need for other high quality protein sources, which are very expensive (Okai, 1998). Okai *et al*. (1989) observed that pigs intended for slaughter at or near 50kg liveweight can be fed diets containing up to 30% cassava leaf meal (CLM) without any adverse effect on growth rate. However, feed efficiency was not as good as on the control diet but feed cost was reduced considerably.

2.5.3 Wheat Bran

Wheat bran is produced in large quantities as a by-product of the flour milling industries in Ghana (Okai, 1998). It is a commonly used by-product in Ghana and is regarded as a good energy feed ingredient in the diets of non-ruminants and contains about 16% CP (Okai, 1998) and 1322 Kcal ME/kg (NRC, 1998). Wheat bran is highly palatable and has a laxative effect. Its amino acid balance is superior to that of wheat but inferior to that of most protein supplements (Okai, 1998). It is extremely high in phosphorus, but low in calcium, so that a nutritional imbalance of calcium to phosphorus occurs if wheat bran is a major component of the diet (Okai, 1998). It contains niacin, but the niacin present is almost completely unavailable (Pond and Maner, 1974). It is common to have pig diets containing at least 25% wheat bran (Okai, 1998) but as high as 70% level of WB can be included in grower finisher diets without any adverse effect. Even though there was a significant decline in growth rates, carcass traits were better and such diets were found to be cheaper and led to reductions in feed cost per kg liveweight gain when high levels of WB (25, 40, 55 and 70%) were fed to finishing pigs at KNUST (Okai *et al.*, 1995).

2.5.4 Rice Bran

Rice has about 75% of the feeding value of maize for pigs and contains relatively high fibre content. However, the grain is a staple food crop and normally too valuable to give to pigs. Rice by-products, known as brans, milling and polishing, consist of the germs and outer layers of the grain and are often the sole source of animal feed in smallholder village production systems (Holness, 2005). Rice that has been dehusked by an industrial process will produce a high quality by-product. However, traditional technologies do not completely separate the husk and bran resulting in high fibre content and excess of silica. Coarse rice bran that includes the germ is rich in polyunsaturated fats and can lead to oily fat in the carcass if too much is given to pigs (Holness, 2005). Rice bran is a mixture of the pericarp, germ, aleurone layer and some endosperm. The proportion of these fractions determine its composition but generally it contains about 14% CP, 2-3% EE and 13% CF (Sikka, 1990; McDonald *et al*., 1995). Pure rice bran is a good and palatable feed for pigs when fed fresh, but because it turns rancid on storage, pigs consume less of it than they do when it is fed fresh resulting in waste and decreased growth rate (Pond and Maner, 1974). Rice bran is of highly variable quality, depending mainly on the quantity of hulls included with the bran (Pond and Maner, 1974; Pond *et al*., 1991). The deleterious effect of hulls is due to the high fibre and silica and the low digestibility of the hulls, which limit dietary energy concentration. The hulls contain 11–19% silica (Pond and Maner, 1974).

Rice bran is readily available in Ghana and it is used as a substitute for wheat bran and as a partial replacement for maize or the cereal component of the diet (Okai, 1998). Rice bran is a poor source of feed for pigs when it is used to substitute for 100% of the grain in growing-finishing pig diets (Pond and Maner, 1974). Satisfactory gains and efficiency of feed utilization can be obtained when moderate levels of rice bran (30–45%) are used in growing-finishing pig diets. However, reduced pig performance can be expected when higher levels are incorporated in the diet. According to Campadadal *et al.* (1976), rice bran can be used at a level of up to 40% in the diets of grower-finisher pigs with good results. Tuah and Boateng (1982) found that up to 50% RB diets were satisfactory for growing- finishing pigs while Tuah *et al.* (1974) reported reduced growth rate ($P<0.05$) when RB levels of 40%, 50% and 60% were fed to finishing pigs. Definitely, for young pigs (5-15kg), levels of more than 20% should not be exceeded (Pond *et al*., 1991; Okai, 1998).

2.5.5 Maize Bran

Maize bran is a by-product obtained from the milling of maize (Pond *et al.*, 1991; Okai, 1998). It consists of the outer coating of the kernels, including the hull and tip cap, with little or none of the starchy part of the germ (Morrison, 1961). Maize bran is very much sought after by both small and medium scale pig and poultry farmers (Okai, 1998). The hull contains about 1.5% CF (Pond *et al.*, 1991). In Ghana, maize bran is a very good partial replacement for maize for poultry and pigs partly because the milling machines are not very efficient and the by-product contains most of the germ, bran and some portion of the endosperm. It is therefore, a high-energy source; unfortunately, during the manufacturing process, water is added to the maize and thus, the maize bran may be quite wet. If not dried immediately, it can easily become mouldy and also rancid. Wherever there are large concentrations of poultry and pigs, the demand is high and can be scarce and the price may be prohibitive (Okai, 1998). However, maize bran is too high in fibre and too low in protein quality to be used as a major component of pig feed (Pond and Maner, 1974).

2.5.6. Plantain/ Banana

Although bananas and plantains are grown largely for export and domestic consumption by the human population, a large quantity of these fruits are available for livestock (Pond and Maner 1974). At the packing plants in the areas of commercial banana production, bananas that are too small or too large, are slightly bruised, have spots, off colour, or are not in an optimal stage of maturity for shipping are rejected. The rejected bananas along with smaller quantities of farm-produced bananas and plantains constitute a good source of carbohydrates for pigs during all phases of the production cycle (Pond and Maner, 1974). The organic matter digestibility of green bananas in pig diets is 70% for the completely green fruit, 90% for the peels of the green fruit and is even higher for the ripe fruit (Gohl, 1981). Ripe bananas are very palatable to pigs. Studies have shown that the growing pig will consume up to 8kg per day. Banana contains just 1% protein but can provide a useful supplementary source of energy in the form of sugar (Holness, 2005). The fresh whole banana with the peeling contains approximately 80% water, 20% dry matter, 1% protein, 1% fibre, 0.2% fat, 1% ash and 16.8% nitrogen-free extract. The CF of the whole banana consists of 60% lignin, 25% cellulose and 15% hemicellulose. The ripe pulp itself contains 0.50% lignin, 0.21% cellulose and 0.12% hemicellulose (Clavijo *et al., 1970)*. The banana can be utilized fresh or as a dried meal. Studies have shown that the pig will daily consume large quantities of banana if they are allowed to ripe before they are fed (Clavijo *et al*., 1970; Oliva *et al.,* 1971).). However, the low protein content and high moisture present in the banana require that a supplemental source of both protein and energy be supplied (Pond and Maner, 1974). In addition, ripe banana, when fed in large quantities, may cause diarrhoea (Gohl, 1981).

Ghana is a major producer of plantains, the bulk of which is processed in the green (mature) or yellow (mature, ripe) forms to make local dishes. Usually, the green peels are discarded and both ruminants and non-ruminants livestock producers use this as feed supplement (Okai, 1998). Data obtained at KNUST indicate that the peels from the ripe plantain (RPPM) can be a good source of energy for growing pigs. In the study the RPPM constituted 0, 10 and 20% of the diet as direct replacement for maize and the growth performance data after four (4) weeks of feeding were similar. The RPPM diets were cheaper because RPPM is a by-product, which is usually discarded (Okai *et al.*, 1991).

2.5.7 Cocoa Pod Husk (CPH)

Ghana is one of the leading cocoa producers in the world. Three major by-products i.e. the cocoa pod husk (CPH), cocoa bean shells (CBS) and cocoa expeller cake (CEC) are obtained from cocoa bean processing (Okai, 1998) .Cocoa pod husk (CPH) is a by-product obtained after removing the beans from the cocoa fruit (Okai *et al*., 1994). It is quite likely that more than a 100,000 metric tonnes of CPH is generated in Ghana annually and the bulk of this is usually left to rot on the cocoa farms (Okai, 1998). Several studies conducted in different countries have shown that CPH can be used as one of the ingredients in poultry, pig and ruminant diets (Tuah *et al.*, 2003). It's inclusion in diets is aimed at reducing feed cost. It has high potassium content and the dried CPH contains 8.1% CP, 34.8% CF, 3.3% EE, 7.6% Ash and 33.6% NFE (Okai *et al.*, 1994). It can be milled ready to be used for feed compounding with other ingredients (Okai *et al.*, 1994). In comparison with maize, it contains less metabolizable energy and crude protein with less of all the amino acids except lysine (Tuah *et al*., 2003). Several experiments have been conducted with CPH using both ruminants and non-ruminants in Ghana. In one such experiments Okai *et al*. (1984) found that finishing pigs can be fed diets containing up to 25% CPH, where the CPH levels studied were replacing similar levels of maize, without any adverse effects on pig performance and carcass characteristics. Such CPH diets were generally cheaper. Gohl (1981) indicated that CPH could be fed to cattle up to 7kg per day and up to 2kg per day for pigs without any adverse effect. However, the high fibre content of CPH could limit the extent of its use in the diets of monogastrics such as pigs and poultry (Okai *et al.*, 1994).

2.5.8. Brewers' Spent Grains

Brewers' spent grains (BSG) are the insoluble residue left after removing the worth. It is bulky, especially when wet, (Pond and Maner, 1974; Chenost and Mayer, 1977). Dried Brewer's grains contain an average of 92% DM, 26% crude protein, 6.2% ether extract, 15% crude fibre, 3.6% ash and 41.4% nitrogen- free extract (Pond and Maner, 1974). The digestibility of most of the nutrients is low: 43.3% for the organic matter, 58.9% for the crude protein, 59.7% for nitrogen-free extract and 7.8% for the crude fibre (Pond and Maner, 1974). Although the high fibre content (15%), low energy and great variability of BSG limit their feed value for pigs, they tend to be widely used in small-scale system of pig production, especially in Africa (Holness, 2005). There are four major breweries in Ghana producing a wide variety of alcoholic and non-alcoholic beverages. Imported malt (from barley) is a major component in the brewing process, and large quantities of BSG are produced annually. It is a relatively cheap alternative feed resource with CP level usually in excess of 20% (DM basis) (Holness, 2005). Both ruminant and non-ruminant livestock farmers use it for their feeding operations (Okai, 1998). The fresh or wet form may contain as much as 80% moisture and over dependence on it for pig feeding may not elicit any reasonable growth performance (Okai and Lamptey, 1983). The limited research data available tend to suggest that it is a reasonably good feed ingredient for both pig and poultry. However, like wet brewer's spent grain, its high moisture content could limit the dry matter intake of pigs and serve as a good medium for mould growth (Okai, 1998).

2.5.9 Dried Bakery By-products

Dried bakery product is produced from reclaimed bakery products that have been blended and processed to provide a product that contains 9.0 to 9.5% CP, 11.0 to 13.0% crude fat and a maximum of 1.5% crude fibre, 3.5% ash and 4.5kcal per gram (Arrington *et al.*, 1964; Sewell, 1965 as cited by Pond and Maner, 1974). It consists of floor sweepings, caked flour, discarded dough and trimmings of dough, stale bread, buns, cakes and discarded biscuits. The nutrient composition of these products vary with the relative amounts and kinds of ingredients used in the dough preparation (Okai *et al*., 1994). Dried bakery product is an excellent ingredient in starter rations for young pigs. The product is highly palatable and the high level of fat makes it a good energy source for young pigs (Pond and Maner, 1974). Studies in Florida have shown that dried bakery product has no practical value as a vitamin source for rats and growing-finishing pigs, but that the high fat content (11 to 13%) makes it a high-energy ingredient that can be used to substitute for dietary maize or other grain sources when cost of the product is similar to that of the grain (Pond and Maner, 1974). Owing to the high level of fat, increasing the level of dried bakery product reduces the amount of feed required per unit of body weight gain (Pond and Maner, 1974).

The bakeries and biscuit factories in Ghana use mainly wheat flour in their operations and do generate some waste products that could be useful energy sources for pigs (Okai, 1998). Even though no accurate figures are yet available, the few biscuit factories in the country produce substantial quantities of various by-products, which are usually discarded. With about 10.6% CP, 0.7% CF, 4.0% EE, 72.3% NFE and 2.2% ash, these bakery by-products could be useful as a replacement for some or all of the maize in pigs' diets. KNUST research has shown that a dried bakery waste product (DBWP) containing 10.6% CP can constitute up to 30% of the diet of pigs as a direct replacement for maize and thereby reduce feed cost (Okai, 1998). In an experiment at KNUST, researchers incorporated up to 30% of a DBWP consisting of caked wheat flour, waste dough and discarded biscuits in a ratio of 2:2:1 in the diet of the starter pigs as a direct replacement for maize. Even though performance was not adversely affected by the inclusion of DBWP, a slightly higher incidence of scours was reported. However, the 30% DBWP diet was cheaper than the control diet. Using a slightly different bakery by-product (4:1 Gem: cabin), no incident of scours with diets containing bakery by-products were observed; growth rate and feed cost were again better (Okai *et al*., 1994). In another trial, discarded stale biscuits (DSB) were incorporated into pig diets at levels of 0, 15, 30 and 45%. Pig performance was similar but the DSB-containing diets were slightly cheaper. Carcass traits measurements were also similar for the four (4) dietary treatments (Okai, *et al*., 1991). It was suggested therefore that up to 30% of these by-products could be used in the diets of growing pigs (Okai *et al*., 1994).

2.6 DISCARDED BISCUITS (DB)

2.6.1 Source, Availability and Processing of DB

Discarded biscuit (DB) is an agro-industrial waste product found in substantial quantities in biscuits producing industries (Eniolorunda, 2010). It is a constituent of reclaimed bakery waste and consists of burnt, broken and mis-shapen biscuits (Okai-Amankwa, 1986; Okai *et al.*, 1994). Discarded biscuit is a palatable, high-energy feed produced from wheat flour, skimmed milk powder, vegetable fat, sugar, salt and flavour materials (Eniolorunda, 2010). The nutrient composition of DB varies with the relative amounts and kinds of ingredients used in the dough preparation. The biscuit factories use mainly wheat flour in their operations to generate the discarded biscuits (DB) and could make a good replacement for some or all of the maize in pig diets (Okai, 1998) and other cereal grains in fattening ram for market or for slaughter (Longe, 1986).

The "processing" of DB involves the removal of all extraneous materials (Plate 1). This process is labour intensive and may be time consuming depending on the amount of extraneous materials in the DB (Heloo, 1984; Okai-Amankwa, 1986). Discarded biscuits (DB) (Plate 2) often contain extraneous materials such as nails, wires, strings, pieces of paper, small pieces of sticks, pins, rubbers and sometimes may grow mouldy. Removal of these extraneous materials involves spreading out the DB and then picking out the foreign matter before milling (Okai- Amankwa, 1986).

Plate 1: Extraneous materials in DB.

Plate 2: Discarded Biscuits (DB).

2.6.2. Nutritive Value of DB

Analysis of DB showed that it contained substantial amount of nutrients such as protein, energy and minerals required for animal growth and performance (Longe, 1986; Olayeni *et al.,* 2007). Longe (1986) noted that the crude protein (CP) and energy contents of DB were 10.80% and 4.70 GE\DE respectively. Ajasin *et al. (*2010), in their study to determine the feeding value of DB as a replacement for maize in the diets of growing snails, observed that DB is another source of energy with protein and energy content relatively close to that of maize. They analysed both maize and DB and obtained 69.78% DM, 9.56% CP, 5.62% CF, 4.56% EE, 8.94% Ash and 71.32% NFE and 95.67% DM, 10.36% CP, 4.67% CF, 5.98% EE, 10.21% Ash and 68.78% NFE for maize and DB respectively.

Atakora (1982) analysed DB and obtained 11.9% CP, 0.73% CF, 14.7% EE, and 70.33% NFE. Okai and Bonsi (1989) also reported that dried bakery by-products including DB contain about 10.6%CP, 0.7% CF, 4.0% EE, 72.3% NFE and 2.2% ash. It has high fat and salt contents (Abdullatif *et al.,* 2004). Waldroup *et al.* (1982) reported that the fat content varies from 5.3 to 14.4%. Similarly, Thomas *et al.* (1981) observed high variation in the nutrient content with salt content ranging from 1.8 to 3.4%. According to Longe (1986), DB has no anti- nutritional factor.

2.6.3 Feeding Trials of DB

In evaluating biscuit waste meal (BWM) and *Leucaena leucocephala* leaf hay as sources of protein and energy for fattening Yankasa rams, Eniolorunda *et al*. (2010) replaced the maize portion of the diets with BWM at 0 (Control), 25, 50, 75 and 100% inclusion levels. Dry matter intake, crude protein intake and daily weight gains were all significantly (P<0.05) affected by the dietary treatments with the DB containing diets performing significantly better. They also observed that dry matter, crude protein and energy digestibilities and feed cost (/kg) declined significantly (P<0.05) with increase in inclusion level of BWM in the diet. Gross energy intake and chilling loss were not significantly (P>0.05) influenced by dietary treatments. However, the values obtained for wholesale cuts in terms of the shoulder, the rack, the breast shank and flank and loin as percentage of carcass weight were significantly (P < 0.05) affected.

Abdullatif *et al*. (2004) included five levels of a dried bakery waste (DBW) which included discarded biscuits at 0, 5, 10, 20 and 30% respectively in the diets of broiler chicks. They observed no significant (P > 0.05) differences in body weight between the control group (0% DBW) and those fed 5% and 30%. They concluded that DBW including DB could replace 30% of the maize in the broiler and other monogastric diets without negatively affecting the performance. Ajasin *et al.* (2010) replaced the maize portion with 0, 50, 75 and 100% discarded biscuits (DB) in the diets of growing snails. They recorded no significant (P>0.05) difference in weight gain between the control diet and those fed 100% DB diet. The feed conversion ratios were relatively similar (P>0.05). The dressing percentage of the snails were also not different (P>0.05) in all the treatments. Their cost analysis showed that cost/ kg feed and total feed cost reduced as the level of DB in the diet increased. The lowest cost per weight gain was recorded for the 100% DB diet while the highest cost per weight gain was observed in the control (0% DB) treatment. A research at KNUST has shown that dried bakery waste products (DBWP) containing, 10.6% CP can constitute up to 30% of the diet of pigs as direct replacement for maize and thereby reduce feed cost (Okai, 1998). In another trial, Okai *et al.* (1991) incorporated discarded biscuits (DB) into pig diets at levels of 0, 15, 30 and 45% as replacement of the maize portion and recorded no significant differences (P > 0.05) in mean feed conversion efficiency. Mean live-weight at slaughter, mean dressed weight and mean dressing percentage were similar (P>0.05) for all treatments even though numerical differences were observed. They obtained no significant differences (P > 0.05) for mean weights for liver, kidney and empty GIT. Mean back fat thickness and loin eye muscle area values were statistically not significant (P<0.05). However, the mean loin eye muscle area of pigs fed control diet was slightly higher. Feed cost and economy of gain were lower for the diets containing DB.

In another experiment at KNUST, researchers incorporated up to 30% of a dried bakery waste product (DBWP) consisting of caked wheat flour, waste dough and discarded biscuits (DB) in a ratio of 2:2:1 in the diet of starter pigs as a direct replacement for maize. Even though growth performance was not adversely affected by the inclusion of DBWP, a slightly higher incidence of scours was reported. However, the 30% DBWP diet was cheaper than the control diet. Using a slightly different bakery by-product (4:1 Gem: cabin), no incidence of scours were observed for diets containing bakery by-products; growth rate and feed cost were again better. It was suggested that up to 30% of these by-products could be used in the diets of growing pigs (Okai *et al*., 1994). Tibiru (1980) included 0, 10, 20 and 30% DBWP in the diets of starter pigs to replace maize. With regard to health grounds, he recorded incidence of scours on all the treatments. Scours were more frequent in pigs on 30% DBWP diet than those on other diets. He recorded no significant

(P>0.05) differences in mean daily feed intake, mean daily live weight gain and mean feed conversion efficiency. There was a significant (P<0.05) difference in feed cost\kg between pigs on 30%, 20%, and 10% DBWP diets and the control diet with the DBWP diets significantly better. Heloo (1984) included 0, 15 and 30% DB in the diets of growing pigs to replace maize. He observed no significant (P>0.05) differences in the feed intake, average daily gain and feed conversion efficiency. Feed cost reduced as the level of DB increased in the diet since DB had lower price than the maize. Okai- Amankwaah (1986) also included 0, 15, 30 and 45% DB in the diets of rats. She recorded a significant (P<0.05) difference in mean daily live weight gain and mean daily feed intake between rats on the 0, 15, 30% DB and those on 45%. Mean daily live weight gain increased in the order of 0 >15>30>45% DB respectively. There were no significant differences in feed conversion efficiency and mean liver weight. She also recorded reduction in feed cost as the level of dietary DB increased.

2.7 GROWTH PERFORMANCE OF PIGS

2.7.1 Feed Intake of Pigs

Pigs are omnivores and will consume a wide range of feeds from both plant and animal sources, which are usually given on dry matter basis (Muys, 1984). Adequate feed intake is hard to maintain on many farms, and is an important factor limiting productivity. Surveys show that feed intake varies by at least 25% among commercial farms (NRC, 1998). Stressors such as high temperature increased stocking density and reduced health status, together with genotype influence feed intake and growth. Dietary factors, including energy density, deficiencies or excesses of nutrients, antibiotics, flavours, feed processing and availability of water all influence feed intake (NRC, 1998). The various stress factors affecting how much pigs eat are grouped into environmental (temperature, humidity, air circulation etc), and social (space allocation, group size, regrouping etc) factors.

Cold temperatures increase feed intake while hot temperatures reduce feed intake when compared to temperature in the comfort or thermal-neutral zone (Revell and Williams, 1993). When the room temperature is too hot, grower-finisher pigs eat about 40g per day less for each 1^0C above the comfort zone. Under cold temperatures, pigs eat about 30g more per day for each 1^0C below the comfort zone (Revell and Williams, 1993). For social factors, space restriction reduces feed intake. For example, a 37% reduction in space allowance from 0.55 to $0.35m^2$/ pig for grower pigs reduced feed intake by 11% (Edmond *et al.*, 1998), whereas 55% reduction from 0.56 to $0.25m^2$/ pig reduced feed intake by 8% (Hyun *et al.*, 1997). Mixing unfamiliar pigs reduces feed intake, different group size alters the feed intake pattern of pigs and these changes alter overall daily feed intake (Johnson, 1997). Immunological stress or activation of the immune system results in reduced feed intake of grower-finisher pigs (Johnson, 1997). Feed composition in terms of nutrient content and nutrient balance is an important determinant of feed intake. In general, pigs try to eat to meet the requirement of the most –limiting nutrient, which in most cases is energy. Therefore, the current assumption is that dietary energy content mainly determines voluntary feed intake of grower-finisher pigs from 15 to 110kg (NRC, 1998). According to Hancock (1999), the presentation of feed can influence voluntary feed intake. Generally, pelleting of feed reduces feed intake but results in an improved growth performance due to improved nutrient digestibility of the feed. Presentation of a mash in a wet versus a dry form increase voluntary feed intake by 5% (Gonyou and Lou, 1999). In the standard test to measure DE content of pigs, feed allowance is maintained at 2.5 to 3 times DE intake required for maintenance (Scott *et al*., 1998). It is suggested that actual return per pig place / day is considerably greater on feeding *ad libitum* than on restricted feeding (Meat and Livestock Commission, 1982). Studies by Pluske *et al.* (1997) have shown that increased feed intake in newly weaned pigs' leads to an improved growth performance and may also reduce post-weaning diarrhoea. However, low feed intake immediately after weaning further affects the nutrient and energy requirements. The weanling pigs' energy requirement for maintenance is not met until day 5 after weaning and the pre-weaning energy intake level is not attained until the end of the second week post-weaning (Le Dividich and Herpin, 1994). Mahan *et al.* (2004) demonstrated that daily feed intake increased during the initial week post-weaning as dietary lactose levels increased from 0 to 30%. McMeekan (1940) gave the range and changes in weights of various tissues and organs of pigs from birth to 28 weeks of age.

2.7.2 Body Weight Gain

Body weight gain is the amount of weight the animal puts on over certain period of its life cycle. Average daily weight gain (ADG) is the amount of weight the pig puts on each day over a certain period of its life cycle (Okai and Bonsi, 1989). In practical pig production, increase in body weight gain is the most meaningful and useful measure of growth (Pond and Maner, 1974). The ADG obtained over a certain growth phase depends on the breed of pig, sex, feed and feeding and general farm management like sanitation and disease control practices (Okai and Bonsi, 1989). Okai *et al.* (1991) obtained no significant ($P > 0.05$) differences in mean final and daily weight gain when they fed varying levels of DB at 0, 15, 30 and 45%

to growing pigs. Abdullatif *et al.* (2004) and Tibiru, (1980) also reported similar (P > 0.05) values for mean body weight gain. However, Okai Amankwa, (1986) and Eniolorunda *et al.* (2010) observed significant (P < 0.05) differences in MDG and MFWG respectively in their respective trials.

2.7.3 Feed Conversion Efficiency

Feed conversion efficiency (FCE) is the measure of the rate of conversion of feed taken by the pig into body weight (Okai and Bonsi, 1989). It can be expressed as gain per feed (Okai and Bonsi, 1989). Ajasin *et al.* (2010) reported similar (P > 0.05) FCE when they replaced the maize portion with 0, 50, 75 and 100% discarded biscuits (DB) in the diets of growing snails. Okai *et al.* (1991) recorded no significant (P > 0.05) differences in mean FCE when they incorporated DB into pigs' diet at the levels of 0, 15, 30 and 45% respectively. Okai-Amankwa (1986) and Tibiru (1980) also reported similar (P > 0.05) FCE in their respective experiments at KNUST.

2.8 BLOOD

Blood is a unique fluid containing cells that is pumped by the heart around the body of animals in a system of pipes known as the circulatory system (Wiki Books, 2012). It circulates through the heart, arteries and veins. Approximately 8% of mammalian adult body weight is made up of blood with the whole blood making about 4.5-5.5 times as viscous as water (Ajmani *et al*., 1998). According to Saladin (2004), and Marieb (1998), blood performs three main functions, namely; transport, protection and regulation.

Blood transports the following substances;

- Gases, namely oxygen and carbon dioxide between the lungs and rest of the body.
- Nutrients from the digestive tract and storage sites to the rest of the body.
- Waste products to be detoxified or removed by the liver and kidneys.
- Hormones from the glands in which they are produced to their target cells
- Heat to the skin so as to help regulate body temperature.

Blood has several protective roles in inflammation:

- Leukocytes, or white blood cells, destroy invading microorganisms and cancer cells.
- Antibodies and other proteins destroy pathogenic substances
- Platelet factors initiate blood clotting and help minimize blood loss.

Blood helps regulate:

- pH by interacting with acids and bases.
- Water balance by transferring waste to and from tissues.

2.8.1 Composition of Blood

The blood of an animal is composed of the plasma, red blood cells (RBC), white blood cells (WBC) and platelets (Bone, 1988; Wiki books, 2012).The plasma consists of a light yellow fluid (Wiki books, 2012). Plasma contains just fewer than 55% of the total volume of blood (Saladin, 2004). Plasma consists of 91% water in which substances such as salts or electrolytes, proteins, nutrients, waste products, dissolved gases and other chemicals such as hormones are dissolved (Wiki books, 2012). The protein concentration in the plasma is a function of nutritional status, water balance, hormonal balance and health status (Swenson, 1970).

RBC or erythrocytes are discs or doughnuts-shaped with a thin central portion surrounded by a fatter margin (Wiki books, 2012). The RBC is denser than plasma and so become packed at the bottom to make up 45% of the total volume known as haematocrit (Marieb, 1998). The RBC is what make blood red and are by far the most common cells in the blood, (i.e. about 5 million per milliliter). They are made in the bone marrow and live about 120 days. The matured RBC of mammals are thought of as sacks of haemoglobin. Low RBC production results in anaemia (Wiki books, 2012).

White blood cells (WBC) or leucocytes are far less numerous than RBCs, about one white cell for every 1000 RBC. (Wiki books, 2012). According to Marieb (1998) and Saladin (2004), WBC are grouped into granulocytes (presence of granules) and agranulocytes (absence of granules). The granulocytes consist of neutrophils, eosinophils and basophils while the agranulocytes consist of lymphocytes and monocytes. The WBC is colourless and contains no haemoglobin (Wiki books, 2012). The platelets also known as thrombocytes are small fragment of bone marrow cells. The secretion of vasoconstrictors, platelet plug formation and blood clotting (coagulation) by platelets are indication of the important haemostatic mechanism by platelets during bleeding (Coagulation cascade, 2003). Low count of platelets leads to clotting problems resulting in excessive bleeding (Wiki books, 2012).

2.8.2 Haematological and Serum Biochemical Studies on Pigs

Hematology and blood biochemistry, according to Mafuvadze and Erlwanger (2007), are routinely used in veterinary medicine to evaluate the health status of livestock and poultry. Swenson (1970) mentioned RBC counts, WBC counts, Pack Cell Volume (hematocrit), MCV, MCH and MCHC as some haematological and biochemical parameters that are normally studied. The RBC and WBC counts show the number of RBC and WBC in the blood sample. Haematocrit or PCV refers to the volume of packed RBC in the blood sample. The MCV shows the average cell size while the MCH indicates the average weight of Hb, while the MCHC indicates the average percentage of the mean cell size (MCV) which the Hb occupies (Swenson, 1970). Haematological values of domestic pig and wild boar have been reported. The values reported include 5.0 – 9.04 $x10^{12}$/l and 6.0 – 32.9 x 10^{9}/l for RBC and WBC respectively (Friendship *et al*., 1984; Rispat *et al.*, 1993; Harapin *et al*., 2003 and Thorn, 2006), 6.7- 15g/l, 17.20 – 38.0g/dl and 66 – 88g/l for Hb, MCHC and total protein (Friendship *et al.*, 1984; Rispat *et al.*, 1993; Harapin *et al.*, 2003; Eze *et al*., 2010), 29 – 69.4% for HCT (Friendship *et al.*,1984; Harapin *et al.*,2003 and Thorn,2006), 19 – 36g/l for Albumin (Friendship *et al.*, 1984, Harapin *et al*., 2003), 0.05 -3.18mmol/l for Triglycerides (Friendship *et al*., 1984; Rispat *et al*., 1993), 215- 898 units for platelets (Rispat *et al*.,1993) and 15 – 20pg for MCH

(Friendship *et al*., 1984).

Mbanasor *et al*. (2003) stated that hematological profiles of animals are indispensable in the diagnosis and treatment of many diseases in animals. The level of disease condition of animals can be determined by the PCV, RBC and Hb. Factors including sex, age, exercise, nutritional status, blood volume, breed, pregnancy and lactation, stage of estrus cycle, environmental temperature and excitement are some factors affecting RBC counts, Hb concentration and PCV (Swenson, 1970).

2.9 EFFECT OF NUTRITION ON BLOOD CHEMISTRY

Nutrition, especially dietary protein intake is known to affect the live weight and haematological parameters of animals (Makinde *et al*, 1991). Ologhobo *et al.* (1993) and Otesile *et al*. (1996) reported that diets have great influence on hematological variables. Madubuike and Ekenyem (2006) established that haematology and serum biochemistry analysis of livestock indicate the physiological disposition of the animals to nutrition. Esonu *et al. (*2001) also indicated that the hematological constituents reflect the physiological responsiveness of the animals to its internal and external environment, which include feed and feeding. According to Mbanasor *et al.* (2003) the hematological profiles are important indicators of health and disease in animals and have become indispensable in the diagnosis, treatment or prognosis of many diseases. The physiological condition of an animal is affected by the quality and quantity of ration given to it (Machebe *et al.*, 2010). Proteins form the basic unit of cells and other substances that are necessary for body building, repairs and maintenance of homeostasis, regulation of vital body functions, energy source and defense against infectious agents (Kaneko, 1989). Protein deficiency has been reported to reduce most hematological and serum parameters through reduced or impaired synthesis of blood cells which are largely proteinaceous (Jain, 1986).

Ostrowska *et al.* (2004) fed varying levels of brown onions at 0, 10 and 25g/MJ to grower pigs. The results indicated an influence of onion on the haematological parameters including Hb, MCV, MCHC, PCV, WBC, RBC, Basophils, Eosinophils, lymphocyte activation, lymphocytes, Monocytes, and Neutrophil: Lymphocyte ratio and segmented neutrols. Over all, the consumption of onions resulted in significant reductions in plasma triacylglycerol. Total plasma cholesterol and LDL: HDL ratios were not significantly (P>0.05) different. Onion supplementation resulted in reductions in RBC counts and Hb levels while the WBC concentrations, particularly lymphocytes were increased in pigs that consumed onions. Furthermore, indices of blood clotting were largely unaffected by onion consumption. In conclusion, dietary supplementation with raw brown onions had moderate lipid-modulating and immunostimulatory properties. However, daily onion intake above 25g/MJ digestible energy could be detrimental to erythrocyte numbers.

In another experiment, Ekenyem and Madubuike (2007) reported an influence of *Impomoea asarifolia* leaf meal (IALM) on haematological parameters when they fed varying levels of 0, 5, 10 and 15% to growing pigs. The results showed reduction in PCV, MCV, Hb, MCH, MCHC indices as the level of IALM increased in pigs' diets. The WBC values and the blood clotting time were also found to increase with increasing levels of IALM, an indication that the leaf meal contains substances, which interfere with clotting. They concluded that up to 15% level of inclusion of IALM had no deleterious effect on hematological and serum biochemistry of growing pigs.

Machebe *et al.* (2010) fed varying levels (16, 18 and 20%) of crude protein to gilts and concluded that different dietary protein levels affect haematological or blood parameters (ie Hb, PCV, RCB, MCHC, MCH, MCV and WBC). There were no significant differences (P > 0.05) in the values for MCH, MCV, and WBC for all the levels. However, they recorded significant (P<0.05) differences in the values for Hb, PCV, RBC and MCHC for all the levels. The values for Hb were 14.61g/100ml for gilts fed 18%CP which was significantly (P<0.05) higher than the 13.25 and 13.03g/100ml for gilts fed 20% and 16% CP respectively. The values for RBC were 4.89 x $10^6 mm^3$for gilts fed 18%CP which was significantly (P<0.05) higher than 4.40 and 4.33 x $10^6 mm^3$ for gilts fed 20% and 16% CP diets respectively. The values for PCV were 43.53% for gilts fed 18% CP which was significantly (P < 0.05) higher than 39.55 and 38.03% for gilts fed 20% and 16% CP respectively. In addition, the values for MCHC were 35.56% for gilts fed 18% CP which was significantly (P < 0.05) higher than the 32.50 and 32.49% for gilts fed 20%and 16% CP respectively. The values for Hb, PCV, RBC and MCHC increased up to the level of 18% CP and dropped as the level of CP increased. In their experiment, Olabanji *et al.* (2009) fed five diets containing processed mango (*Mangifera indica*) seed kernel meal (MSKM) at 0% MSKM, 10 and 20% sundried MSKM and 10 and 20% parboiled MSKM to rabbits. The Albumin and Alkaline Phosphatase levels were observed to be significantly (P < 0.05) affected. The values for albumin were 4.33, 4.07 and 4.00g/dl for rabbits fed the 0% (Control diet), 20% sundried and 20% parboiled MSKM which were significantly (P < 0. 05) higher than 3.83 and 3.17g/dl values for those rabbits fed the 10% sundried MSKM and 10% Parboiled MSKM respectively. The Alkaline Phosphatase value of 196.67g/dl for rabbits fed 10% sundried MSKM was significantly ($P < 0.05$) higher than the 161.33, 160.68 and 149.67g/dl values for rabbits feed the 20% sundried, 10% Parboiled and 20% Parboiled MSKM diets respectively but was similar ($P > 0.05$) to the values for rabbits fed the Control diet. Adesehinwa *et al.* (2008) fed growing pigs with 45% cassava peel meal based diets supplemented with Avizyme® 1300 at 0.0% (control), 0.1% and 0.2%. The result showed no significant ($P > 0.05$) effect of the dietary treatments on all the observed hematological parameters (ie PCV, Hb, RBC, MCV, MCH and WBC) except MCHC which was significantly ($P < 0.05$) affected. There was reduction in the concentrations of erythrocytic parameters (such as PCV, RBC counts and Hb concentration) and elevation in MCV, which are indications of macrocytic (regenerative) anaemia emanating from increased destruction in the liver, spleen, and kidneys (Jain, 1986).

2.10 SOME PATHOLOGICAL STUDIES ON FEEDSTUFFS

According to the data of the International Feed Industry Federation, 4 billion tons of animal feed is produced annually worldwide of which only 600 million tons are compounded feed (Hinton, 1993). For effective protection of the animal and public health, feed safety must be ensured at all stages, including primary production. Animal feed is exposed to various biological, chemical, physical and other agents. All these factors may adversely affect animals and indirectly, human health (Hinton, 1993; Radanov-Pelagic *et al.*, 2003). Animals feed, due to its composition, provides a favourable environment for microorganism's growth. Microorganisms found in the feedstuffs can be saprophytic, pathogenic, conditionally pathogenic and toxic

(Dordevic and Dinic, 2007). Their growth and proliferation in the feed depend on numerous factors such as moisture, temperature, type of feed, aerobic and anaerobic conditions, chemical and physical properties of raw material feed pH value, presence of feed supplements, storage periods and conditions as well as feed decomposition products (Radanov- Pelagic, 2000; Dordevic and Dinic, 2007).

Feed may be contaminated during processing, storage or transport. Contaminated feed frequently causes zoonosis and for that reason, it is necessary to establish surveillance programme for microbiological feed hazards (Radanov-Pelagic, 2000). Some microorganisms introduced during storage, primarily moulds, can negatively affect feed quality including reducing dry matter and nutrients contents, causing musty or sour odours, and producing toxins. Mouldy raw materials are not appetizing and can considerably reduce feed consumption (Meeusen, 1997). Any piece of equipment, process or production line or entire feed manufacturing plant pose a source of contamination threatening quality of final product (Sredanovic *et al*., 2005).

Given this background, microbiological analysis is the useful way to assess the safety and quality of food. Substantial number of microorganisms suggests a general lack of cleanliness in handling and improper storage practices. Although it is generally agreed that bakery products are microbiologically safe food, post baking processes, including packaging and wrong handling cannot be overlooked (Prasad and Vyas, 2011). Bakery products have been an important part of the diets for both humans and livestock. Due to substandard handling operations, mould spoilage has become a serious threat to bakery industries (Prasad and Vyas, 2011). According to Bloomfield (1990) bacteria and fungi are the most common causes of feed poisoning and food- borne diseases. These microorganisms are ubiquitous and are found in a variety of habitats, either as transient or permanent “dwellers”. Recent agreement in taxonomy has led to the discovery that a specific, very limited fungus (mycobola) is associated with food spoilage (Borg *et al.*, 1996) as cited by Prasad and Vyas (2011). Moulds are filamentous (fuzzy or dusty appearing) fungi that occur commonly in feedstuffs, including roughage and concentrates. Similarly, the effect of poisoning by mycotoxins from fungus is through food consumption. Mycotoxins prominently affect human and animal health (Michael, 2007).

Mycotoxins induce various biological effects such as liver diseases, alteration in growth rates, change in the mechanism of immunogenesis and carcinogenic and mutagenic effects in different animal species (Pier, 1973). Various vital organs such as the alimentary canal, liver, kidney and nervous tissues are badly affected after ingesting spoiled food and the raw food such as meat, fish, milk and vegetables grown in sewage that are likely to be contaminated. Recent studies have shown that pathogenic microbes, which can cause serious illness and affect different systems and organs of humans and animals (Pier, 1973), infest food grains, legumes and oil seeds when stored in a humid atmosphere.

In a research study, Prasad and Vyas (2011) attempted to determine the microbial contaminations of local bread, a bakery product, and reported the presence of mycotoxins in the contaminated bread samples. They also observed that ingestion of mycotoxin in yeast and mould contaminated bread by albino rats increased the mucosal susceptibility by infecting the mucosa. Mucous is the barrier between fungal and bacterial invasion. Belquees and Parneen (1996) as cited by Prasad and

Vyas (2011) also observed the loss of mucosa and sub-mucosa in parasite infected *Nesokia indica* (Short- tailed Indian mole rat). In 30 hours, the aedenomatous stages of villi mucosa were observed and that might be an indication of frist hand counter attack by the body to kill the pathogen. Khatooni (2004) as cited by Prasad and Vyas (2011) made similar observations in short-tailed Indian rodent, *Nesokia indica*. The term alimentary mycotoxicosis poisoning by mycotoxin through food consumption and mucomycosis are the common name given to different diseases caused by fungus. In another research to evaluate the microbiological quality and safety of animals' feedstuffs, 8% of a total of 100 analysed samples did not meet microbiological criteria specified in the regulation (Sluzbeni, 1990). Of a total of 50 analysed samples of feedstuffs, one sample (soyabean) had total number of bacteria exceeding limit values prescribed in the regulation (Sluzbeni, 1990). Total number of bacteria in this sample was 137.000.000/g, while maximum permissible limit value set out in the regulation is 100.000.000/g. In other analysed samples, total number of bacteria was considerably lower ranging from 100-6.000.000/g (Sluzbeni, 1990). Saprophytic bacteria are frequently found in analysed samples. Of 50 analysed samples of feedstuffs, four samples had increased total number of moulds, ranging from 350.000 -885.000/g. In another analysed samples total number of moulds was considerably lower ranging from 0-180.000/g. The lowest mould contamination level was observed in the feeds of animal origin, such as fishmeal, meat and bone meal, because of processing and storage conditions (Dilas *et al*., 2001). Markovic *et al.* (2005) analysed 765 feed samples during a ten-year study conducted in the period, 1995-2005.The results indicated that 35.71% of samples of complete feedstuffs for young chicks were unsafe in terms of total number of moulds. Of samples of complete feedstuffs for adult animals, samples ranked as unsafe accounted for 7.54% with mould number ranging from 800-8.000.000/g (Markovic *et al*., 2005). Lower levels of mould contamination were detected in the feedstuff samples analysed in 2007 (Bengin *et al.*, 2008). Sulphite reducing clostridia were detected in 18 samples but their number was below the limits prescribed by the regulation. The presence of sulphite reducing clostridia can be considered to be etiologically related to health disorders only when their number is verified by confirmation of toxin-producing bacteria, i.e. toxin in the feed (Masic *et al., 2002).*

Analysis of dried bakery waste products (DBWP) including discarded biscuits (DB) samples by Tibiru (1980) showed that no pathogenic bacteria were present. However, heavy growth of fungi, specifically, *Mucor spp.* and *Aspergillus spp.* were observed. He noted that most of the species of Mucor were saprophytes or weak pareasites but few were obligate parasites while most of the *Aspergillus spps* were pathogenic fungi. He concluded that the presence of these fungi might have caused the high incidence of scours in the DBWP containing diets. He also attributed the cause of scours to the presence of coliform bacteria (*Escherichia coli*), as these were identified in the postmortem examination of two piglets. Kuo and Sai (1966) reported that pigs fed 20% and 30% levels of groundnut cake died because of aflatoxins produced by *Aspergillus niger* and *Aspergillus flavus* in the meal.

2.11 STUDIES ON CARCASS CHARACTERISTICS OF PIGS.

According to Shi-Zheng and Su-Mei (2009), the attractiveness of the meat to consumers is determined by the quality of the meat, which includes colour, tenderness, marbling, water holding capacity and flavour. Intramuscular fat (IMF) content which refers to the chemically extractable fat from a muscle of meat especially from adipocytes and mycocytes (Shi-Zheng and Su-Mei, 2009) have been found to be one of the most important traits influencing meat quality characteristics (Verbeke *et al*., 1999). Aberle *et al.* (2001) noted that pigs usually produce more carcass fat and consequently are less efficient in converting feed to lean meat when fed concentrate diet than when fed slightly below *ad libitum* energy intake.

Carcass characteristics are influenced by nutritional, non-nutritional, genetic and other environmental factors. Levels and sources of dietary nutrition have effect on porcine IMF content (Shi-Zheng and Su-Mei, 2009). Gondret and Lebret (2002) indicated that moderate long-term feed restriction (low protein and energy intake) results in decreased lipogenic capacity of muscle adipocytes and decreased IMF content. Reducing the energy intake by incorporating high level of fibrous feedstuffs in the diet of pigs produce a leaner carcass while high-energy diets tend to produce fatter carcasses. According to Shi- Zheng and Su-Mei (2009), changes in growth performance and carcass characteristics of pig are caused by porcine somatotropin, a non- nutritional factor. Azain *et al.* (1992) and Lafaucher *et al. (*1992) noted that the porcine somatotropin treatment results in improved growth rate, increased carcass fat and IMF contents, increased unsaturated fatty acids and decreased fat cell diameter in the backfat without any effect on other meat quality traits. The IMF content is also affected by environmental factors. Shi-Zheng and Su-Mei (2009) reported that rearing pigs at a high temperature of about 32ºC resulted in an increased carcass length but had no effect on other measurements or IMF. According to Warris *et al. (*1983) and Enfalt *et al. (*1997) pigs reared indoor generally showed greater backfat thickness than outdoor ones due to slower growth rates, which favour muscle deposition rather than fat, resulting in leaner carcasses.

Abdullatif *et al*. (2004) fed five levels of Dried Bakery Wastes (DBW) at the rates of 0, 5, 10, 20 and 30% to 250 broiler chicks. They obtained no significant (P>0.05) differences in feed conversion values, feed intake and weight gain. They also reported that dressing percentage was affected by sex of the birds, with female birds recording higher dressing percentage than the male. Eniolorunda *et al.* (2010) replaced maize and wheat offal mixture with biscuit waste meal (BWM) and *Leucaena leucocephala* leaf hay (LIh) mixture at 0, 25, 50, 75 and 100% as sources of protein and energy for fattening Yankasa rams. They observed that dry matter intake, crude protein intake and daily weight gain were all significantly (P<0.05) affected by the dietary treatments. It was also observed that dry matter, crude protein and energy digestibility and feed cost/kg increased significantly (P>0.05) with increasing inclusion level of BWM and LIh mixture in the diet. In addition, the values obtained for wholesale cuts in terms of shoulder, rack, breast, shank, flank and loin as percentage of carcass weight were significantly (P<0.05) affected. They also concluded that BWM and LIh could be used as potential sources of energy and protein for livestock.

2.12 PESTS INFESTATION OF FEEDSTUFFS

Insects feed on most feed ingredients and contaminate them with feaces, webbing, body parts, foul odours, and microorganisms (Howe, 1965; Cockerell *et al*. 1971). Direct damage by feeding insects reduces grain weight, nutritional value and germination of stored grain. Infestations also cause mould and heat-damage problems that reduce the quality of the grain making them unfit for processing into food for humans or animals. Several species of insects may infest grains in storage.

The worldwide movement of stored product insects through commerce has often caused economic and political problems (Freemen, 1973). The principal pests that caused damage are the adult and larval stages of beetles, and the larval stage of moths. According to Howe (1965) and cockerel *et al. (*1971), beetles and moths are the most destructive of the grain insects, and many are capable of destroying an entire store of feed.

Howe (1965) categorized losses occurring during storage into four: weight loss, quality loss, health risk and economic loss. These losses arise from foraging activities of insects, microorganisms and animals; improper handling, physical and chemical changes all of which are interrelated. He indicated that storage loss in a feed mill is primarily due to material eaten or destroyed by insect and animal pests and fungi. The first three categories of storage loss are of primary concern to the compounded feed manufacturer. According to Howe (1965) and Cockerel *et al*. (1971) weight loss due to loss of moisture content or the presence of a large insect population in stored feed is problematic in developing countries where post-harvest handling and processing are often improperly conducted.

Pelliteri and Boush (1983) assessed stored product insect pests in twenty feed mills and identified over 100 insect species. Coleopterans made up 90.6% of the insect collected. Of the 83 species of beetles recorded, 62 are associated with stored products. The flat and rusty grain beetles, *Cryptolestes turcicus* and *C. ferrugineus* were the most abundant insects encountered (Aitken, 1975). *Attagenus megatoma* was the most widely distributed insect. Beal (1970) has recognized two subspecies of *Attagenusmegatoma*; *A.megatoma canadensis* and *A. megatoma megatoma* with only the latter present in the survey. *Sitophilusgranaries,* the granary weevil, was found to be abundant and widely distributed. Other economically important stored product pests recorded include the cadelle beetle, *Tenebriodes mauritanicus*, the drug store beetle, *Stegobium paniceum*, and the lesser grain borer, *Rhizopertha dominica*. Both *Triboliumcastaneum* and *T.confusum* were widely distributed and in some cases abundant. Laboratory experiments by Yoshida (1976) have shown that *Tribolium spp*. cannot coexist in a closed system. *Tribolium* population was largest in the heated manufacturing mills. The tenebrionids, *Tenebriomolitor* and *T.obscurus*,were found to coexist in a number of sampled mills, but in all cases, *T. molitor* was more numerous. Of the total number of beetles, fungal *spp*. made up of 32%. *Ahasverus advena*, the foreign grain beetle was the most abundant fungus beetle. The hairy fungus beetle, *Typhaea stercorea* was the most widely distributed mycetophilous beetle. *Carpophilus hemipterus* and *Glishrochilus quadrisignatus* are the most widely distributed and most numerous sap beetles, which often infest corn in the field (Daugherty and Brett, 1966).

A number of dipterans are normally not associated with stored feedstuffs. Members of the families: Chironomidae, Dolichopodidae, Syrphidae, Tabanidae, Caliphoridae and Helicomyzidae do not normally breed in stored products habitats, or feed on stored product. Their presence in the feed mills is therefore considered accidental (Pellitteri and Boush, 1983). Damp, mould-ridden stored products often support populations of mycetophilous Diptera. Species associated with this condition include members of the families: Cecidomyidae, Scatopsidae, Psycodidae, Mycetophilidae, Anthomyiidae and Muscidae (Pelliteri and Boush, 1983). Pupae of *Fannia canicularus*, specimens of *Muscina stabulans* and *Muscadomestica* were also found in stored products by James and Hardwood (1969). Both adults and larvae of windowpane fly, *Scenopinus fenestralis*, were found to be associated with stored or spilled grain and feed (Hinton and Corbet, 1955). The meal moth, *Pyralis farinalis*, is the most abundant and widespread lepidopteran, which normally breeds in damp products (Anonymous, 1965). The Indian meal moth, the Mediterraen flour moth and webbing clothes moth are some common Lepidoptera associated with stored feedstuffs.

Howe (1965) and Cockerell *et al*. (1971), enumerated factors affecting insect pest infestation of feedstuffs as source of insects, available food, temperature, moisture, air, condition of the feedstuff, presence of other organisms and the efforts to exclude or kill the pests. They also listed temperature, relative humidity and moisture content of the feed ingredient as the major factors affecting population growth of most insect species.

2.13 INFERENCES FROM THE LITERATURE REVIEW

In Ghana, feed cost represents between 70 and 80% of the total cost of pig production. The bulk of the commercial pig feed consists of high-energy cereals. Maize has as for along time been a traditional and indispensable cereal grain in the commercial diets of monogastrics in Ghana and typically forms 50–60% of such diets (Okai *et al*., 2003). However, the competition between humans and livestock has brought about high demand for maize resulting in an escalating price of maize and consequently the cost of feeding pigs in Ghana. It may be inferred from the literature that the solution to this problem of escalation in prices of maize, in addition to the scarcity of maize during certain period in the year lies in the use of alternative feed resources that are cheaper and not competed for by man (Okai and Aboagye, 1990). Several studies have pointed to the suitability of some agro-industrial by-products as alternative feed ingredients to either totally or partially replace the conventional feed ingredients and at a reduced or low cost. The most relevant aspect is to establish their nutrient compositions, optimum level of inclusion without deleterious effect on the animals and whether further treatments are required to render them safe and palatable for consumption. From the literature, Ghana abounds in a wide variety of these agro-industrial by-products and other crop residues that can constitute alternative feed resources for pigs to help reduce the competition for maize. The few biscuit factories in Ghana produce substantial quantities of various by–products, which are usually discarded and some now being used for commercial feeding. Indications are that the DB appear promising and can readily and economically be utilized as good replacement for maize and other energy sources in the diets of pigs.

A number of studies have been done on DB in Ghana but all of them have been short –term in nature and have not provided detailed information on DB. The main objective of this current study therefore, was to determine the nutrient composition, pest and microbial status of DB and effects on growth performance, carcass characteristics, blood and other economic profiles of growing-finishing pigs.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Study area and Duration of Experiment

The experiment was conducted at the Livestock Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The experimental site is located on Latitude 06 41º N and Longitude O1º 33^{I} West (Agrometeorology Division, Station Nº 0601 – 050 – 17, Kumasi) and falls within the humid forest zone. The average rainfall in the area for the period was 99.9mm with average temperature ranging between 22.3ºC minimum and 33.5ºC maximum while the mean relative humidity was between 66.5% and 88.5%. The study spanned ten (10) weeks, from Tuesday, 31st January to Wednesday, 18th April, 2012.

3.2 Feed Ingredients and Experimental Animals

3.2.1 *Sources of Feed Ingredients*

The ingredients used for the experiment were maize, discarded biscuits (DB), fishmeal, soyabean meal, wheat bran, oyster shell, salt and vitamin / trace mineral premix. The test ingredient, discarded biscuits (DB), was obtained from Britannia Biscuit Factory, Spintex Road, Accra, Ghana through a local (Kumasi) agent. The other ingredients were purchased from open markets within the Kumasi Metropolis.

3.2.2 *Experimental Animals and Design of the Experiment*

A total of twenty (20) Large White starter pigs aged 9-10 weeks with an average initial weight of 16.6 kg, consisting of 12 females and 8 males, were purchased from the Livestock Section of the Department of Animal Science, Kwame Nkrumah

University of Science and Technology, Kumasi, Ghana. They were then randomly allotted to four (4) dietary treatments, namely, T1, T2, T3 and T4 with T1 as the Control diet. The allocations were done on the basis of weight, sex, litter origin and age. Each treatment was replicated five (5) times. The mean initial weights were 16.6, 16.6, 16.7and 16.7kg for treatmentsT1, T2, T3 and T4 respectively. The design used was the Randomized Complete Block. The design had block distribution of 2 males and 3 females per replicate.

3.3 HOUSING

The pigs were housed in a 160 x 66 x 103 cm welded wire mesh , individual concrete-floored cages (Plate 3), constructed within aluminium-roofed pens each measuring 365 x 315 x 100 cm. Each pen had four (4) of the individual cages. Each cage was provided with a wooden feed trough. Shallow feeding troughs (Plate 4a) measuring 46 x 23 x 13 cm were used for the first three weeks after which they were replaced with deeper and heavier troughs (Plate 4b) measuring 60 x 31 x 27 cm. All the feeding troughs had wooden battens across the top.

Plate 3: Pigs housed in individual concrete-floored wire-mesh cages

The changing of the feeding troughs from shallow to deeper and heavier ones and the use of wooden battens across the tops were done for the common purpose of minimizing feed wastage. Each cage was also provided with concrete water trough measuring 50 x 24 x 13 cm (Plate 5).

3.4 MANAGEMENT OF THE EXPERIMENTAL PIGS

A week prior to the start of the experiment, all the experimental pigs were dewormed with Kepromec (Ivermectin).[1] They were subsequently washed with Gammatox[2] solution to destroy mange mites three days to the start of the experiment.

Plate 4a: Shallow feed trough

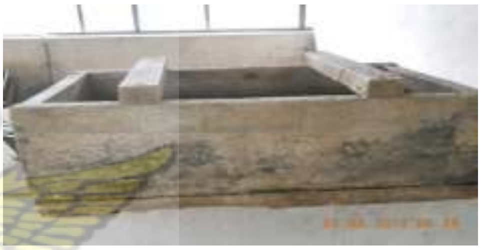

Plate 4b: Deep feed trough

Plate 5: Front view of concrete water trough

Plate 4. Equipment for feeding pigs. Shallow feeding trough used for the first three weeks with dimensions 46 x

23 x 13 cm. Deeper feeding troughs used to replace the shallow troughs with dimensions 60 x 31 x 27 cm.

1. 10mg of Ivermectin per ml solution. Dosage: Pigs- 1ml per 33kg body weight. KEPRO B.V. Holland.
2. Gammatox: A chemical for controlling ecto parasites in farm animals with benzene haxachloride as active ingredient. 5ml/4.5 litres of water. Bayer, Germany.

The pigs were routinely observed for signs of ill-health and any sign of in appetence or ill health were treated with Multivite[3] and antibiotic (Oxytetracycline[4]) by intramuscular injection. A week to the commencement of the experiment, the pens and the cages were swept clean and all the cobwebs removed. The concrete floors, feed and water troughs were scrubbed and washed with a mild powdered detergent (Omo).[5] Three day after, the pens, cages, water and feed troughs were again cleaned and disinfected Quincide[6]. The water and feed troughs were topped up or refilled later in the day whenever it became necessary.

3.5 DIETS FORMULATION AND COMPOUNDING

3.5.1 Diet Formulation

Four (4) diets containing DB at levels of 0, 10, 20 and 30%, replacing equivalent amounts of maize, were formulated. These were labeled as treatment 1 (T 1), treatment 2 (T 2), treatment 3 (T 3) and treatment 4 (T 4) respectively. The percentage composition of the diets is shown in Table 4.

The diets were formulated to have an analysed crude protein level of 18%. Apart from maize and the DB which were included in varying amounts for the four diets, the other ingredients were included at the same level for each of the four diets.

---

3. Multivite: Treatment of vitamin deficiencies and as supplement to inadequate diet and a supportive therapy. Dosage: 0.5-1ml/10kg body weight. Active ingredients: Vit. A, 50000 IU,Vit.D_3 25000 IU; Vit. B_2, 10mg, Vit B_{12}, 0.04mg, Vit B_6, 1mg; and Nicotinic acid, 5mg; Manufactured by Kela N.V., Belgium.

4. Oxytetracycline 2% (an antibiotic). Dosage 1ml per 10 kg body weight. Active ingredients: Each ml contains 200mg oxytetracycline dehydrate and 50mg magnesium oxide. Manufactured by Telvet International, Belgium.

5. Omo. Cleaning agent. Ingredients: Surfactant, Sodium Carbonate, Sodium Silicate, Sodium Sulphate, Perfume, Sodium Carboxymethyl Cellulose, Optical brightener, enzyme. Manufactured by Uniliver Nigeria, Pic. RC 113, agbara.

6. Quatemary ammonium compound 50% and glutaraldehyde 50%, Virucidal disinfectant and water sanitizer. Liverpool, England.

Table 4: Percentage Composition of the Experimental Diets

DIETARY TREATMENTS

INGREDIENT	0 % DB	10 % DB	20 % DB	30 % DB
Maize	60	50	40	30
Discarded Biscuits	0	10	20	30
Fishmeal	8	8	8	8
Soyabean Meal	6	6	6	6
Wheat bran	24.5	24.5	24.5	24.5
Oyster shell	1	1	1	1
Common Salt	0.25	0.25	0.25	0.25
Vitamin-Trace Mineral Premix	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100
Calculated composition (%)				
Crude protein	17.00	17.00	17.12	17.40
Calcium	0.77	0.78	0.79	0.88
Phosphorus	0.71	0.70	0.70	0.70
Lysine	0.89	0.89	0.89	0.89
Tryptophan	0.18	0.19	0.20	0.20
D.E. (Kcal/kg)	3175.5	3217.2	3258.7	3300.2
Analysed composition (%)				
Fraction			**As Fed**	
Crude protein	18.00	18.00	18.00	18.00
Ether extract	3.00	4.00	5.50	7.00
Crude fibre	2.27	2.27	1.73	1.31
Moisture	9.50	10.00	9.00	8.00
Ash	5.00	5.00	5.00	5.00
Nitrogen Free Extract	63.03	60.23	60.87	56.69
Dry matter	90.50	90.00	91.00	92.00

Provided the following/kg diet:Vitamin A–8,000 IU, Vitamins D_3 –3,000 IU, Vitamins E–8 IU, Vitamin K –2mg, Vitamin B_1– 1 mg, Vitamin B_2–0.2 mg, Vitamin B_{12}–5 mg, Nicotinamide –10 mg, Selenium– 0.1 mg, Ca Pantothenate – 5 mg, Folic acid –0.5 mg, Choline Chloride –150 mg, Iron –20 mg, Manganese –80 mg, Copper –8 mg, Zinc –50 mg, Cobalt –0.225mg, Iodine –2 mg Antioxidant – 0.1ppm

3.5.2 Feed Compounding

Feed was compounded mechanically at weekly intervals. The DB, maize and soyabean meal were ground in a corn mill and the other ingredients were used in their original state. The required quantities of these ingredients were weighed out using either a hanging scale (maize, DB, fishmeal, wheat bran and soybean meal) or table–top weighing scale (salt, oyster shell and vitamin-trace premix).

These were mechanically mixed, one diet at a time. Each compounded diet was then put in a labeled sac and kept in a cool dry store room for use later. Representative samples of each batch of compounded feed were taken and kept in a freezer for chemical analysis.

3.5.3 Feeding

Six kg each of the compounded experimental diets (Table 5) were weighed into well labeled plastic buckets and given *ad libitum* to the pigs in their individual feeding troughs. Watering was also done *ad-libitum.* Spilled feed not soaked in water was swept back into the feeding troughs and the soaked feed was air dried and added to the leftover feed. Feeding was terminated whenever a pig attained a liveweight of 65±2.5kg at the weekly weighing.

3.6 PARAMETERS MEASURED

3.6.1 Feed Intake

Weekly feed intake (WFI) was measured and recorded weekly as the difference between the quantities of feed offered to a particular pig and the left over feed collected. The total feed intake (TFI) for a particular pig was determined as the sum of the weekly feed intakes for the period that particular pig stayed on the experiment. The average daily feed intake (ADFI) was determined by dividing the total feed intake by the relevant number of days.

3.6.2 Live Weight Changes

The initial body weight of each pig taken and subsequently weighed weekly using a Gascoigne[7] precision scale. The total weight gained (TWG) was determined by subtracting the initial weight from the weight of each pig when it attained the weight of 65±2.5kg. The average daily weight gain (ADWG) was determined by dividing the total weight gained by the total number of days each pig remained on the experiment.

3.6.3 Feed Conversion Ratio

Feed conversion ratio (FCR) was estimated as the total feed intake divided by total weight gain by each pig.

$$FCR = \frac{\text{Total feed intake (kg)}}{\text{Total weight gained (kg)}}$$

3.6.4 Haematological and Serum Biochemical Analysis

3.6.4.1 Blood sampling

On attainment of the final weight and prior to slaughter, blood samples were taken from each pig through the ear-vein using 2ml syringes. The blood samples were transferred into vacutainers containing ethylene diamine tetra-acetic acid (EDTA), an anticoagulant, and then sent to a clinical laboratory for analysis.

7. Gascoigne precision scale. Capacity: 150 kg x 500g. Manufactured by Precision Weighters, Reading, England.

analysis. The haematological parameters measured were haemoglobin (Hb), haematocrit (HCT), red blood cell (RBC) count, white blood cell (WBC) count, mean cell haemoglobin (MCH), mean cell volume (MCV) and platelets; The remaining blood samples were used for the serum biochemical analysis and the parameters measured were total cholesterol, albumin, total protein, triglycerides, high density lipoprotein, low density lipoprotein and globulins.

3.6.5 Carcass Evaluation

At the attainment of the target weight of 65 ± 2.5kg the pigs were sent to the Meat Processing Unit of the Department of Animal Science, KNUST, for slaughtering. The pigs were stunned with an electric stunner, bled, scalded, singed and eviscerated. The dressed weight of the carcasses, viscera, lungs, heart, liver, spleen, kidneys and the weights of the head, trotters and gastro-intestinal tract (GIT) were recorded on the day of slaughter.

The eviscerated carcasses were then sent to the cold room and chilled overnight at a temperature of 4^{o}C after which the chilled dressed carcass weight, carcass length, mean backfat thickness, loin eye area, P2 and primal cuts were measured as described below:

3.6.5.1 Warm and chilled dressed weight

The warm dressed weight was recorded as the weight of the whole carcass including the head and trotters without the viscera. After chilling, the eviscerated carcass was again weighed to determine the amount of water loss from chilling and this weight was recorded as the chilled dressed weight.

3.6.5.2 Dressing percentage

The dressing percentage was obtained from the warm dressed weight expressed as a percentage of the live weight at slaughter.

$$\text{Dressing percentage} = \frac{\text{Warm carcass weight}}{\text{Live weight at slaughter}} \times 100$$

3.6.5.3 Weight of viscera, GIT and other internal organs

The weight of the viscera was recorded in absolute and relative terms. The viscera was collected into a container, washed with water and weighed to obtain the absolute weight. The relative weight was recorded as the weight of the viscera expressed as percentage of the live weight at slaughter. After this, the heart, respiratory tract, liver, spleen, kidneys and the gastro- intestinal tract (GIT) were detached and weighed separately. The GIT was weighed when full (i.e. GIT and contents) and when empty.

3.6.5.4 Carcass length

After weighing, each chilled carcass was sawn (cut) longitudinally into two equal halves through the vertebral column and further measurements taken from the right half of each carcass. Carcass length was measured from the edge of the first rib to the anterior edge of the aitch bone (Os pubis).

3.6.5.5 Backfat thickness

Backfat thickness, which is the fat layer between the skin and the muscles, was measured as the average of the back fat measurement taken from three areas ie the first rib, last rib and the last lumbar vertebra.

3.6.5.6. Weight of primal cuts

After the leaf or abdominal fat and other measurements had been determined, the right half carcass was separated into thigh, shoulder, loin and belly. The absolute weights of these parts were measured and recorded.

3.7. STATISTICAL AND CHEMICAL ANALYSIS

All the data collected were subjected to Analysis of Variance (ANOVA) using the Genstat Statistical Software (Genstat, 2008) to determine the significant differences between the treatment means. All the statistical tests were done at a significance level of 5% and the Least Significance Difference (LSD) procedure was used to separate treatment means. The pest and microbial analysis were done using the streak plate technique. Potato Dextrose agar was used in isolating fungi which were then identified using the light microscope (Atlas, 1995).

The proximate composition of the DB and the experimental diets were determined as described by AOAC (2002).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Health of the Experimental Pigs

Generally all the pigs remained healthy throughout the experiment. However, the few signs of ill health were brought under control by the administration of multivite and antibiotic injections as described earlier. No symptoms of diarrhoea were shown by any pig and also no mortality was recorded.

4.2. Pests and Microbial Status of DB

Laboratory examination of the samples of the DB showed that the samples were infested with *Tribolium species* (both live and dead insects were observed) with the presence of insect remains (exuviae, wings, etc). For the 158.9g of the feed examined, 14 of this insect pest were found. Pelliteri and Boush (1983) assessed stored-product insect pests in twenty feed mills and found *Tribolium species* (both *T. castaneum* and *T. confusum)* widely distributed and abundant stored product pests. The insect, according to Buss and Fasulo (2006) is known to produce certain potential carcinogenic substances such as benzoquinone. Fasulo *et al. (*2005) noted that infestation of biscuits by the insects is a common occurence in biscuit stored under poor conditions and severe infestation may cause unfavourable changes in chemical composition and damage to dry commodities of animal origin. Fasulo *et al.* (2005) and Buss and Fasulo (2006) indicated that the presence of large numbers of larval skin, setae and body parts may cause dermatitis and allergic reactions, contaminate grain and caused gastrointestinal irritation. To ensure healthy diets, Fasulo *et al.* (2005) and Granovsky (2006) recommended that infested products should be kept at a temperature of 0^{o}F (18^{o}C) until the cold penetrates all areas. In addition, heating will kill stored product pests if temperatures of 130 to150^{o}F (54^{o}C to 66^{o}C) are maintained for 24 hours.

The microbial analysis of DB showed the presence of three fungi species namely, *Penicillium species, Aspergillus niger* and *Aspergillus versicolor* with *Penicillium species* being the most frequently isolated followed by *Aspergillus niger* and then *Aspergillus versicolor.* The isolated fungi species are normally associated with contaminated biscuits (Fasulo *et al.*, 2005*). Aspergillus speci*es, especially *A. flavus* and *A. parasiticus* produce aflatoxins, a potent carcinogen, which can lead to adverse health effects such as liver cancer in many animals(Fasulo *et al.,* 2005*).* Other mycotoxins eg *ochratoxins* are also produced by *Penicillium species* (Fasulo *et al.,* 2005*).*

4.3 CHEMICAL COMPOSITION OF DB.

The proximate composition of DB as analysed is shown in Table 5.

Table **5:** Proximate composition (%) of discarded biscuits

Proximate Parameters	**% As fed**	**% Dry matter**
Moisture	17.00	-
Crude protein	9.90	11.93
Crude fibre	0.63	0.76
Ether extract	11.00	13.25
Ash	0.50	0.60
Nitrogen-free extract	60.97	73.46
TOTAL	100.00	100.00

The 17% moisture content recorded in this study was high compared to the 10.2 and 10.48% reported by Longe (1986) and Okai and Bonsi (1989). The difference may be due to the length of storage before processing, temperature difference and post manufacturing management of the biscuit.

The CP content of 9.90% was a bit lower compared to the 11%, 10.6% and 10.48% recorded by Atakora (1982), Longe (1986) and Okai and Bonsi (1989) but was in harmony with the 9.91, 9.61 and 9.5% reported by Pond and Maner (1974), FAO, (1975) and Ajasin *et al.* (2010) respectively. The CF values of 4.47% and 1.36% reported by Longe (1986) and Ajasin *et al*. (2010) are higher than the 0.63% recorded in this study but this value (0.63% CF) is similar to 0.73, 0.70 and 1.00% reported by Pond and Maner (1974), Atakora (1982), Okai and Bonsi (1989) respectively. With regards to the EE content, the 11.00% recorded in this study was lower than the 14.7% reported by Atakora (982) and higher than the 5.72%, 4.0% and 4.7% reported by Longe (1986), Okai and Bonsi (1989) and Ajasin *et al.* (2010) respectively but similar to the 11.40% reported by Pond and Maner (1974). The difference may be due to the product differences. The ash content of 0.5% was very low compared to the 2.2, 5.72 and 9.77% reported by Longe (1986), Okai and Bonsi (1989) and Ajasin *et al.* (2010) respectively. The NFE value of 60.97 obtained in this study was low compared to 65.80%, 65.02%, 70.33%, 74.69% and 72.30% reported by FAO, (1975), Atakora (1982), Okai and Bonsi (1989) and Ajasin *et al.* (2010) respectively. These variations might be due to the high moisture content, the product differences, method of processing, and length of storage before processing and post manufacturing management of the biscuits.

Comparing the chemical composition of DB to that of maize, the CP content of DB which was 9.90% (as fed) and 11.93% (DM) was higher than 8.9% (DM), 8.3% (as fed) and 9.56% (DM) of maize reported by NRC (1968), NRC (1998) and Ajasin *et al.* (2010) respectively but falls within the of 8 -12% reported by Ranjhan (2001). The CF content of the DB (0.76%) was lower than 2.0% and 5.62% reported by NRC (1968) and Ajasin *et al.* (2010) for maize. The EE value of DB (13.25%) was very high compared to the 4.56 and 3.9% for maize as reported by NRC,(1988) and Ajasin *et al.* (2010). The Ash content of DB (0.60% as fed) was lower than 1.1 and 8.9% reported by NRC (1968) and Ajasin *et al.* (2010). The 73.46% (DM) NFE of DB recorded in this study was similar to the 73.10% NFE for maize reported by NRC (1968) but higher than 71.32% reported by Ajasin *et al. (*2010). These variations might be due to the aforementioned factors.

In conclusion, the proximate analysis has confirmed that the DB is similar in composition to maize and therefore its use as an energy source in feed formulation will require probably no adjustments of the protein and energy levels of the other ingredients in order to meet the recommended CP and energy levels for pigs and other monogastrics.

4.4 Chemical Composition of the Experimental Diets

The calculated and analysed proximate compositions of the diets are presented in Table 4. There was variation in the analysed values for CP and NFE as the level of DB increased. The CP values for DB containing diets were slightly higher than the Control diet, but this was the reverse for the NFE values. The analysed CP values were slightly higher than the calculated values. They were also higher than 15.15%

(T1), 14.48% (T2), 14.30% (T3), 14.19% (T4) and 14.05% (T5) obtained by Eniolorunda *et al.* (2010) but slightly lower than 18.20% (T1), 18.40% (T2), 18.70% (T3) and 18.50% (T4) obtained by Okai *et al.* (1991). These variations in the current study may be attributed to the differences in the crude protein levels of the ingredients used i.e. maize and the DB.

The CF content decreased as the level of DB increased in the diet. This may be due to the fact that the CF content of DB is lower than maize. Ajasin *et al.* (2010) reported CF values of 5.62 and 4.67% for maize and DB respectively The Ash content was similar for all the dietary treatments. The CF and Ash values were lower than those recorded by Ajasin *et al.* (2010) and Eniolorunda *et al*. (2010). The EE content increased as the level of DB in the diet increased. This is also due to the fact that the EE content of DB is higher than maize. Ajasin *et al.* (2010) analysed both maize and DB and reported EE values of 4.56 and 5.98% respectively. The values were lower than those obtained by Okai *et al.* (1991) except T4 which was higher. These differences might also be due to the differences in the inclusion levels of the DB. The percentage DM content of the diets also increased as the level of DB increased. The values were lower than those obtained by Eniolorunda *et al.* (2010) and Ajasin *et al*. (2010). The differences observed may be attributed to the differences in the moisture content of the diets.

4.5 GROWTH PERFORMANCE OF PIGS.

The summary of the growth performance of the pigs and the economics of production for the four diets is presented in Table 6.

4.5.1 Feed Intake

The mean total feed intake (MTFI) values which were 125.00, 132.60, 131.90, and 121.80kg for 0%DB, 10%DB, 20%DB, and 30%DB respectively were not significantly (P> 0.05) different. Ajasin *et al.* (2010) observed no significant (P> 0.05) difference in MTFI when they replaced the maize fraction with DB at 0% (T1), 50% (T2), 75% (T3) and 100 %(T4) respectively in the diet of growing snails.

Table 6: Growth performance of pigs and the economics of production.

	Dietary treatments				**LSD**	**Sig.**
	0%DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
PARAMETER						
Mean initial weight, kg	16.60	16.70	16.70	16.60	2.308	NS
Mean final weight, kg	63.40	64.50	64.40	63.90	1.869	NS
Mean total weight gain, kg	46.80	47.80	47.80	47.20	2.061	NS
Mean daily weight gain, kg	0.72	0.70	0.72	0.74	0.081	NS
Mean total feed intake, kg	125.00	132.60	131.90	121.80	17.09	NS
Mean daily feed intake, kg	1.90	1.94	2.04	1.90	0.189	NS
Mean FCR (feed/gain)	2.70	2.76	2.76	2.60	0.325	NS
Mean duration (days)	65.80	68.60	64.40	64.40	7.230	NS
Feed cost/kg, GH¢	0.87	0.80	0.80	0.70	-	-
Feed cost/kg liveweight gain, GH¢	2.32	2.25	2.10	1.83	0.248	NS

LSD – Least significant difference, Sig – Significance, NS – Non –significant.

The mean daily feed intake (MDFI) values were quite similar (P> 0.05) (Table 6). This result is similar to those reported by Okai *et al.* (1991); Heloo (1984) and Tibiru (1980) who recorded no significant (P > 0.05) differences in MDFI when they replace maize with DB at the levels of 0, 15, 30 and 45%; 0, 15 and 30% and 0, 10, 20 and 30% respectively. The similarities in feed intake are an indication that the energy content of the diets was similar since pigs eat to satisfy their energy requirements (Pond *et al.,* 1995; NRC, 1998). It is also an indication that the nutrient composition of the control diet and the experimental (DB containing) diets were similar. According to NRC (1998), feed composition in terms of nutrient content and nutrient balance is an important determinant of feed intake.

4.5.2 Live Weight Changes

There were no significant (P>0.05) differences in mean initial weight (MIW), mean final weight (MFW), mean total weight gain (MTWG) and mean daily weight gain (MDWG) for all the dietary treatments (Table 6). Okai *et al.* (1991) recorded similar (P>0.05) results when he fed varying levels of DB to growing pigs. Ajasin *et al.* (2010) and Eniolorunda *et al.* (2010) observed significant (P< 0.05) differences in MFW, MTWG and MDWG respectively. Even though there were no significant (P > 0.05) difference in all the live weight parameters in this study, the numerical values for the DB -containing diets were slightly higher than those for the control (maize -containing) diet for all the parameters. The MFW, MDWG and MTWG values corresponded with the MTFI and MDFI values since high feed intake of a well balanced diet usually result in high growth rate as indicated by Sotolu and Byanyiko, (2010), which linked the higher growth rate pattern to better utilization of the diet when they fed ALBP -based diet to fingerlings.

4.5.3. Feed Conversion Ratios

The mean feed convention ratios (FCR) were similar (P > 0.05) for all dietary treatments. It is clear that the inclusion of DB up to the level of 30% of the diet did not have any significant (P>0.05) adverse effect on the feed conversion ratio. Similarly, Okai *et al.* (1991) recorded no significant (P > 0.05) differences in FCR when they fed growing pigs with diets containing varying (0-45) levels of DB. Eniolorunda *et al.* (2010) also did not observe any significant (P>0.05) differences among treatment means for FCR when diets containing 0-100% DB were fed to Yankasa rams. Furthermore, Ajasin *et al.* (2010) reported no significant (P>0.05) difference in FCR when they replaced 0-100% of the maize fraction with DB in the diets of growing snails. Bakery by-products, according to Davidson (1966), can affect nutrient utilization and growth rate by forming a ball and becoming dough in the stomach. However, there was no indication of such incidence happening in this experiment. The absence of the dough formation in the stomach may possibly be due to the presence of high amount of wheat bran in the diets (Table 4) which might have opened up the feed.

4.6 Duration of the Experiment

The mean duration was similar for pigs on all dietary treatments (Table 6). The pigs fed on 10% DB stayed slightly longer than those on 0% DB, 20% DB and 30% DB, before attaining the stipulated slaughter weight. These differences were however, not significant (P>0.05). There was a relationship between mean daily weight gain (MDWG) and mean duration. The MDWG corresponded with the mean duration. This means that pigs that gained more weight per day matured earlier. It appears that pigs on diets containing higher percentage of DB (20 and 30%) gained more weight per day and therefore took shorter period to reach maturity than those on higher levels of maize (0 and 10% DB).

4.7 Feed Cost and Economy of Gain

The cost of the various diets and the feed cost per kg live weight gain values are shown in Table 6. Feed cost per kg (GH¢/kg) decreased with increasing levels of DB which replaced some of the maize fraction of the diets. Okai *et al*. (1991). Tibiru (1980) and Heloo (1984) made similar observations in their feeding trials with pigs in which they fed diets containing varying levels of DB as a replacement for maize. The decline in the feed cost as the amount of maize in the diet was reduced by replacement with DB was mainly due to the huge price disparity between maize (GH¢0.84 / kg) and the DB (GH¢0.28). Ajasin *et al.* (2010) and Eniolorunda *et al.* (2010) reported similar trends in feed costs when they replaced the maize portion of the diet with DB at varying levels.

The values for feed cost per kg live weight gain were similar ($P > 0.05$) for all dietary treatments. The absolute values clearly show that feed cost per kg live weight gain decreased with increasing levels of DB similar to the trend observed for the cost of the various diets. This result is similar to those observed by Tibiru (1980), Heloo (1984), Okai *et al.* (1991) and Eniolorunda *et al*. (2010). Eniolorunda *et al.* (2010) and Ajasin *et al*. (2010) also reported similar trend of decreasing feed per kg live weight gain with increasing DB in the diets but observed significant (P<05) difference among the treatment means.

4.8. CARCASS CHARACTERISTICS

The values obtained for the mean carcass parameters are show in Table 7.

4.8.1. Live weight at Slaughter, Dressed Weight and Dressing Percentage

There were no significant (P>0.05) differences between the treatment means for live weights at slaughter, warm dressed carcass weights, dressing percentages and chilled carcass weight (Table 7). Okai *et al.* (1991, 2001a, 2001b) made similar observations when they fed varying levels of DB, Obatanpa and Normal maize to growing pigs. The similarities might be because all the pigs were slaughtered at stipulated weight of 62.5$\pm$ 2.5 kg.

4.8.2. Carcass Length, Backfat Thickness and Abdominal Fat.

There were no significant (P>0.05) differences among treatment means for carcass length (Table 7). The mean backfat thickness and abdominal fat values were statistically not significant (P>0.05). Okai *et al*. (1991) obtained similar results for backfat thickness when they fed diets containing varying levels of DB to growing pigs. The mean backfat values recorded in this experiment were above the USDA maximum standard for pork carcass backfat thickness of 2.80cm except for the pigs on dietary treatment, 10% DB, which fell slightly below the maximum standard (Sterle, 2000). The difference may be attributed to the factors outlined by Warris *et al.* (1983); Enfant *et al.* (1997); Azain *et al.* (1992); Lafaucher *et al.* (1992).

4.8.3. Weight of Primal Cuts

The mean shoulder, loin, belly and thigh weights were statistically not significant (P>0.05) among the treatment means. These results are similar to those of Okai *et al*. (2001a, 2001b and 2007) when they used Obatanpa (QPM) and normal maize varieties in grower- finisher pig diets.

Table 7: Carcass parameters of pigs fed diets containing varying levels of DB.

	Dietary treatments				**LSD**	**Sig.**
	0%DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
PARAMETER						
Mean liveweight at slaughter ,kg	63.40	64.50	64.40	64.00	-	-
Mean dressed weight ,kg	48.24	48.95	48.99	48.91	2.572	NS
Mean dressing percentage	76.08	75.88	76.06	76.53	2.665	NS
Mean chilled carcass weight, kg	41.50	42.20	42.21	41.70	2.197	NS
Mean carcass length, cm	70.42	71.80	71.36	70.58	1.289	NS
Mean shoulder weight, kg	3.46	3.71	3.68	3.72	0.3227	NS
Mean loin weight ,kg	6.10	6.37	6.22	6.12	0.4746	NS
Mean belly weight, kg	4.09	4.39	4.36	3.76	0.5015	NS
Mean thigh weight,kg	6.03	6.10	5.93	6.37	0.4245	NS
Mean backfat thickness, cm	1.16	1.69	1.21	1.19	0.912	NS
Mean abdominal fat, kg	0.59	0.54	0.60	0.54	0.170	NS
Mean head weight, kg	4.28	4.40	4.36	4.48	0.244	NS
Mean trotters weight, kg	0.96	1.05	0.95	1.03	0.109	NS
Mean fillet weight, kg	0.28	0.30	0.30	0.30	0.053	NS
Mean viscera weight, kg	9.20	8.94	9.68	9.08	0.981	NS
Mean GIT weight (full), kg	6.37	5.93	6.49	5.86	1.084	NS
Mean GIT weight (empty), kg	2.68	2.75	2.77	2.67	0.304	NS
Mean empty stomach, kg	0.45	0.45	0.40	0.44	0.059	NS
Mean heart weight, kg	0.18	0.19	0.18	0.19	0.140	NS
Mean kidney weight, kg	0.21	0.22	0.23	0.26	0.044	NS
Mean liver weight, kg	1.27	1.29	1.01	1.43	0.372	NS
Mean lungs weight, kg	1.04	1.12	1.12	1.13	0.217	NS
Mean P2, cm	0.80	0.78	0.82	0.70	0.216	NS
Mean spleen	0.10	0.11	0.11	0.12	0.022	NS

LSD – Least significant difference, Sig – Significance, NS – Non –significant.

4.8.4. Weight of Other Body Components

The mean weights for the head and trotters were similar (P > 0.05) among treatment means. The mean weight of some internal organs such as empty stomach, full GIT, empty GIT, heart, liver, lungs, spleen and kidney were also similar (P>0.05). These observations confirm the earlier findings by Okai and Boateng (2007); Okai *et al*. (1991, 2001a) and De Oliveira *et al.* (2011) when they fed varying levels of DB, Obatanpa and Normal maize to growing pigs. Also, no significant (P>0.05) differences were obtained for viscera, fillet and P2 measurements.

4.8.5. Relative Weight of Some Body Components

The summary of the mean relative weights of the head, shoulder, trotters, thigh, loin, belly and the internal organs is presented in Table 8.

The mean relative head, trotters, thigh, loin, shoulder and belly weights were similar (P>0.05) for all the dietary treatments. It was however, observed that the relative weights of the head and shoulder of the pigs generally increased as the level of the DB in the diets increased. The mean relative head and shoulder weight followed a pattern similar to their absolute weights. It was again observed that pigs on dietary treatment, T4 (30% DB) recorded the highest percentages for mean relative head, shoulder and thigh weights. The mean relative weights of some internal organs such as empty stomach, full GIT, empty GIT, heart, liver, lungs, spleen and kidney were similar (P>0.05) for all the dietary treatments (Table 8). In addition, the relative weighs of viscera and fillet were similar (P>0.05) for all the dietary treatments. The relative values of the internal organs recorded in this experiment were within the ranges reported by McMeekan (1940) and also confirm the findings by Okai *et al.* *(*2001a; 2001b).

Table 8: Relative weight (%) of some body components.

	Dietary treatments				LSD	Sig.
	0% DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
PARAMETER						
Mean head weight	6.75	6.82	6.77	7.00	0.375	NS
Mean trotters weight	1.51	1.62	1.46	1.61	0.186	NS
Mean thigh weight	9.51	9.45	9.21	9.95	0.582	NS
Mean shoulder weight	5.46	5.76	5.71	5.81	0.408	NS
Mean loin weight	9.77	9.87	9.70	9.57	0.702	NS
Mean belly weight	6.45	6.81	6.77	5.87	0.783	NS
Mean fillet weight	0.44	0.45	0.47	0.47	0.103	NS
Mean viscera weight	14.51	13.86	14.89	14.20	1.344	NS
Mean GIT weight (full)	10.04	9.19	10.07	9.16	1.387	NS
Mean GIT weight (empty)	4.23	4.20	4.30	4.17	0.516	NS
Mean empty stomach	0.68	0.70	0.62	0.69	0.127	NS
Mean liver weight	2.00	1.99	1.89	1.89	2.44	NS
Mean kidney weight	0.33	0.34	0.36	0.41	0.074	NS
Mean heart weight	0.28	0.29	0.28	0.30	0.046	NS
Mean lungs weight	1.64	1.74	0.62	0.77	0.199	NS
Mean abdominal fat	0.91	0.84	0.93	0.85	0.273	NS
Mean spleen	0.16	0.17	0.17	0.9	0.036	NS
Mean P2	1.40	1.21	0.27	1.09	0.350	NS

LSD – Least significant difference, Sig – Significance, NS – Non –significant.

4.9 HAEMATOLOGICAL AND SERUM BIOCHEMICAL PROFILES OF THE PIGS

The results of the analysis of the blood samples of the experimental pigs are shown in Table 9.

Table 9: Haematological and serum biochemical parameters of the pigs.

	Dietary treatment				LSD	Sig.
	0% DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
PARAMETER						
HAEMATOLOGICAL PROFILE						
Hb (g/dl)	13.10	14.10	13.94	14.02	1.57	NS
HCT (%)	45.30	48.60	47.80	48.68	5.24	NS
MCH (Pg)	17.86	17.88	18.34	17.62	1.10	NS
MCHC (g/dl)	28.98	29.40	29.18	28.74	1.11	NS
MCV (fL)	61.68	61.50	62.86	61.38	3.27	NS
Platelets (x 10^9/l)	249	250	250	217	97.10	NS
RBC (x 10^{12}/l)	7.36	7.88	7.58	7.96	1.08	NS
WBC (x 10^9/l)	13.46	14.92	15.28	16.18	4.58	NS
SERUM BIOCHEMICAL PROFILE						
HDL Cholesterol (mmol/l)	0.80	0.80	0.80	1.00	0.18	NS
LDL Cholesterol (mmol/l)	0.20	0.20	0.20	0.30	0.08	NS
Total Protein(g/l)	2.10	2.00	2.10	2.50	0.30	NS
Total Cholesterol (mmol/l)	2.08	2.02	2.08	2.50	0.32	NS
	41.60	41.80	42.00	42.00	2.49	NS
Albumen (g/l)						
Globulin (g/l)	18.00	18.60	20.20	19.40	2.09	NS
Triglycerides (mmol/l)	0.50	0.50	0.50	0.70	0.19	NS

LSD – Least significant difference, Sig – Significance, NS – Non –significant.

4.9.1 Haematological Analysis

All the haematological indices showed no significant (P>0.05) differences among treatment means (Table 9) and were within the normal ranges for pigs (domestic boars) reported by Friendship *et al*. (1984), Rispat *et al. (*1993), Harapin *et al.* (2003), Thorn (2006) and Eze *et al.* (2010). However, the values for Hb, HCT, RBC and WBC showed numerical increase as the level of DB in the diets increased whilst the mean platelets showed the reverse. These results were similar to those of Adesehinwa *et al.* (2008) when they fed varying levels (16, 18 and 20%) of CP to gilts but different from those reported by Olufemi *et al*. (2003). The MCH, MCV and MCHC values showed no numerical trend. However, the MCH and MCV values were similar (P> 0.05) to those of Adesehinwa *et al*. (2008) and Machebe *et al*. (2010) whilst the MCHC values differed.

The results of the heamatological analysis presented above indicate that the varying levels of DB studied in this experiment did not have any detrimental effect on the blood parameters of the pigs. According to Mbanasor *et al.* (2003), the haematological profiles are important indicators of health and diseases in animals and have become indispensable in the diagnosis and treatment of many diseases. However, the numerical differences observed in some of the parameters might be due to the interactions of factors such as stage of estrus cycle, breed, age, diet, sex, time of the day, exercise, excitement, environmental temperature and other environmental factors as stated by Swenson (1970), Friendship *et al.* (1984) and Rispat *et al.* (1993).

4.9.2. Biochemical Analysis

The results of the serum biochemical analysis of the blood of the experimental pigs are presented in Table 9. Statistically, the results showed no significant (P>0.05) differences among the treatment means for all the parameters mentioned. However, there were slight numerical increases in the values recorded for all the parameters measured as the level of DB in the diet increased. The values recorded for all the biochemistry parameters measured were within the normal ranges reported by Friendship *et al.* (1984), Rispat *et al.* (1993) and Harapin *et al*. (2003) and slightly higher than those reported by Adesehinwa *et al.* (2008).

It could generally be inferred from the haematological and biochemical results that both DB and maize had no influence over any of the parameters measured. Again, the results showed that the DB did not have any negative effect on the physiology of the pigs. This confirms the accession by Longe (1986) that DB has no anti-nutritional factor.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The results of the study showed that DB is similar in nutrient composition to maize. Its high energy and CP content are comparable to maize. The results of pests and microbial analysis showed that the level of infestation of the DB was not severe and that the DB could be fed to pigs. The results also showed similar feed intake, growth rate, and feed conversion ratio for all dietary treatments. Economically, the results showed that DB was cheaper than maize. All carcass, haematological and biochemical parameters were similar for all the dietary treatments but DB containing diets gave slightly higher values than the maize (Control) diet in absolute terms. It was also established that the levels of DB in the diets showed no adverse effect on the health of the pigs. The DB could constitute as much as 30% of the diet and replace nearly 70% of the maize in the diet of growing-finishing pigs without any adverse effect on growth performance, carcass characteristics, haematological and serum biochemical characteristics. In conclusion, DB and perhaps other bakery products could serve as very useful sources of alternative energy for pigs and their use as feed ingredient will help reduce competition between humans and livestock for maize.

5.2 Recommendations

1. Based on the results of the study, 30% inclusion level of DB is recommended for pig farmers in Ghana.
2. It is also recommended that higher inclusion levels of DB, up to about 60%, in pig diets need to be studied.
3. Further studies should be conducted to establish the national availability and actual tonnage of DB and other bakery by-products produced in Ghana.
4. Finally, the study on DB could be extended to other livestock.

REFERENCES

Abdullatif, A., Al-Tulaihan A., Huthail, N. and Salah, M. Al-Eid. (2004). Nutritional evaluation of locally produced dried bakery waste (DBW) in broiler diets. Pakistan Journal of Nutrition 3(5): 294-299.

Aberle, E.D., Forest, J.C., Gerrard, D.E. and Mills, E.W. (2001). Principles of Meat Science. Fourth Edition, Kendall/Hunt Publishing Company, Iowa, USA. pp 63.

Abu, A.A., Okai, D.B. and Tuah, A. K. (1984). Oil Palm Slurry (QPS) as a partial replacement for maize in the diet of growing-finishing pigs. Nutri. Rep. Int. 30(1): 121-127.

Addo-Quaye, A.A., Saah, M.K., Tachie-Menson, C.K.B., Ibrahim, A., Tetteh, J.P., Rockson-Akorly, V.K. and Kitson, J.E.(1993), General Agricultural for Secondary Schools, H. Gangaram and Sons Publishers, Bombay, India. pp 11-88

Adesehinwa, A.O.K., Dairo, F.A.S. and Olagbegi B.S. (2008). Response of growing pigs to cassava peel-based diets supplemented with Avizyme 1300: Growth, serum and haematological indices. Bulgarian Journal of Agricultural Science, 14: 491-499.

Aitken, A.D. (1975). Insect Travellers- Vol. 1.Coleoptera. Min. of Ag., Fishery and Food Ag. Development and Advisory Service, Pest Control Lab. Tech. Bull. 31.

Ajasin, F. O., Omole, A. J., Fapohunda, J. B., Obi, O. O. (2010). The feeding value of biscuit waste as a replacement for Maize in the diet of growing-finishing snails (*Archachatina marginata).* J. America Sci. 2010; 6(2).

Ajmani, RS. and Rifkind, JM. (1998). Haematological changes during human aging. Gerontology. 44 (2): 111-120.

Andah, D.O. (1974). Towards increased efficiency in pig production in Ghana.

Proc. 7th Animal Science Symposium University of Ghana, Legon. Pp 1-3.

Anonymous, (1965). Stored-Grain Pests. Farmers ' Bull. 1260. U.S.D.A., Market Quality Research Division, Stored Product Insect Research Branch. Washinton, D.C.

Anthony, Y, Ezedinma, F.O.C. and Ochapa, G.O. (1990). Introduction to Tropical Agriculture, Second Edition, Longman Group (FE) Limited, U.K. Pp 16-28.

ARC (Agricultural Research Council), (1981). The Nutrient Requirements of pigs: Technical Review Edition Slought, England. Commonwealth Agricultural Bureau. pp 22: 307.

Arrington, L.R., Moore, J.E., Ancalmo, R., Raulerson, D.E. and Cunha, T.J. (1964). The vitamin value of dried bakery product in rats and growing-finishing pigs. Journal of Animal Science 23: 866 (Abstr.).

Association of Official Analytical Chemists AOAC (2002). Official methods of analysis. 18th Edition. Washinton, D.C. USA.

Atakora, J.K.A. (1982). Nutrient composition of some feedstuffs available in Ghana. B.Sc. Dissertation, Faculty of Agriculture, KNUST, Kumasi. pp. 32-40.

Atlas, M.R. (1995). Principles of Microbiology. Year Book Inc., St. Louis, Missouri, U.S.A.

Atuahene, C.C., Donkoh, A. and Swatson, H. (1987). Oil palm slurry as a partial replacement for maize in the diets of broiler chickens. Anim. Feed Sci. Tech. 17: 157-162.

Azain, M. J., Bullock,K. D., Kasser, T. R. and Veehuizen, J. J. (1992). Relationship of model of porcine somatotropin administration and dietary fat to the growth performance and carcass characteristics of finishing pigs. Journal of Animal Science. 70(10): 3086-3095.

Banerjee, G.C. (1988). Feeds and Principles of Animal Nutrition Oxford & IBH Publishing Co. (PVT) Ltd. India. Pp. 114-133.

Beal, R.S. (1970). A taxonomic and biological study of species of *Attagenni (*Coleoptera: Dermestidae) in the United States and Canada. Entomological Americana 45:141-235.

Bengin, D., Katic, I., Pupavac, S., Kostic, M. and Protic, N. (2008). Kvalitet i mikrobiolocka ispravnost hraniva I krmnih smesa u 2007.Godini, Zbornik naucnih radova, 14: 3-4.

Blakely, J. and Bade, D.H. (1994). The Science of Animal Husbandry (6th ed.). Prentice Hall Career and Technology. Prentice Hall, Upper Saddle River, New Jersey 07458. pp 368-419.

Bloomfield, B. (1990). Microbiological quality of take-away cooked rice and chicken sandwitches: effectiveness of food hygiene training of the management. J. Food Protection. 24(1): 722-30.

Bone, J.F. (1988). Animal Anatomy and Physiology. Third Edition. A. Reston Book, Prentice Hall, Englewood Cliffs, New Jersey 07632. USA. pp. 233-259.

Brody, S. (1945). Bioenergetics and growth. Hafner, New York. pp. 37-576.

Burgoon, K.G., Hansen, J.A., Knabe, D.A. and Bockholt, J.A. (1992). Nutritional value of Quality Protein Maize for starter and growing swine. Journal of Animal Science. 70: 811-817.

Buss, I.J and Fasulo T.R. (2006). Stored product pest. UF/IFAS.CD-ROMS W185.

Cameron, C.W. (1970). Feeding pigs for profit. Proceedings 3rd Gh. Anim. Sci. Assoc. Symp., U.S.T., Kumasi. pp. 57-63.

Campadadal, C.D., Cross, H.D., Wallace, E.D. and Combs, G.E. (1976). Nutritional value of rice bran for pigs. Tropical Agric. (Trinidad) 53(2): 141-149.

Chenost, M. and Mayer, L. (1977). Potential contribution and use of agroindustrial by-products in animal feeding. In: New Feed Resources. Proceedings of Technical consultation held in Rome. pp1-27. http://www.fao.org/docrep/004/x6503e00.htm

Clavijo, H., Calles, A., Oliva, F. and Maner, J.H. (1970). Unpublished data.INIAP. Santo Domingo, Ecuador. Pp 267-276.

Coagulation cascade [online].2003[cited2007Sep.9]. Available from: URL:http://labtestsonline.org/understanding/analytes/coag_cascade/coagulation_cascade.html [Accessed October 8, 2012.].

Cockerell, Y., Francis, B. and Halliday, D. (1971). Changes in nutritive value of concentrate feeding-stuffs during storage. In Proceedings of the Conference on the development of feed resources and improvement of animal feeding methods in the CENTO region countries, Tropical Products Institute, London. pp. 181-192.

Cole, D.J.A. (1984). The nutrient density of pig diet-allowances and appetite. In: Fat In Animal Nutrition. J. Wiseman, (ed.). London: Butterworth. pp. 301-312.

Cole, D.J.A., Duckworth, J.E. and Holmes, W. (1967). Factors affecting voluntary feed intake in pigs. The effects of two levels of crude fibre in the diet on the intake and performance of fattening pigs. Animal. Production. 9: 149-155.

Cooke, R., Lodge, G.A. and Lewis, D. (1972). Influence of energy and protein concentrations of diet on the performance of growing pigs. 3, Responses to differences in levels of both energy and protein. Animal. Production. 14: 219-223.

Cotton, R.T., and Good, N. E. (1937). Annotated list of the insects and mites associated with grain and cereal products, and of their arthropod parasites and predators. U.S. Dept. Agr. Misc. Publ. 258.

Davidson, H.R. (1966). The production and marketing of pigs. Longman,Green and Co. Ltd. London. Pp. 66.

Daugherty, D.M., and C.N. Brett. (1966). Nitidulidae associated with sweet corn in North Carolina and influences affecting their damage to this crop. N. Carolina Ag. Exp. Station, Tech. Bull. No. 171.

De Oliveira, G.C., Moveira, I., de Souza, A.L.P., Murakami, A.E., Parra, A.R.P., Carvalho, P.L.O. and Borile, M.D. (2011). Corns with different nutritional profiles on growing and finishing pigs feeding. *Asian* – Aust. J. Anim. Sci. 24(7): 982-992.

Devendra, C. (1992). Non-conventional Feed resources in Asia and the Pacific: strategies for expanding at the small farm level (4th edition) FAO: Regional Anim. Production and Health Commission for Asia and the Pacific. FAO (APHCA), Bangkok, Thailand.

Devendra, C. and Fuller, M.F. (1979). Pig Production in the Tropics. Oxford University Press. pp 25-50.

Dilas, S., Zivkov –Balom, M., Mrden, N., Mihaljev, Z. and Masic, Z. (2001). Kontaminiranost hrane za zivotinje plesnima tokom 2001 .godine. Veterinarski zurnal Repblike srpske, Banja Luka, 1, 3, 97-212.

Dordevic, N., Dinic, B. (2007). *Hrana za zivotimje, Cenzone tech-Europe, Arandelovac.* In: Microbiological safety of animal feed. Biotechnology in Animal Husbandry 25 (5-6): 1155-1162.

Dunsford, B.R., Knabe, D.A. and Hoensly, W.E. (1989). Effects of dietary soybean meal on the microscopic anatomy of the small intestine in the early weaned pig. Journal of Animal Science. 67:1855-1863.

Edmond, M.S., Arentson, B.E. and Mente, G.A. (1998). Effect of protein levels and space allocations on performance of growing-finishing pigs. Journal of Animal. Science. 76:814-821.

Ekyenyem, B.U. and Madubuike, F.N. (2007). Haematology and serum biochemistry characteristics of grower pigs fed varying dietary levels of *Ipomoea asarifolia* leaf meal. *Pakistan Journal of Nutrition.* 6(6): 603-606.

Enfalt, A.C., Lundstrom, K., Hasson, I., Lundeheim, N., and Nystrom, P.E. (1997). Effect of outdoor rearing and sire breed on carcass composition and sensory and technological meat quality. Meat Science. 45: 115-116.

Eniolorunda, O.O. (2010). Evaluation of biscuit waste meal and *Leucaena leucocephala* leaf hay as sources of protein and energy for fattening "Yankasa" rams. African Journal of Food Science 5(2):57-62 (Available online http:www.academicjournals.org/ajfs ISSN 1996-0794 @ 2011 Academic Journals). [Accessed October 8, 2012].

Esonu, B. O., Enemalom, O. O., Udedibie, A. B. I., Herbert, U., Ekpor, C. F., Okoli, I. C. and Iheukwumere, F. C. (2001). Performance and blood chemistry of weaner pigs fed red mucuna (Velvef bean) meal. Tropical Animal Production. 4: 49-55.

Eze, J.I., Onunkwo, J.I., Shoyinka, S. V.O., Chah, F.K., Ngene, A.A., Okolinta, N., Nwanta, J.A. and Onyenwe, I.W. (2010). Haematological profiles of pigs raised under intensive management system in South-Eastern Nigeria. *Nigerian Veterinary Journal* 31 (2): 115-123.

FAO (2002). FAOSTAT Agriculture. Date: http;//apps.fao.org. [Accessed December 10, 2011].

FAO (2004). Protein sources for the animal feed industry. Expert consultation and workshop, 29th April- 3rd May, 2002, Bangkok. Executive summary xi-xxv.

Fasulo, T.R., Kern, W., Koehler, P.G. and Short, D.E (2005). Pest around the Home.Version 20. University of Florida/IFAS.CD-ROM SW 126.

Fetuga, B.L., Babatunde, G.M. and Oyenuga, V.A. (1977). The value of palm kernel meal in finishing diets for pigs. J. Agric. Sci., Camb. 88: 655-661.

Freeman, J. A. (1973). Infestation and Control of Pests of Stored Grains in International Trade, Grain Storage: Part of a System, R.N. Sinha and W.E. Muir (Ed.), The Avi Pub. Co., Inc., Westport, CN. Pp.99-136.

Friendship, R. M., Lumsden, J. H., McMillan, I. and Wilson, M. R. (1984). Haematological and biochemical reference value for Ontario swine. Canadian Journal of Medicine. 48:390-393.

Frobish, L.T., Hays, V.W., Speers, V.C. and Ewan, R.E. (1969). Effect of diet form and emulsifing agents on fat utilization by the young pig. Journal of Animal Science. 29: 320-326.

Genstat Statistical Software (2008). *Discovery edition 3 (*Genstat 7.22DE) copy right 2008, VSN International limited.

Gillespie, J.R. (1992). Modern livestock and poultry production. 4th Ed. Delmar Publishers Inc. Albany, NY.pp 89-95.

Gohl, B. (1981). Tropical feeds. Feed information summaries and nutritive values. F.A.O. Animal Production and Health Series No. 12. Rome, Italy. Pp 333-337.

Granovsky, T.A. (2006). Stored product pests. In: Handbook of pest control (by-A. Mallis). 8th edition Technical training and Co. pp635-728.

Hancock, J.D. (1999). The benefits of pelleted feed on pig performance. Feed Tech. *3(6):*37-39.

Gondret, F. and Lebret, B. (2002). Feeding intensity and dietary protein level affect adipocyte cellularity and lipogenic capacity of muscle homogenates in growing pigs, without modification of the expression of sterol regulatory element binding protein. Journal of Animal Science. 80 (12): 3184-3193.

Gonyou, H.W. and Lou, Z. (1999). Effects of eating space and availability of water in feeders on productivity and eating behaviour of grower-finisher pigs. Journal of Animal Science: 63(Suppl. 1):163-164.

Gopalakrishnan, C. A. and Lal, G.M.M. (1996). Livestock and Poultry Enterprises for Rural Development.Vikas Publishing House. PVT Ltd. 576, Masjid Road, Jangpura, New Delhi-110014. Pp.755-850.

Harapin, I., Bedrica, L.J. Hahn, V., Sostarie, B. and Gracner, D. (2003). Haematological and biochemical values in blood of wild boar (*Sus scrofa ferus*). Veterinary Arhive. 73:333-343.

Heloo, J.W.K. (1984). Discarded biscuits (DB) as an ingredient in the diets of starter pigs. A BSc. Dissertation, Faculty of Agriculture, KNUST. Pp.27-35

Hl, L.O., Rust, J.W. and Wase D.F. (1969). Effect of protein content on performance of the young pig. J. Anim. Sci. 28 : 473-477.

Hinton, M. (1993). Spoilage and pathogenic microorganisms in animal feed. International Biodeteriotion and Biodegradation, pp. 32, 67-74.

Hinton, H.E. and Corbet, A.S. (1955). Common Insect Pests of Stored Products, a guide to their identification, British Museum (National History) Economic series 5, London.

Holness, H.D. (2005). The Tropical Agriculturalist. Pigs, Revised ed. Macmillan. Green Inc. Ltd. UK. Pp. 9-69.

Howe, R.W., (1965). Losses caused by insects and mites in stored foods and feedingstuffs. Nutrition. Abstract. 35 (2):285-303.

Hulse, J.H., Laing, E.M. and Pearson, O.E (1980). Sorghum and Millets: Their Composition and Nutritive Value. International Development Research Centre. Canada. KIG 3H9.Academic Press, London, U.K.

Hyun, Y., Ellis, M., McKeith, F.K. and Wilson, E.R. (1997). Feed intake pattern of group-housed growing-finishing pigs monitored using a computerized feed intake recording system. Journal Animal Science. 75: 1443-1451.

Jain, N.C. (1986). Schalm's Veterinary Heamatology 4th edition, (ed. N.C. Jain), Philadelphia: Lea and Febiger, pp.20-86.

Jakic-Dimic, D., Sinovec, Z. and Markovic, M. (1994). Prisustvo uzrocnika iz grupe krostridij u stocnoj hrani.Savetovanje veterinara Srbije, VII.Zbornik kratkih sadrzaja radova.

J**ames, M. T., and R. F. Hardwood.(1969).** Herm's Medical Entomology. The MacMillan Company, Collier-MacMillan Ltd., London.

Johnson, R.W. (1997). Inhibitions of growth in the immunologically challenged pig. In: Proc. Eastern Nutrition Conference, Guelph, Ontario. Pp. 28-33.

Kaneko,J.J., (1989). Clinical biochemistry of domestic animals.4th Edition. Academic Press, Inc. N. York.

Kellems, R.O. and Church, D.C. (2002). Livestock Feeds and Feeding. 5th Ed. Pearson Education, Inc. , Upper Saddle River, New Jersey 07458. Pp. 16-39.

Kim, B. G., Lee, J.H., Zung, H.J., Han, Y.K., Park, K.M. and Han, L.K. (2001). Effect of partial replacement of soybean meal with palm kernel meal and copral meal on growth performance, nutrient digestibility and carcass characteristics of finishing pigs. Asian Australasian Journal of Animal Science, 14: 821-830.

Kuo, L.M., and Sai, C.Y. (1966). The occurrence of aflatoxin in Malayan imported cakes and groundnut kernels. The Malayan Agricultural Journal, 45: 8-11.

Lafaucheur, L., Missohou, A., Ecolan, P., Monin, G. and Bonneau, M. (1992). Performance, plasma hormones, histochemical and biochemical muscle traits, and meat quality of pigs administered exogenous somatotropin between 30 or 60 kilograms and 100 kilograms body weight. Journal of Animal Science. 70(11): 3401-3411.

Le Dividich, J. and Herpine, P. (1994). Effects of climatic conditions on the performance, metabolism and health status of weaned pigs. Livestock Production. 38:79-90.

Lekule, F.P., Homb, T. and Kategile, J.A. (1986). Digestibility and effect of copra cake on rate of gain, feed efficiency and protein retention of fattening pigs. Tropical Animal Health and Production. 18 (4): 243-247.

Longe, O. (1986). Replacement value of biscuit waste for maize in broiler diets. Nigerian Journal of Animal Production. 13:70-78.

Longe, O.G. (1988). Meeting the energy needs of non-ruminants from non-conversional feed resources in Nigeria. In: Proceedings of National workshop on alternative formulation of livestock feeds in Nigeria, ARMTI, Ilorin, November, 21-25, 1988. Pp 192-203.

Machin, D.H. (1992). Overview of needs and justification for use of root tubers. plantain and banana in animal feeding. Proceeding of the F.A.O. Expert consultation held in C.I.A.T. Cali., Colombia. 21-25 Jan. 1991. pp 54-58.

Machebe, N.S., Ezekwe, A.G. and Anaenugwu, M.O. (2010). Physiological response of breeding gilts to varying protein diets. *International Journal of Science. 1(1):* 136-139.

Madubuike, F. N. and Ekeyem B.U. (2006). Haematology and serum biochemistry characteristics of broiler chicks fed varying dietary levels of *Ipomoea asarifolia* leaf meal . International Journal of Poultry Science. 5: 9-12.

Mafuvadze, B. and Erlwanger, K.H. (2007). The effect of EDTA, heparin and storage on the erythrocyte osmotic fragility, plasma osmolarity and haematocrit of adult ostriches (*Struthio camelus).* Veterinarski Arhiv. 77:427-434.

Mahan, D.C., Fastinga, N.D. and Peters, J.C. (2004). Effects of diet complexity and dietary lactose levels during three starter phases on postweaning pig performance . Journal of Animal Science. 82: 2790-2797.

Makinde, M.O., Umapathy, E., Akingbemi, B.T., Mandisodza, K.T. and Skadhauge, E. (1996). Effects of dietary soybean and cowpea on gut morphology and faecal composition in creep and non creep-fed pigs. Journal of Veterinary Medicine. (Ser. A) 43: 75-85.

Maner, J. H., Pond, W. G., Gallo, J. T., Henao, A., Portella, R., and Linares, F. (1971). Performance of rats and swine fed Collumbian Floury-2 or normal maize. Journal of Animal Science. 33:791-796.

Marieb, E.N. (1998) . Human anatomy and physiology. 4th ed. Menlo Park, Calif.: Benjamin/Cummings. pp 1-4.

Markovic. R., Jovanovic,N., Sefer,D. and Sinovec, Z. (2005). Kontaminacija smesa za ishranu svinja i zivine plesnima i mikotoksinima.Zbornic Matice srpske, 109: 89-95.

Masic, Z., Jakic-dimic, D. and Sinovec, Z. (2002). Pregled kvaliteta smesa za ishranu svinja. Veterinarski glasnic, 56(1-2): 41-52.

Mbanasor, U. U., Anene, B. M., Chime, A. B., Nnaji, T. O., Eze, J. I. and Ezekwe, A. G. (2003). Haematology of normal and trypanosome-infected Muturu cattle in southeastern Nigeria. Nigerian Journal of Animal Production. 30(2): 236-241.

McDonald, I. and Low, J. (1994). Livestock rearing in the Tropics. Macmillan Education Limited. Hong Kong. Pp. 102-250.

McDonald, P.M., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. (1992). Animal Nutrition.5th Edn. Addison Wesley Longman group Ltd., Singapore. Pp. 491-498.

McDonald, P.M., Edwards, R.A.,Greenhalgh, J.F.D. and Morgan, C.A.(1988). Animal Nutrition. Singapore Publishers, PTC Ltd., Pp. 444-462.

McDonald, P.M., Edwards, R.A.,Greenhalgh, J.F.D. and Morgan, C.A.(1995). Animal Nutrition. 5th Edn. Addison Wesley Longman, Singapore Pte. Ltd. Livestock Health and Welfare. Pp. 305-510.

McDonald, P.M., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. (2002). Animal Nutrition, 6th Edn. Pearson Education Ltd. Edinburg Gate. Harlow, Essex CM20 2JE, England. Pp. 20-520.

Mckeon, M.P. and O'Doherty, J.V. (2001). A note on the nutritive value of extruded raw and beans for growing and finishing pigs. Irish Journal of Agriculture and Food Research, 39:419-431.

McMeekan (1940). Cited by Pond, W.G and Maner, J.H (1974). Swine production in temperate and tropical environments. By W.H. Freeman and Company. United States of America. Pp.121-128.

Meade, R.J., Vermedahl, L.O., Rust, J.W. and Wase D.F. (1969). Effect of protein content on performance of the young pig. J. Anim. Sci. 28 : 473-477.

Meat and Livestock Commission.(1982). Commercial Product Evaluation, Trial 8. Milton Keynes: Meat and Livestock Commission.

Meeusen, A. (1997). Tretiranje zitarica radi sprecavanja plesni I mikotoksina prilikom skladistenja sirovina.VII Simpozijum technologije stocne hrane-Unapredenje technologije stocne hrane, Tara.Zbornic radova, Vol.1. pp 113-118.

Michael, M. (2007). Microbial evaluation of Spanish potato omeiette and cooked meat samples in University restaurants. Journal of Food Protection. 63(0): 1273-1276.

Morrison, F.B. (1961). Feeds and Feeding. Abridged 9th Edn. The Morrison Publishing Company, Clinton lowa. U.S.A. pp 950-953.

Muys, D. (1984). Pigs Husbandry in the Tropics. (2nd Revised ed.) CTA. Agromisa Wageningen, The Netherlands. Pp. 38-45.

National Research Council. (NRC, 1998). Nutrient Requirements of Swine – Nutrient Requirements of Domestic Animals 10th Revised Edition, National Academy of Science, Washinton, U.S.A. pp. 8-118.

National Research Council. (NRC, 1998). Nutrient requirement of swine, 9th Rev. Ed. National Academy Press., Washington D.C. 3-127.

National Research Council. (NRC, 1988). *Quality Protein Maize*. National Academy Press, Washington D.C. pp. 1-70.

National Research Council. (NRC, 1968). Nutrient Requirements of Swine. National Academy of Sciences. Publ. 1599, Washinton, D. C. pp. 6-121.

Nedeljkovic, J., Sefer, D., Jovanovic, N. and Sefer, Z. (1994). Kontaminacija krmnih smesa za ishranu svinja bakterijama i plesnima. Uzgoj I zastita zdravlja svinja, Zbornik radova simpozijuma, Novi Sad, pp 31-33.

Nestle, B.L. (1975). World animal production and feed supplies. Proceedings of the conference on animal feed of tropical and subtropical origin. Tropical Products Institute-London School of Pharmacy 1-5 April, 1975. pp 59-62.

Ngou, J.N. and Mafeni, J.M. (1983). The value of cotton seed meal in poultry diets. Annual Report , Institute of Animal Research, Manikoon. pp 34-36.

O'Doherty, J.V. and Keady, U. (2000). The effect of extrusion on nutritive value of peas for growing and finishing pigs. Animal Science, 70:265-274.

Okai-Amankwa, O. (1986). A study on the effect of higher levels of discarded biscuits (DB) on the performance of weanling rats. A BSc. Dissertation, Faculty of Agriculture, KNUST. Pp 46-51.

Okai, D.B. (1998). Alternative Feed resources for pigs in Ghana. Degraft Graphics and Publication, Kumasi. Pp. 1-12.

Okai, D.B. (2005). Some important considerations in the environmental management of pigs in Ghana. A paper presented at a farmers forum organised by the Ghana Society of Animal Production (GSAP) at the Hebron Farms, Tamale, Northern Region.

Okai, D.B., Olympio, O.S. and Anim, P.K. (2000). Response of grower-finisher pigs to diets containing varying levels of wheat bran with or without Optizyme- An exogenous enzyme complex. Journal of University of Science and Technology 20(1-3): 55-61.

Okai, D.B. and Aboagye, J. (1990). The effects of mango seed kernel meal (MSKM) on the performance of growing rats. *Biological Wastes*. 34:171-175.

Okai, D.B. and Lamptey E.L. (1983). Wet brewers' spent grains (WBSG) in the diet of finisher pigs, Proc. 14th Gh. Anil. Sci. Assoc. Symp., UST, Kumasi Abstr. P.19.

Okai, D.B. and Opoku-Mensah, D. (1988). The effects palm kernel meal (PKM) on growth performance and carcass characteristics of pigs, Proc. 18-19th Gh. Anim. Sci. Assoc. Symp., UST, Kumasi. Pp. 54-57.

Okai, D.B., Buadu, M.K. and Nunekpeku, C.B. (1991). The performance and carcass characteristics of pigs fed diets containing discarded Biscuits (DB), a bakery by-product. Journal of University of Science and Technology. 11(2): 63-66.

Okai, D.B., Topps, J.H., English, P. and Tuah, A.K. (1994). The growth performance and organ characteristics of rats fed diets containing sheanut cake (SNC) and groundnut skins (GNS). Ghana Journal of Biochem. Biotech. and Mol. Biol.vol 2:37-43.

Okai, D. B., Olympio, O. S. and Anim, P. K. (2000). Reponses of grower-finisher pigs to diets containing varying levels of wheat bran with or without Optizyme an exogenous enzyme complex. Journal of University of Science and Technology, 20 (1/2/3): 54-61.

Okai, D.B., Osei, S.A. and Tuah, A.K. (2001). Growth performance and economic traits of pigs fed diets containing either normal maize or Obaatanpa- A Quality Protein maize. Journal of University of Science and Technology. 21:1-5.

Okai, D.B., Tuah, A.K. and Owusu-Aseidu, A. (2001). Phase feeding of pigs using Obatanpa-A Quality Protein Maize. Journal of *University of Science And Technology*.. 21(1, 2, 3): 5-11.

Okai, D.B., Haag, W.L., Osei S.A., Dzah, B.D. and Nyannor, E.K.D. (2003). Improving animal performance and reducing feed cost through the use of Obatanpa, a Quality Protein Maize (QPM) in Ghana. Sasakawa Global 2000. QPM Workshop, Arusha-Tanzania.

Okai, D.B., and Boateng, M. (2007). Pig Nutrition Research in Ghana- Some Achievements, Prospects and Challenges. Ghanaian Journal of Animal Science. Vol. 2 & 3. No.1 pp. 19-25.

Okai, D.B., and Bonsi, M.L.K. (1989). Pig production. In: Poultry and Pig Production Handbook for Ghanaian Farmers. CITA Press, Kumasi. Pp 52-55.

Okai D. B. and Bonsi M. L. K. (1994). *Pig production*: In: Okai, B. D., Bonsi, M. L. K., Olympio, O. S. and Sam, E. (eds.), Poultry and Pig Production Handbook for the Ghanaian Farmer. Degraft Graphics and Pub., Kumasi, Ghana. pp. 30-66.

Okai, D.B., Akolgo, R.A., Osafo, E.L.K., Bonsi, M.L.K. and Tuah, A.K. (1995). The effects of higher dietary wheat bran levels on the growth performance, feeding economy and carcass characteristics of growing-finishing pigs, Proc. 8th Ann. Gen. Conf. GSAP, Univ. Of Ghana, Legon. Abstr. (in press).

Okeudo, N.J., Eboh, K.V. and Izugboekwe, N.V. (2005). Growth rate, carcass characteristics and organoleptic quality of broilers fed graded levels of palm kernel cake. International Journal of Poultry Science. 4(5): 330-333.

Olabanji, R.O., Ojebiyi, O.O., Tona, G.O. and Olaogun O. (2009). Haematological and serum biochemical response of growing rabbits fed diets containing processed mango (*mangifera indica*) seed kernel meal. Proceedings 14th Annual Conference of Animal Science Association of Nigeria (ASAN). LAUTECH Ogbomoso, Nigeria., pp. 270-273.

Olakojo, S.A., Omueti, O., Ajomale, K. and Ogunbodede, B.A. (2007). Development of Quality Protein Maize: biochemical and agronomic evaluation.

Tropical and subtropical agroecosystems, 7:97-104.

Olayeni, T.D., Farinu,G.O. and Ojebiyi, O.O. (2007). Replacement value of biscuit waste on the performance and egg quality parameters of laying hens. Proc. 32nd Ann., 313-230.

Oliva, F., Alvarado, F., Celler, H. and Maner, H. (1971). Unpublished data.INIAP. Santo Damingo, Ecuador.

Ologhobo, A.D., Apata, D.F, Oyejide, A. and Akinpelu, R.O (1993). A comparison of protein fractions prepared from Lima beans (*Phaseolus lunatus*) in starter diets for broiler chicks. Journal Appl. Anim. Res., 4: 13-30.

Olufemi, B. E., Assiak, I.E., Ayoade, G. O. and Onigemo, M.A. (2003). Studies on the effects of *Amaranthus spinosus* leaf extract on the haematology of growing pigs. African Journal of Biomedical Research, 6: 149-150.

Ostrowska E., Nicholas, K. G., Sam. J. S., Brendan G. T., Rodney, B.J., David, R. E., Mark J. and Frank R. D. (2004). Consumption of brown onions (*Allium cepa var. cavaliar and var. destiny*) moderately modulates blood lipids, haematological and haemostic variables in healthy pigs. British Journal of Nutrition, 91: 211-218.

Otesile, E. B., Fagbemi, B.O. and Adeyemo, O. (1991). The effect of *Trypanosoma brucei* infection on serum biochemical parameters in boars on different planes of dietary energy. Veterinary Parasitology, 40: 207-216.

Panigrahi, S. (1991). Behaviour change in broiler chicks fed on diets containing palm kernel meal. Applied Animal Behaviour Science, 3:273-279.

Payne, W.J.A. (1990). An Introduction to Animal Husbandry in the Tropics (4th ed.). Longman Scientific and Technical. Longman Group Uk Ltd. Longman House, Burnt Mill, Harlow, Essex CM 20 2JE, England. Pp. 650-700.

Payne, W.J.A. (2000). An Introduction to Animal Husbandry in the Tropics (6thed.). Longman Scientific and Technical. Longman Group Uk Ltd. pp 156-210.

Pellitteri, P. and Boush, G.M. (1983). Stored-product insect pests in feed mills in Southern Wisconsin.Wisconsin Academy of Sciences, Arts and Letters. 71(2): 103-111.

Pier, A.C. (1973). An overview of the mycotoxicosis of domestic animals. Journal of Animal Veterinary Medicine Association. 163: 1259-1261.

Pluske,J.R., Hampson, D.J. and Williams, I.H. (1997). Factors influencing the structure and function of the small intestine in the weaned pig: a review. Livestock Production Science. 51: 215-236.

Pond, W.G., Church, D.C. and Pond, K. (1995). Basic Animal Nutrition and Feeding, 4th edition. John Wiley and Son's Inc. Canada. Pp. 331-332.

Pond, W.G. and Maner, J.H. (1974). Swine Production in Temperate and Tropical Environments. W.H. Freeman and Co. San Francisco, USA. pp 162-239.

Pond, W.G., Maner, J.H. and Harris, D. I. (1991). Pork Production Systems and Efficient Use of Swine Feed Resources. Van Nostrand Reinhold publication. New York. pp. 135-137.

Prasad, A. and Vyas, L. (2011). Histo-pathological alteration in the intestinal tissues of Swiss albino mice (*mus musculus*) fed with contaminated bread: An unnoticed serious health hazard. African Journal of Food Science and Technology (ISSN:2141-5455)Vol.2(8)pp.173-178.

Prasanna, B.M., Vasal, S. K., Kassahun, B. and Singh, N.N. (2001). Quality Protein Maize. Current Science. 81(10): 1308-1319.

Radanov-Pelagic, V. (2000). Mikrobiologija hrani za zivotinje.Univerzitet u

Novom Sadu, Poljoprivredni fakultet. Novi Sad. Pp 156-161.

Radanov-Pelagic, V., Juric, V., Kunc, V., Ristic, M. and Knezevic, P. (2003). Kontrola kvaliteta u proizvodnji stocnoj hrani. X Simpozijum Technologije hrane za zivotinje 19-23. Oktobar, Vrnjacka Banja. 279-283.

Radanov-Pelagic, V., Juric, V., Kunc, V., Ristic, M. and Koljajic, V. (1999). Odnos mikroflore I kolicine mikotoksina u stocnoj hrani. Savremena poljoprivreda, Novi sad, 48: (1-2): 281-284.

Ralph, S.R. (1987). Manual of Poultry Production in the Tropics. Anthony Rove Ltd. Chippehem, U.K. pp 38-49.

Ranjhan, S.K. (2001). Animal Nutrition in the Tropics. (5thed.). Vikas Publishing House. PVT Ltd. 576, Masjid Road, Jangpura, New Delhi- 110 014. Pp. 210-450.

Ranjhan, S.K. (1999). Animal Nutrition in the Tropics. (4thed.). Vikas Publishing House.PVT Ltd, New Delhi, India. pp 159 & 167.

Revell, D.K. and Williams, I.H. (1993). A review: physiological control and manipulation of voluntary food intake. In: Manipulating Pig Production (MPP) IV (ed. E.S. Batterbam) APSA, Attwood, Vic., Australia, pp 55-80.

Rispat, G., Slaoui, M., Weber, D., Salemink, P., Berthoux, C. and Shrivastava, R. (1993). Haematological and plasma biochemical values for healthy Yucatan micropigs. Laboratory Animals 27: 368-373.

Robinson, D.W. and Lewis, D. (1964). Protein and energy nutrition of bacon pigs. The effect of varying the protein and energy levels in the diets of finishing pigs. Journal of Agricultural Science. 63:185-190.

Robinson, D.W., Prescott, J.H.D and Lewis, D. (1965). The protein and energy nutrition of the bacon pig. Journal of Agricultural Science. 64: 59-65.

Saladin, K.S. (2004). Anatomy and Physiology-The Unity of Form and Function. 3rd Ed. New York: McGraw-Hill. Pp. 1-21

Say, R. R. (1987). Manual of Poultry Production in the Tropics, CAB International Willington, UK. pp. 45-51.

Scott, T. A., Silversides, F. G., Classen, H. L., Swift, M. L., Bedford, M. R., Hall, J. W. (1998). A broiler chick bioassay for measuring the feeding value of wheat and barley in complete diets. *Poultry Science.* 77: 449-455.

Serres, H. (1992). *Manual of Pig Production in the Tropics*. CAB International, Willington, UK. Pp16-17.

Shi-Zheng, G. and Su-Mei, Z. (2009). Physiology, affecting factors and strategies for control of pig meat intramuscular fat. *Food, Nutrition and Agriculture*. 1: 59-74.
x**Sikka, S.S. (1990).** Comparative utilization of nutrient in poultry and swine. Ph.D. Dissertation submitted to Punjab Agricultural University, Ludhiana. India. pp 2-24.

Sluzbeni, L.F. (1990). Pravilnik o maksimalnim kolicinama stetnih materija I sastojaka u stocnoj hrani, pp 2-27.

Sotolu, A.O. and Byanyiko, S.Y. (2010). Nutritive potentials of *Parkia biglobosa* pulp meal in partial replacement for maize in the diets of African catfish (*Clarias gariepimes*) juvenile. ISSN: 1579 -4377. EJEAFChe, 9(7) 2010 (1196 – 1202) 1197.

Sredenovic, S., Levic, J. and Duragic, O. (2005). Technologija proizvodnje hrane za zivotinje-novi zahtevi trazae nova resenja.XI Medunarodni simpozijum technologija hrane za zivotinje – obezbedenje kvaliteta, Vrnjacka Banja, Zbornik radova, 19-31.

Sterle, J. (2000). *Carcass quality.* Available on the internet from: *htt//animalscience-extension.tamu.edu/ [*Date Retrieved: 13th September, 2011].

Swenson, M.J. (1970). Physiology of Domestic Animals. 8th Ed. Dukes. Vail-Ballou Press Inc., USA, pp. 21-61.

Thomas, O.P., Bossard, E.H., Tamplin, C.B. and Laurans, A. (1981). Maryland practical broiler nutrition studies. pp. 50-53. In Proc. Maryland Nutrition Conference, College Park, MD.

Thorn, C. E. (2006). Normal haematology of the pig. In : Feldman, B. F., Zinkl, J. G. Jain, N. C. (eds.), Chalm's Veterinary Haematology, 5th ed., Blackwell Publishing, Narayana Press, Denmark. Pp. 1085-1095.

Tibiru, A.A. (1980). A study of the performance of starter pigs fed rations containing different levels of a dried bakery waste product (DBWP). A BSc. Dissertation, Faculty of Agriculture, KNUST. pp. 34-46.

Tuah, A.K., Buadu, M.K. and Boa-Amponsem, K. (1974). Effects of three (3) different levels of rice mill feed (Rice Bran) in the finishing diets on the performance and carcass characteristics of pigs fed basal maize diets, Proc. 7th Gh. Anim. Sci. Assoc. Symp., Univ. of Ghana, Legon, pp. 61-72.

Tua, A.K. and Boateng, S.A. (1982). The effects of rice mill feed (Rice Bran) in the finishing diets on the growth performance and carcass quality of pigs fed basal maize diets, *Kumasitech Journal of Agricultural Science*. 1:1-14.

Tuah, A.K., Okai, D.B., Osei, S.A., Atuahene, C.C., Amponsah, K.B., Barnes, A.R., Rhule, S.W.A. and Adomako, D. (2003). Utilisation of cocoa pod husk in animal feeding systems in Ghana. In: *Proceedings of the international Workshop on the Utilization of Cocoa By-products."* Enhancing farmers incomes through the processing of cocoa by-products", Accra, Ghana. Pp. 1-2.

Verbeke, W., van Oeckel, M. C., Warnants, N., Viene, J. and Boucque, C. V. (1999). Consumer perception, facts and possibilities to improve acceptabilities of health and sensory characteristics of pork. Meat Science. 53: 77-99.

Vogt, H. (1966). World's Poultry Science. J. 22: 113: In: **Pond, W.G. and Maner, J.H. (1974).** Swine Production in Temperate and Tropical Environments. W.H. Freeman and Co. San Francisco, USA. pp. 245-301.

Waldroup, P.W., Whelchel, D.L. and Johnson, Z.B. (1982). Variation in nutrient content of samples of dried bakery product. Animal Feed Science. Technology. 419-421.

Warris, P. D., Kestin, S. C. and Robinson, J. M. (1983). A note on the influence of rearing environment on meat quality in pigs. Meat Science. 9:271-279.

Whittemore, C. (1993). The Science and Practice of Pig Production. Longman Group of Publishing, UK. pp. 48-75.

Whittemore, C. (1987). Introduction to Animal Husbandry in the Tropics. Third Edition, Longman group Ltd. Essex, England. pp. 559.

WIKIBOOKS, (2012). Anatomy and Physiology of Animals/Cardiovascular System/Blood.

http://en.wikibooks.org/w/index.php?title=AnatomyandPhysiologyofAnimals/Cardiovascular System/Blood&oldid=2254506" [accessed October 08, 2012].

Williamson, G. and Payne, W.J.A. (1964). An Introduction to Animal Husbandry in the Tropics. Longman, Green and Co. Ltd. 48 Grosvenor Street, London, W.1. pp 290-316.

Yoshida, T. (1976). Interspecific competition among the stored product insects. In Proceedings of the joint U.S.- Japan Seminar on Stored Product Insects. Kanas State University, Manhattan, KN. Pp. 103-112.

APPENDIX: ANALYSIS OF VARIANCE (ANOVA) TABLES FOR PIGS

GROWTH PERFORMANCE

Variate: ADG					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.014083	0.014083	3.92	
SEX.*Units* stratum					
TREATMENT	3	0.004000	0.001333	0.37	0.775
Residual	15	0.053917	0.003594		
Total	19	0.072000			

Variate: ADI					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.09075	0.09075	4.64	
SEX.*Units* stratum					
TREATMENT	3	0.06550	0.02183	1.12	0.373
Residual	15	0.29325	0.01955		
Total	19	0.44950			

Variate: COST_GAIN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00936	0.00936	0.26	
SEX.*Units* stratum					
TREATMENT	3	0.70452	0.23484	6.60	0.005
Residual	15	0.53400	0.03560		
Total	19	1.24788			

Variate: DAYS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	235.20	235.20	8.18	
SEX.*Units* stratum					
TREATMENT	3	58.80	19.60	0.68	0.577
Residual	15	431.20	28.75		
Total	19	725.20			

Variate: FCR					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00533	0.00533	0.09	
SEX.*Units* stratum					
TREATMENT	3	0.09350	0.03117	0.54	0.664
Residual	15	0.87067	0.05804		
Total	19	0.96950			

Variate: FD_COST					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0000000	0.0000000		
SEX.*Units* stratum					
TREATMENT	3	0.0733750	0.0244583		
Residual	15	0.0000000	0.0000000		
Total	19	0.0733750			

Variate: FINAL_WT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.752	0.752	0.39	
SEX.*Units* stratum					
TREATMENT	3	3.850	1.283	0.67	0.585
Residual	15	28.848	1.923		
Total	19	33.450			

Variate: GAIN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	34.133	34.133	14.60	
SEX.*Units* stratum					
TREATMENT	3	3.600	1.200	0.51	0.679
Residual	15	35.067	2.338		
Total	19	72.800			

Variate: INTAKE					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	116.4	116.4	0.72	
SEX.*Units* stratum					
TREATMENT	3	423.1	141.0	0.88	0.475
Residual	15	2410.0	160.7		
Total	19	2949.5			

Variate: INTIAL_WT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	45.019	45.019	15.35	
SEX.*Units* stratum					
TREATMENT	3	0.050	0.017	0.01	0.999
Residual	15	43.981	2.932		
Total	19	89.050			

RELATIVE CARCASS CHARACTERISTICS

Variate: BACKFAT_THICKNESS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.92927	0.23232	2.86	
REP.*Units* stratum					
TREATMENT	3	0.26725	0.08908	1.10	0.388
Residual	12	0.97337	0.08111		
Total	19	2.16989			

Variate: BELLY					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	1.4498	0.3624	1.12	
REP.*Units* stratum					
TREATMENT	3	2.8057	0.9352	2.90	0.079
Residual	12	3.8722	0.3227		
Total	19	8.1277			

Variate: EMPTY_GIT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.7459	0.1865	1.33	
REP.*Units* stratum					
TREATMENT	3	0.0454	0.0151	0.11	0.954
Residual	12	1.6856	0.1405		
Total	19	2.4769			

Variate: EMPTY_STOMACH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.019630	0.004907	0.58	
REP.*Units* stratum					
TREATMENT	3	0.016820	0.005607	0.66	0.591
Residual	12	0.101730	0.008477		
Total	19	0.138180			

Variate: FILLET					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.007370	0.001842	0.33	
REP.*Units* stratum					
TREATMENT	3	0.003280	0.001093	0.20	0.897
Residual	12	0.066670	0.005556		
Total	19	0.077320			

Variate: FILLET					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.007370	0.001842	0.33	
REP.*Units* stratum					
TREATMENT	3	0.003280	0.001093	0.20	0.897
Residual	12	0.066670	0.005556		
Total	19	0.077320			

Variate: FULL_GIT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	11.836	2.959	2.92	
REP.*Units* stratum					
TREATMENT	3	3.894	1.298	1.28	0.325
Residual	12	12.153	1.013		
Total	19	27.882			

Variate: HEAD_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	1.34285	0.33571	4.54	
REP.*Units* stratum					
TREATMENT	3	0.18926	0.06309	0.85	0.491
Residual	12	0.88707	0.07392		
Total	19	2.41918			

Variate: HEART_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.010270	0.002567	2.26	
REP.*Units* stratum					
TREATMENT	3	0.001000	0.000333	0.29	0.830
Residual	12	0.013650	0.001137		
Total	19	0.024920			

Variate: INSIDE_FAT_THICKNESS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	1.26768	0.31692	8.10	
REP.*Units* stratum					
TREATMENT	3	0.03274	0.01091	0.28	0.840
Residual	12	0.46956	0.03913		
Total	19	1.76998			

Variate: KIDNEY_WEIGHT					
Source of variation	d.f.	s.s.	m.s	v.r.	F pr.
REP stratum	4	0.028430	0.007108	2.45	
REP.*Units* stratum					
TREATMENT	3	0.017700	0.005900	2.03	0.163
Residual	12	0.034850	0.002904		
Total	19	0.080980			

Variate: LIVER_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.4614	0.1154	0.62	
REP.*Units* stratum					
TREATMENT	3	0.8780	0.2927	1.58	0.245
Residual	12	2.2170	0.1847		
Total	19	3.5564			

Variate: LOIN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	2.3781	0.5945	2.29	
REP.*Units* stratum					
TREATMENT	3	0.2412	0.0804	0.31	0.818
Residual	12	3.1134	0.2594		
Total	19	5.7327			

Variate: LUNGS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.12905	0.03226	1.55	
REP.*Units* stratum					
TREATMENT	3	0.07788	0.02596	1.25	0.336
Residual	12	0.24967	0.02081		
Total	19	0.45660			

Variate: P_2					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	1.17027	0.29257	4.53	
REP.*Units* stratum					
TREATMENT	3	0.24562	0.08187	1.27	0.330
Residual	12	0.77521	0.06460		
Total	19	2.19109			

Variate: SHOULDER					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	3.21207	0.80302	9.17	
REP.*Units* stratum					
TREATMENT	3	0.36210	0.12070	1.38	0.297
Residual	12	1.05093	0.08758		
Total	19	4.62509			

Variate: THIGH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.3107	0.0777	0.44	
REP.*Units* stratum					
TREATMENT	3	1.4328	0.4776	2.68	0.094
Residual	12	2.1371	0.1781		
Total	19	3.8806			

Variate: THIGH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.3107	0.0777	0.44	
REP.*Units* stratum					
TREATMENT	3	1.4328	0.4776	2.68	0.094
Residual	12	2.1371	0.1781		
Total	19	3.8806			

Variate: TROTTERS_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	0.14593	0.03648	2.00	
REP.*Units* stratum					
TREATMENT	3	0.08822	0.02941	1.61	0.239
Residual	12	0.21911	0.01826		
Total	19	0.45326			

Variate: VISCERA_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	4	8.5855	2.1464	2.26	
REP.*Units* stratum					
TREATMENT	3	2.9349	0.9783	1.03	0.415
Residual	12	11.4123	0.9510		
Total	19	22.9327			

ABSOLUTE CARCASS WEIGHT

Variate: BACKFAT_THICKNESS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	1.1136	1.1136	2.43	
SEX.*Units* stratum					
TREATMENT	3	0.9294	0.3098	0.68	0.580
Residual	15	6.8700	0.4580		
Total	19	8.9131			

Variate: BELLY					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.3521	0.3521	2.54	
SEX.*Units* stratum					
TREATMENT	3	1.2870	0.4290	3.10	0.059
Residual	15	2.0759	0.1384		
Total	19	3.7150			

Variate: CARCASS_LENGTH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	2.8830	2.8830	3.16	
SEX.*Units* stratum					
TREATMENT	3	6.3800	2.1267	2.33	0.116
Residual	15	13.7050	0.9137		
Total	19	22.9680			

Variate: CHILLED_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	14.077	14.077	5.30	
SEX.*Units* stratum					
TREATMENT	3	1.930	0.643	0.24	0.866
Residual	15	39.855	2.657		
Total	19	55.862			

Variate: DRESSED_CARCASS_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	15.052	15.052	5.15	
SEX.*Units* stratum					
TREATMENT	3	1.038	0.346	0.12	0.948
Residual	15	43.848	2.923		
Total	19	59.938			

Variate: DRESSED_CARCASS_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	15.052	15.052	5.15	
SEX.*Units* stratum					
TREATMENT	3	1.038	0.346	0.12	0.948
Residual	15	43.848	2.923		
Total	19	59.938			

Variate: CHILLED_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	14.077	14.077	5.30	
SEX.*Units* stratum					
TREATMENT	3	1.930	0.643	0.24	0.866
Residual	15	39.855	2.657		
Total	19	55.862			

Variate: DRESSED_CARCASS_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	15.052	15.052	5.15	
SEX.*Units* stratum					
TREATMENT	3	1.038	0.346	0.12	0.948
Residual	15	43.848	2.923		
Total	19	59.938			

Variate: EMPTY_G_I_T					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.22533	0.22533	4.43	
SEX.*Units* stratum					
TREATMENT	3	0.03737	0.01246	0.24	0.864
Residual	15	0.76367	0.05091		
Total	19	1.02638			

Variate: EMPTY_STOMACH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.003521	0.003521	1.85	
SEX.*Units* stratum					
TREATMENT	3	0.008500	0.002833	1.49	0.257
Residual	15	0.028479	0.001899		
Total	19	0.040500			

Variate: FILLET					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.000021	0.000021	0.01	
SEX.*Units* stratum					
TREATMENT	3	0.001500	0.000500	0.33	0.806
Residual	15	0.022979	0.001532		
Total	19	0.024500			

Variate: FULL_G_I_T					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	4.7005	4.7005	12.15	
SEX.*Units* stratum					
TREATMENT	3	1.4794	0.4931	1.27	0.319
Residual	15	5.8045	0.3870		
Total	19	11.9844			

Variate: HEAD_WEIGHT					
Source of variation	d.f.	s.s.	m.s .	v.r.	F pr.
SEX stratum	1	0.33075	0.33075	10.08	
SEX.*Units* stratum					
TREATMENT	3	0.10400	0.03467	1.06	0.397
Residual	15	0.49225	0.03282		
Total	19	0.92700			

Variate: HEART_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.050021	0.050021	5.96	
SEX.*Units* stratum					
TREATMENT	3	5.828500	1.942833	231.33	<.001
Residual	15	0.125979	0.008399		
Total	19	6.004500			

Variate: INSIDE_FAT_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.45880	0.45880	29.00	
SEX.*Units* stratum					
TREATMENT	3	0.01604	0.00535	0.34	0.798
Residual	15	0.23728	0.01582		
Total	19	0.71212			

Variate: KIDNEY_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.009187	0.009187	8.72	
SEX.*Units* stratum					
TREATMENT	3	0.007000	0.002333	2.21	0.129
Residual	15	0.015812	0.001054		
Total	19	0.032000			

Variate: LIVER_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00208	0.00208	0.03	
SEX.*Units* stratum					
TREATMENT	3	0.46000	0.15333	2.01	0.155
Residual	15	1.14292	0.07619		
Total	19	1.60500			

Variate: LOIN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.6901	0.6901	5.57	
SEX.*Units* stratum					
TREATMENT	3	0.2284	0.0761	0.61	0.616
Residual	15	1.8589	0.1239		
Total	19	2.7774			

Variate: P_2					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.35208	0.35208	13.76	
SEX.*Units* stratum					
TREATMENT	3	0.04150	0.01383	0.54	0.662
Residual	15	0.38392	0.02559		
Total	19	0.77750			

Variate: RESPIRATORY_TRACT_LUNGS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00675	0.00675	0.26	
SEX.*Units* stratum					
TREATMENT	3	0.02638	0.00879	0.34	0.798
Residual	15	0.38925	0.02595		
Total	19	0.42238			

Variate: SHOULDER					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.80033	0.80033	13.96	
SEX.*Units* stratum					
TREATMENT	3	0.22637	0.07546	1.32	0.306
Residual	15	0.85967	0.05731		
Total	19	1.88637			

Variate: SPLEEN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0030000	0.0030000	11.25	
SEX.*Units* stratum					
TREATMENT	3	0.0010000	0.0003333	1.25	0.327
Residual	15	0.0040000	0.0002667		
Total	19	0.0080000			

Variate: THIGH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.12033	0.12033	1.21	
SEX.*Units* stratum					
TREATMENT	3	0.53238	0.17746	1.78	0.194
Residual	15	1.49367	0.09958		
Total	19	2.14638			

Variate: TROTTERS_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.056333	0.056333	8.56	
SEX.*Units* stratum					
TREATMENT	3	0.037375	0.012458	1.89	0.174
Residual	15	0.098667	0.006578		
Total	19	0.192375			

Variate: VISCERA_WEIGHT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	2.3380	2.3380	5.63	
SEX.*Units* stratum					
TREATMENT	3	1.5495	0.5165	1.24	0.329
Residual	15	6.2300	0.4153		
Total	19	10.1175			

PIGS BLOOD BIOCHEMISTRY

Variate: ALBUMEN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	10.800	10.800	2.28	
SEX.*Units* stratum					
TREATMENT	3	0.550	0.183	0.04	0.989
Residual	15	71.200	4.747		
Total	19	82.550			

Variate: HDL					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.10208	0.10208	6.78	
SEX.*Units* stratum					
TREATMENT	3	0.12200	0.04067	2.70	0.083
Residual	15	0.22592	0.01506		
Total	19	0.45000			

Variate: LDL					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.048000	0.048000	9.47	
SEX.*Units* stratum					
TREATMENT	3	0.044000	0.014667	2.89	0.070
Residual	15	0.076000	0.005067		
Total	19	0.168000			

Variate: TGS					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.09633	0.09633	3.69	
SEX.*Units* stratum					
TREATMENT	3	0.14000	0.04667	1.79	0.193
Residual	15	0.39167	0.02611		
Total	19	0.62800			

Variate: T_CHOL					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.28033	0.28033	4.87	
SEX.*Units* stratum					
TREATMENT	3	0.73800	0.24600	4.27	0.023
Residual	15	0.86367	0.05758		
Total	19	1.88200			

Variate: T_PROTEIN					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	12.68	12.68	0.52	
SEX.*Units* stratum					
TREATMENT	3	8.40	2.80	0.11	0.950
Residual	15	365.73	24.38		
Total	19	386.80			

Variate: HB					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.108	0.108	0.08	
SEX.*Units* stratum					
TREATMENT	3	3.238	1.079	0.81	0.508
Residual	15	19.992	1.333		
Total	19	23.338			

Variate: HCT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	5.72	5.72	0.38	
SEX.*Units* stratum					
TREATMENT	3	37.48	12.49	0.83	0.499
Residual	15	226.21	15.08		
Total	19	269.41			

Variate: MCH					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	3.3333	3.3333	5.00	
SEX.*Units* stratum					
TREATMENT	3	1.3575	0.4525	0.68	0.579
Residual	15	10.0067	0.6671		
Total	19	14.6975			

Variate: MCHC					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	2.5521	2.5521	3.78	
SEX.*Units* stratum					
TREATMENT	3	1.1895	0.3965	0.59	0.632
Residual	15	10.1159	0.6744		
Total	19	13.8575			

Variate: MCV					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	3.234	3.234	0.55	
SEX.*Units* stratum					
TREATMENT	3	6.962	2.321	0.39	0.760
Residual	15	88.654	5.910		
Total	19	98.849			

Variate: PLT					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	31915.	31915.	6.16	
SEX.*Units* stratum					
TREATMENT	3	3896.	1299.	0.25	0.860
Residual	15	77768.	5185.		
Total	19	113579.			

Variate: RBC					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.3741	0.3741	0.58	
SEX.*Units* stratum					
TREATMENT	3	1.1495	0.3832	0.60	0.627
Residual	15	9.6259	0.6417		
Total	19	11.1495			

Variate: WBC					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	1.18	1.18	0.10	
SEX.*Units* stratum					
TREATMENT	3	19.21	6.40	0.56	0.653
Residual	15	173.06	11.54		
Total	19	193.45			