UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

Potential of Groundnut *Arachis hypogaea* vines meal as a feed stuff in rural pig production in the Upper East Region of Ghana.

MARY AWINI

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BY

MARY AWINI (B.SC. AGRICULTURE TECHNOLOGY)

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A THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE (PRODUCTION OPTION)

2017

DECLARATION

STUDENT

I, Mary Awini hereby declare that this work is the outcome of a research carried out on my own. I further declare that this work has not been submitted for any degree elsewhere. All sources of information and assistance received in the preparation of this work have been duly acknowledged by way of references.

Candidate's Signature…………………………… Date……………………

Name: Mary Awini

Supervisor

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Supervisor's signature…………………………… Date……………………

Name: Mr. Benjamin Alenyorege

Co-Supervisor signature…………………………… Date……………………

Name: Prof. Hebert Kwabla Dei

ABSTRACT

In an earlier survey supported by AFRICA RISING Project on rural pig production in Northern Ghana, farmers indicated that cost of feed and feeding was a major problem. This was one of the reasons for leaving pigs to scavenge for food. Consequently, this study was intended to assess the value of groundnut vines for use as a cheap and locally available feedstuff for the preparation of pig diets. Samboligo is one of the geo-tagged AFRICA RISING communities in the Bongo district of the Upper East Region, where groundnut and pig production are important activities among other Africa RISING intervention communities. An on-farm feeding trial was conducted in this community to evaluate the use of groundnut vines as a feed ingredient in the diets of grower pigs. These pigs were fed five different diets of varying levels (0%, 4%, 8% and 12%) of groundnut vines in a Randomized Complete Block Design (RCBD). Pigs were fed twice daily and water provided *ad libitum.* The experiment lasted eight weeks. Parameters measured included feed intake, daily weight gain, feed conversion efficiency and final body weight gain. Economics of gain was also calculated. Proximate composition of the various treatments were conducted in accordance with the AOAC (1999) method. Data were analyzed by ANOVA using GenStat 12th edition. There were no significant (P>0.05) differences among all parameters across all treatments. There were significant differences (P< 0.05) observed in week one average daily weight gain and feed conversion ratio. No significant differences were recorded among all treatments in the rest of the weeks. Economics of gain for the experimental diets at GH₵ 0.25 per Kilogram of groundnut vine indicated that, Farmer diet cost lowest (GH₵ 0.48) whereas T4 was the highest (GH₵ 0.96). Feed intake and weight gain were significantly (P<0.05) affected by protein and fat respectively. Feed conversion efficiency was negatively correlated with protein.

Regression analysis between fat and protein to mean feed intake and weight gain were positive and linear at ($p<0.01$). Groundnut vines contained nutrients that are useful in pig nutrition including carbohydrate and protein. Addition of groundnut vines in the diets did not affect feed intake and weight gain of the pigs negatively and can therefore be included in pig diets up to 12%. Cost of producing a Kg Live weight of pig increased with the inclusion of groundnut vines, because it did not systematically replace any of the more expensive ingredient in the diet.

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DEDICATION

I dedicate this dissertation to my husband Mr. Ramson Adombilla, children Addilyn and Aaron and to the entire family.

LIST OF ACRONYMS

ABP:	Ashanti Black Pigs
ADFI:	Average Daily Feed Intake
ADWG:	Average Daily Weight Gain
AgSSIP:	Agricultural Sector Services Investment Programme
ALBP:	African Locust Bean Fruit Pulp
AOAC:	Association of Official Analytical Chemists
ASF:	African swine fever
DCP:	Dried Cashew Pulp
FAO:	Food and Agriculture Organization
FEU:	Forage Evaluation Unit
GIT:	Gastro - Intestinal Tract
IDF:	Insoluble Dietary Fiber
ME:	Metabolizable Energy
NCFR:	Non-Conventional Feed Resources
NFE:	Nitrogen Free Extract
NGO:	Non-Governmental organization
NLSP:	National Livestock Service Project
NRC:	National Research Council

NSP: Non Starch Polysaccharides

PPM: Parts Per Million

RCBD: Randomized Complete Block Design

SDF: Soluble Dietary Fiber

SED: Standard Error of Difference

TDF: Total Dietary Fiber

TDS: Total Dissolved Solids

TABLE OF CONTENTS

LIST OF TABLES

TABLE **PAGE**

LIST OF FIGURES

FIGURE **PAGE**

LIST OF PLATES

PLATE **PAGE**

CHAPTER ONE

1.0 INTRODUCTION

Pig is one of the oldest domesticated animals and is found throughout the tropical and temperate regions of the universe (Serres, 1992). Pig rearing is a lucrative venture in animal production since pigs are prolific and grow fast (Alenyorege, 1998; Rahjan, 2001).There are numerous potentials in pig production that include income for farmers through the sale of pig products, source of employment to the people involved in its value chain, the provision of quality manure for crop production (Otchere *et al*., 1999) and meat and lard for human consumption (Whittemore, 1987). Pork has digestible fatty acids and good quality protein that helps to nourish the human body and build up worn out tissues thus promoting good growth and development. Recognizing the value of the pig in the livelihood of smallholder producers, Ghana included this species for improvement under the National Livestock Service Project (NLSP). However, pork is disliked in Ghanaian markets because of the unhygienic environments in which pigs are raised (Osei, 2013).

Pig production is not new in Ghana, but the system and practice of production have changed overtime. In the Upper East region, pigs are allowed to roam during the day to find feed for themselves and some amount of agricultural waste and kitchen leftover and water are provided by the producers. Pigs scavenge for feed around the village with occasional supplementation during the dry season when crops are harvested. Several traditional and religious beliefs have deterred off pig production from full scale commercial production, making the industry lag behind its enviable rival, poultry (Osei, 2013). The researcher also observed that, there is a shift from the free range subsistence form of pig production to a confined and commercial system making feeding a serious constraint since most farmers depend solely on "leftovers". In recent years, Ghanaians engaged in commercial pig production experienced low production and productivity due to high feed cost. The cost of feed accounts for between 70 and 80% of the total cost of pig production in Ghana and other developing countries (Okai, 1998). The universities, Research Stations, Ministry of Food and Agriculture (MoFA), and NGOs organized seminars, workshops, agricultural shows and other sensitization campaigns to create awareness and arouse the interest of Ghanaians in pig production (Ayivi,2008). In Ghana pig farming lends itself to commercialization compared to ruminants since the pig has no traditional or religious value, there will be no reason to keep it beyond market weight, if it is not a breeding pig. African RISING project showed interest in the intensification of crop and livestock production in Northern Ghana. The project selected interventions on commodities including pigs.

A preliminary study on the characteristics of rural pig production in northern Ghana identified inadequate feeding as one of the key constraints to pig production hence encouraging the extensive system where pigs are allowed to find feed for themselves. However, crop residues such as groundnut vines, cowpea vines and soya bean thrash are generated in large quantities after harvest in northern Ghana but are not effectively utilized, but rather burnt most times. Analysis of the annual peanut forage indicates very good nutritional value, similar to that of alfalfa and perennial peanut forages (NRC 2000; Myer et al. 2010). Recent research, however, indicates that annual peanut forage may retain less digestible nutrients than perennial peanut through the haying process and subsequent storage (Eckert 2008). Recent experiments evaluated perennial peanut, annual peanut, soybean, cowpea, and pigeon pea hays or haylages fed to lambs. Perennial peanut and annual peanut stored either as hay or haylage were the most promising forage legumes evaluated as they resulted in the greatest improvements of intake, digestibility, and protein retention by the lambs (Foster 2008). Melesse (2013) also reported that, groundnut haulms have good nutritive value and contains about 12.4% crude protein (CP) on dry matter (DM) basis. Further, Reddy (1988) reported nutritional characteristics values of cellulose (22.11-35.55%), carbohydrates (38.06-46.95%), proteins (8.30-15.0%), minerals (1.39-2.88%), crude fiber (22.11-35.35) and moisture (7.13-10.0%) for groundnut haulms though minimal variations can be experienced at different locations due to environmental conditions, varieties, soil type and time of harvest.

At Samboligo, the major problems associated with pig production are feed unavailability/high feed cost, poor housing systems and high disease incidence. The indigenous pigs are well adapted to tropical conditions as they are adapted to the local production systems and the environment (Zanga *et al*., 2003) and have the ability to survive under poor feeding compared to exotic breeds (Drucker and Anderson, 2004), making them better to manage under prevailing conditions; In view of the constraints in feeding pigs, researchers such as Brouns *et al*., (1994); Jin, *et al*., (1994) and Noblet and Le Goff (2001) looked at fibrous materials such as crop residues as alternatives and concluded that, they have positive significant effects on pigs at various growth stages and development. Legume and cereal cultivation are major activities in the Upper East Region and the abundance of their residues in the study area after harvest, has called for the need to investigate their value as cheap feedstuff to minimize feed cost in pig production.

1.1 Research Questions

- Will the inclusion of groundnut vines in the diet of grower pigs positively affect feed intake?
- Will the inclusion of groundnut vines in the diet of grower pigs positively affect their weight gain?
- Will the inclusion of groundnut vines in the diet of grower pigs minimize feed cost?

1.2 Research Objectives

1.2.1 Main Objectives

To determine the significance of groundnut vines as a feed ingredient in rural pig production in northern Ghana.

1.2.2 Specific Objectives

To determine the nutrient composition of groundnut vines

To determine the level of inclusion that:

- Results in high feed intake,
- Results in high average daily weight gain,
- Results in low feed cost

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Pigs in Africa

The domestic pig in Africa had its ancestor from the wild pig, *Sus scrofa* which is native to North Africa extending along the Atlantic coast at least as far as the Rio de Oro (Epstein, 1971). The Maghreb race is sometimes known as *Sus scrofa barbarous* and there was in addition a Saharan race known as *sahariensi* (Epstein, 1971). Recent classifications group these into single race *Sus scrofaalgria* (Groves, 1981). There is no positive evidence for the domestication of pig in Africa although this was argued by some writers in the early part of this century and that *Sus scrofa* gave rise to all domesticated pigs which continues to thrive in the wild (Epstein, 1971). Serres (1992) also noted that the domestic pig, *Sus scrofa domesticus*, was derived from the wild boars of Europe (*Sus scrofa)* and Asia (*Sus vittatus)*. Zoologically, it is a member of the order *ungulata* through the sub-order *Artiodactyla* and the family *Suidae* (Serres, 1992).

2.2 Breeds of Pigs in Africa

Conventionally, pigs in sub-saharan Africa are divided into “indigenous” and the exotic breeds (Devendra and Fuller, 1979). According to these researchers, the indigenous types are usually black or pied with medium, semi-erect, swept- black ears, a straight tail and a long snout. These are now found in the remote areas, especially in hilly regions where there has been less opportunity to mate with incoming exotics. Authors such as Mason (1988) grouped the West African (indigenous) pigs such as Ashanti black (Ghana) and the Bakosi (Cameroon) into the “West African”, and Iberian type. The exotic pigs of Africa that arrived in the colonial period came originally from Europe, America and the Far East (Mason, 1988). Almost all modern piggeries use exclusively exotic breeds especially Large White, Landrace, Duroc and Hampshire (RIM, 1992).

According to Nigeria Agricultural Extension and Research Liaison Services extension bulletin, there are over 90 recognized breeds and an estimated 230 varieties of pigs in the world. These can be grouped into indigenous and modem exotic types which through selection and breeding, have been developed for commercial production.

2.2.1 Indigenous Breed

The indigenous pigs (plate 2.1) are usually of modest size with adults reaching 100 kg maximum but rarely weigh more than 60 kg at one year of age even under the best rearing conditions. In general the indigenous breeds have smaller and shorter legs than the exotic types with the typical unimproved conformation of a large head, well developed forequarters and relatively light hind quarters. These render them more mobile and better able to forage and root for themselves.

They are sexually early maturing and females may show first oestrus as early as three months of age. The skin is often black, brown or occasionally spotted but rarely white. Generally, they are adapted to traditional rearing systems in which the food consists of diverse vegetable waste products. Indigenous sows show excellent mothering ability, which results in very low piglet mortality without sophisticated housing. (Nigeria Agricultural Extension and Research Liaison Services extension bulletin)

Plate 2.1: Indigenous Breed of Pig

Source; Alenyorege et al., 2015

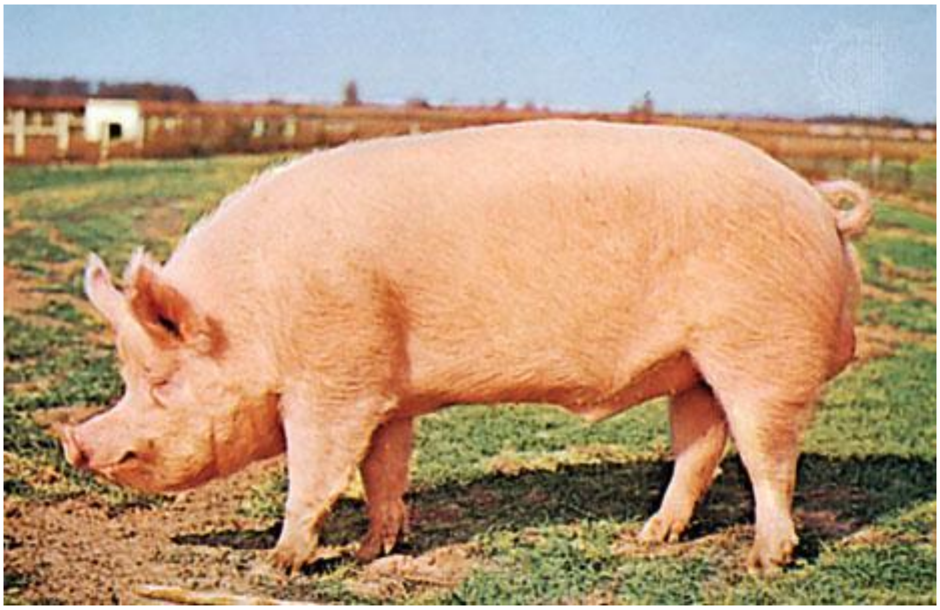
2.2.2 Exotic Breed

Exotic breeds were first brought in from Europe and constitute the commercial herds being reared under semi-intensive and intensive management systems. The following exotic breeds have been tried and are of significance in Africa.

2.2.2.1 Large White (Yorkshire)

It is a very popular breed throughout the world. It is fast growing, strong-framed with good body length. It is renowned for its strength of legs. The females are prolific, good mothers and adapt well to confinement conditions. The breed is widely distributed in Africa and is used extensively for cross- breeding. For instance, the Large White X Landrace female is the most popular cross for commercial production. The white hair and skin render the carcass more acceptable to consumers than that from the coloured breed. However, shade and wallows are essential for the breed to prevent sun burns of skin (plate 2.2).

Plate 2.2: Large White Breed

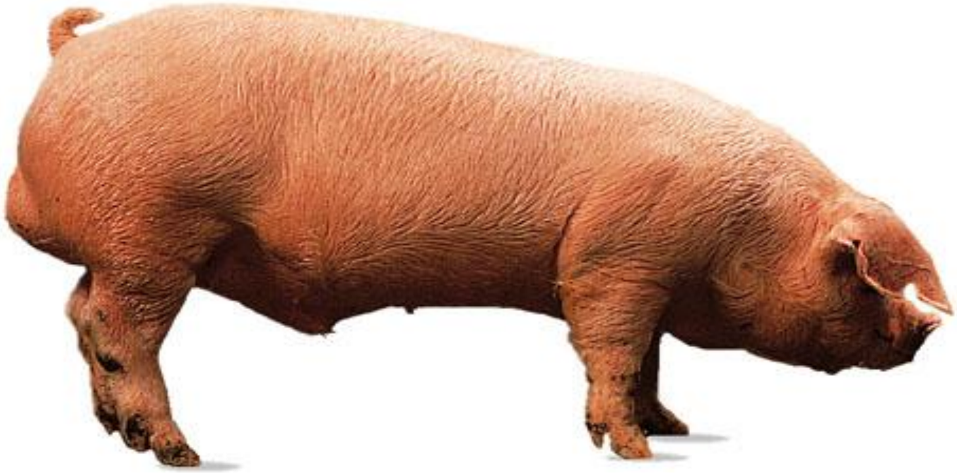


Source; the Pig Site

2.2.2.2 Danish Landrace

The breed is easily known by its forward pointing loop ears. It is characterized by a long, smooth body with light shoulders and well developed hams (plate.2.3). The breed is prolific with excellent mothering ability and produces lean, fast-growing progeny. The landrace has a higher level of susceptibility to stress than some other breeds. It is highly favored for cross breeding purposes.

Plate 2.3 Danish Landrace Breed



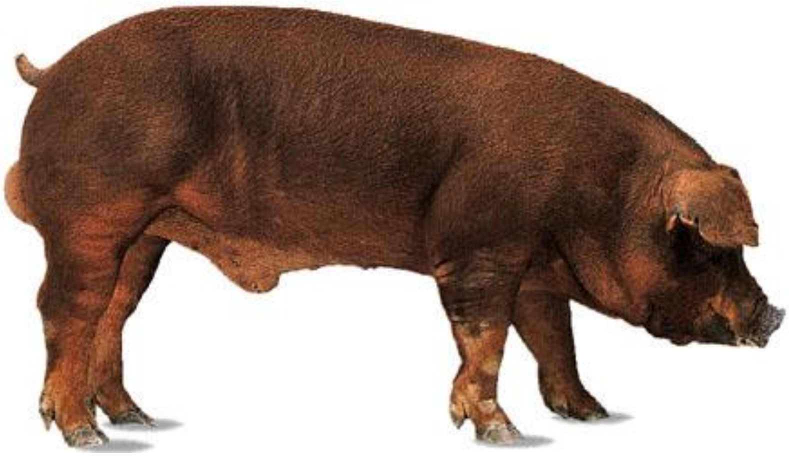
Source; the Pig Site

2.2.2.3 Duroc

Identification of this breed is by its deep red or rusty colour. The Duroc is a fast-growing large breed which has been selected specifically for overall muscle and meat production. It has the ability to grow into heavier weights without depositing too much fat. Litter-size and mothering ability are only average in the females (plate.2.4).

The breed is well known for its hardiness and resistance to stress with lower levels of mortality. This is an important quality in the choice of breeding stock. In commercial pig production, it is frequently used as sire on white-breed females.

Plate.2.4 Duroc Breed



Source; Little Pig Farm

2.2.2.4 Hampshire

This is a medium sized black pig with distinct white saddle which encircles the fore-quarter. The sows are prolific, good mothers and possess above average milking ability. They thrive better on extensive conditions than white breeds (plate.2.5).The breed is meaty with well-developed muscles which show efficiency of food conversion and is also popular in cross- breeding programmes.

Plate 2.5 Hampshire Breed

Source; Little Pig Farm

2.2.2.5 Berkshire

The breed is easily identified by its black coat and characteristic white feet and nose. It is a smaller, early-maturing pig which was first developed in England for the pork trade. In the tropics, it has proved very hardy and cross well with the indigenous stock. However, the Berkshire breed is on the decline on a worldwide basis which may be due to its relatively fatty carcass.

Plate 2.6 Berkshire Breed

Source; Little Pig Farm

2.3 Pig Production in Ghana

The production of all major livestock types used for human consumption in Ghana increased over the past 11-year period from 1995 to 2006, except pigs whose population declined steadily due to the outbreak of ASF disease in early 1995 as shown in Table 2.1. Most of the pigs were destroyed and many of the producers lost their parent stocks as a result. The worse decline was in 2005 with a total national population of 290, 000 as against 365,000 in 1995 due to a second outbreak of ASF. The population however started increasing in 2006 (VSD, 2007). The sharp increase in the pig population (64.5% increase) may be attributed to re-stocking of affected farms through the assistance of FAO.

Due to low productivity of indigenous pigs, most producers preferred the exotic breeds even though ABP are dominant over the exotic breeds (Livingstone and Fowler, 1984).

Table 2.1 Livestock population of Ghana ('000): 1995 – 2006

Year	Poultry	Sheep	Goat	Cattle	Pigs
1995	13,083	2,070	2,156	1,123	365
1996	14,580	2.149	2,233	1,248	355
1997	15,888	2,496	2,659	1,260	347
1998	17,302	2,576	2,792	1,288	332
1999	18,810	2,658	2,931	1,288	332
2000	20,472	2,743	3,077	1,302	324
2001	22,032	2,771	3,199	1,315	312
2002	24,251	2,922	3,230	1,330	310
2003	26,395	3,015	3,560	1,344	303
2004	28,727	3,211	3,925	1,359	297
2005	28,386	3,211	3,923	1,373	290
2006	34,030	3,314	3,997	1,392	277

Source; Veterinary Services Directorate, (2007) MoFA, Accra

Pig production is one of the fastest ways of meat production as they have a short gestation period and large litter size. According to English *et al.*, (1996) and Whittemore (1980) half of all the meat eaten in the world is from pigs. Pigs are omnivores and would consume a wide range of feedstuffs. Pigs are kept primarily for pork production. In addition to pork, pigs supply pigskin for soft leather, bristles for brushes, lard (fat) for cooking, hormones for medicinal purposes and manure for soils and fish ponds (Youdeowei *et al.*, 1986). According to Eusebio (1980), with good husbandry and management, adequate feeding and health care, pigs can produce four or five times more meat than cattle per tonne of live weight. Pork and poultry meat, according to FAO (2001) represented 63% of all meat consumed globally in 1993. This shows how extensively the pig is used as a source of food. According to Holness *et al.* (2005), pig meat consumption in the developing world has shown a steady increase at the expense of beef during the past decade, in part due to the lower fat content and healthier image of pig meat. Okai, (1998) observed that Ghana is not only a net importer of animals, meat and meat products, but imports as much as 70% of its animal protein requirements. In Ghana, among the livestock, pigs are the ones that hold the immediate to short term solution to animal protein deficiency (Annor-Frempong and Segbor, 1994) since they are able to efficiently convert feed (agro-industrial by-products) into edible meat (Annor-Frempong and Segbor, 1994; Barnes, 1994; Morrison, 1961). Their requirements for feed and other digestible nutrients are much less than those required by other farm animals. However, the efficiency of utilization of feed for pork production depends on the provision of a well-balanced diet good husbandry conditions and genetic selection conducive to high efficiency (Pond and Maner, 1974). Pigs have fast growth rate and reach sexual maturity within 5-6 months. On the account of the pig's high fecundity and growth rate, pig production can yield a relatively rapid rate of return on the capital employed (Payne, 1990). The ability of pigs to mature and multiply faster than cattle and sheep confers material advantage in terms of opportunity for rapid genetic change. The inherent prolificacy and early sexual maturity of the sow means that, pig numbers can be expanded very rapidly. This has always been an economically attractive feature for keeping pigs and is one of the reasons why the pig, and the fowl, have been the peasant or small-holder's traditional animal (Taverner and Dunkin, 1996). According to Holness *et al*. (2005) the following are advantages of pig production to the resource- poor farmer in the developing world, such as Ghana, compared to other forms of livestock production:

(i) Pigs could be confined and reared in relatively small area. As a consequence, they are not subject to the same problems which confront cattle, sheep and goat production in many regions where communal land tenure is common.

(ii) For some reason that they require a small area, pig production is particularly appropriate in densely populated areas.

(iii) If pigs are kept in pens, they do not contribute to erosion and land degradation, a trend which continues to expand in developing world associated with grazing lands.

(iv) Pigs would convert a variety of crop waste, kitchen waste and agro-industrial by-products into high quality meat.

(v) Pigs are very efficient converters of concentrate feeds to meat when compared to ruminants. However on low-quality high fiber diets they are less efficient than the ruminants.

(vi) Pigs give a relatively rapid return on investment even on low planes of nutrition; a pig is ready for slaughter at twelve months of age.

(vii) Pigs are often considered as 'living banks' which could be disposed off in times of particular financial need, for example for the payment of medical bills or school fees.

(viii) Pigs have a higher dressing percentage than any other livestock species; that is the carcass forms a higher proportion of the body at slaughter.

(ix) The size of pigs compared to cattle makes slaughter and marketing more flexible and easier process.

(ix) Pigs produce relatively rich manure which becomes a very important resource to the crop farmer when the price of inorganic fertilizer is high.

2.4 Pig Production Systems in Ghana

There are varied pig production systems in Ghana. They range from extensive (traditional) to intensive (commercial) production systems. In between these systems could be found subsistence or semi-intensive production system where the pigs may be kept for varied reasons without much effort to improve upon the system.

2.4.1 The Extensive or Traditional Production System

This system is mainly found in the rural village production unit (Devendra and Fuller, 1979). The output of such system is low as the animals are left to roam in the village for left over household wastes. Supplementation is provided occasionally with locally available agro-industrial by-products such as pito mash, maize bran, palm kernel cake etc. (Ahunu *et al.*, 1995). The Ashanti Black Pig (ABP) constitutes 70-90% of the breed used in the indigenous system with some minimal housing or shelter provided

(Ahunu *et al.*, 1995). During the cropping season, the animals are confined as a way to prevent them from destroying crops sown. In some villages, this is the only time that these animals are under confinement. Most of the time, they are allowed to scavenge for feed around the village. The important role the pig plays in the social life of the village, is exchange of meat as well as in the provision of high-quality protein in the diet, should not be underestimated (Holness *et al*., 2005). The growth rate of pigs under this production system is slow as a lot of energy is expended in scavenging activities in addition to high worm infestation. Improvement in this traditional system of production could be achieved through enclosure of pigs in pens or yards. By so doing, piglet mortalities will reduce, energy loss through scavenging will reduce, and the health status of the animals will improve by ensuring routine programme of vaccinations and parasite control. Separation of pigs into groups according to their final purpose could also be achieved through such confinement. Protection from predators, theft and the harsh weather are other benefits from confining the pigs. A controlled breeding programme could be implemented. Sow oestrus could be monitored and mating can be done at set times in order to optimize the number of litters per sow per year (Holness *et al*., 2005). Most traditional systems of pig keeping are characterized by a small number of pigs per holding, therefore, facilitating their integration with other farming enterprises including cropping.

2.4.2 The Commercial Pig Production

In Ghana is mostly carried out in the peri-urban areas where pigs are kept under total confinement throughout the year. The exotic breeds mostly Large White and Landrace and their crosses are mostly used, especially, in the southern sector of the country (Barnes, 1994). Producers under this system are business minded and, for that matter invest a lot of inputs in the enterprise for rapid maximization of returns. The animals are housed permanently in specially designed structures all year round and fed on well-balanced diets (Ahunu *et al.*, 1995). The motive of such producers is the production of lean meat to satisfy the consumer demand. (Livingstone and Fowler, 1984). Pigs raised by institutions of higher learning and other government and quasi-government organizations do much better because the welfare of the animals is uppermost in their management practices (Barnes, 1994).

2.4.3 Semi-Intensive System

This is a production system where pigs are confined in limited space. Some amount of fodder (agricultural waste and kitchen refuse) and water are provided by the producers at certain times of the day. This system of pig keeping opens up possibilities for improved feed and disease control, which in turn can result in faster growing and healthier pigs and/or in larger litters (Dick and Geert, 2004). As the animals are confined, it prevents the destruction of crops and from being stolen. It serves as a saving account or insurance policy for the owners.

The interest in pig production in Ghana was whipped up after the 1987 Pork Show organized by MoFA with the expectation that production of pork and pork products would rise to high levels. But this has not been the case as the industry is confronted with a number of factors which were identified by Barnes (1994) as housing, feeding and marketing as well as African Swine Fever (ASF) disease. These constraints are found in all the production systems in the country; and if not addressed, the pig production will sometime reach total collapse. In spite of these constraints, production is being carried out throughout the country with some value addition to the pork. Fresh pork is being processed into bacon, ham and sausages which are in high demand by consumers. According to Teye *et al.* (1996), factors such as the age, sex, health and conformation of the animal selected for fattening, system and level of feeding, management and handling practices are some of the most important on-farm and pre-slaughter determinants of meat quality for processing. Payne (1990) mentioned also that factors of major importance for commercial meat production are the age and weight at which an animal produces a carcass of desired conformation, the required degree of fatness and the efficiency of food utilization necessary to obtain these objectives. The dressing percentage of the ABP (70.2%) was found to be higher than that of the Large White (69.4%) in a study conducted by Manyo-Plange and Barnes (1996). The efficiency with which feed is converted into pig meat is governed by the genetic quality of the stock, their environment, stage of growth, feeding method and level of feeding (MAFF, 1977). The efficient feed conversion and ability to utilize a wide range of feed materials are valuable attributes, the pig's outstanding feature is its phenomenal rate of meat production, especially when expressed in terms of output per breeding female. It is resultant of three factors; the ability of the sow to produce large numbers of progeny at frequent intervals, early sexual maturity and (with appropriate nutrition and housing) a rapid growth rate. In combination, these traits translate into much higher annual meat output per breeding female than those of sheep, beef cattle and broiler chicken (Taverner and Dunkin, 1996).

2.5 Breed Description of Ashanti Black Pig (ABP)

The indigenous ABP is described by Devendra and Fuller (1979) and Barnes and Fleischer (1998) as being generally black with a small short body, a relatively long and narrow head with a prolonged snout. The abdomen of a heavily gravid sow almost touches the ground. The ABP is also known to be hardy, tolerant to most common diseases, stresses and survive under poor management and extremes of environmental conditions (Fetuga *et al.*, 1976; Ahunu *et al.*, 1995; Darko and Buadu, 1998). Local breeds of pigs, such as the ABP have a great propensity to put on fat tissues (Serres, 1992). The breed, considering its dominance and adaptation and survival under harsh local environmental conditions, should have been the preferred breed in the development of the pig industry in most developing countries. But this is not the case because of its poor growth and low reproductive performance. According to Baffour-Awuah *et al.* (2005), the ABP may function well in cross breeding programmes with the exotic breeds like Large White and Landrace by exploiting the complimentarity of the hardiness of the local breed and the fast growth and better reproductive performance of the exotic breeds. Holness *et al.* (2005) also described the indigenous pigs as better-adapted to 'harsher' environments and poor management systems. They are more mobile and better equipped to scavenge and root. They are considerably less susceptible to heat stress and more resistant to most local diseases and parasites. These characteristics contribute to hardiness and survivability when crossed with an exotic breed. Indigenous breeds are earlier-maturing than their exotic breeds, and hence would start depositing fat in the carcasses at an earlier age than their exotic counterparts.

2.6 Nutrition of Pigs

A nutrient is an element or compound or a substance which is found in food or feed that aids in the support of life (Gillespie, 1992). Animals and for that matter pigs, require nutrients for the following reasons:

a**.** Replacement of worn out tissue in mature animals and building of new tissue in young and pregnant animals.

b. Maintenance of essential body processes such as respiration, circulation and manufacture of internal secretion(s).

c. Enhancement of productive activities such as milk yield.

d. In the absence of feed, the nutrients required to support maintenance activities must come from breakdown of body tissues itself and this is revealed by a loss in weight in the affected animal. Nutrients are therefore needed by animals for maintenance, growth and reproduction (Gillespie, 1992; Koney, 2004). Nutrients become part of the cells of the body and are vital for cells to live, grow and function properly. Animals require different types of nutrients in their right quantities and proportions. In pig nutrition, the nutrients are grouped into six, namely, carbohydrates, fats and oils, proteins, vitamins, minerals and water (Gillespie, 1993).

2.6.1 Water

Pigs should have free and convenient access to water, before weaning. The amount required varies with age, type of feed, environmental temperature, status of lactation, fever, high urinary output (as from high salt or protein intake), or diarrhea. Normally, growing pigs consume 2–3 kg of water for every kg of dry feed. Lactating sows consume more water because of the high water content of the milk that they produce. Water restriction reduces performance and milk production and may result in death if the restriction is severe. Water quality is important. Water should be relatively free of microbial contamination; if not, chlorination may be necessary. Excessive minerals in water may create problems. Water should have <1,000 ppm of total dissolved solids (TDS). Higher levels of TDS (2,000–3,000 ppm) can cause diarrhea or temporary water refusal, and TDS levels >5,000 ppm should be avoided. Pigs tolerate moderate levels of sulfates in water, but high levels (>3,000 ppm) of sulfates should be avoided.

Next to air, water is the most essential nutrient for life. It should be supplied clean and daily. Most feeds and feeding stuffs especially green leaves, contain appreciable quantities of water. Sixty-five percent of the pigs' body is water. Water is of particular importance to pig production in the tropics as the pig requires water to enable it maintain body temperature. Lack of water quickly leads to a rise in body temperature and death. Also sub- optimal amount of water will have a major effect on food intake and pig performance. Water is one of the most important components of a feeding program for swine. Vital to all body functions, water accounts for as much as 80% of body weight in pigs at birth and declines to about 50% in market pig and lactating sows which must have unlimited access to water if they are to produce milk adequately (Duane *et al*., 2000).

Table 2.2 Water Consumption by Pigs

Class	Water consumption (litres/pig/day)
Gestating sow	9.00 to 13.50
Lactating sow	18.00 to 22.50
Starting pig (5.9 to 20.4 kg)	2.25 to 4.50
Growing pig (20.4 to 59.0 kg)	4.50
Finishing pig (59.0 to 113.4 kg)	6.75 to 9.00

Source: Duane et al. (2000).

2.6.2 Energy

Can be defined as the capacity to do work, it provides the driving force for all the biochemical reactions that go on in the body. The energy requirement of the pig is usually given in terms of Digestible Energy or Metabolisable Energy. Energy is measured in Kilo calories (Kcal) or Mega joule (Mj). The bulk of energy in pig rations is supplied by carbohydrates which are the major components of cereal grains such as maize, guinea corn, millet and root crops such as yams, cassava and potato. Fats contain higher levels of energy than carbohydrates. Fats commonly used in pig rations include palm oil, groundnut oil, soya bean oil and tallow. Cereals (maize, sorghum and wheat) are a major source of carbohydrate high in digestible carbohydrate and are regarded as major energy sources for animal feed with 800-900g/kg DM, 80-120g/kg CP, 3-5g/kg phosphorus, and a good source of vitamin E (Bell and Weaver, 2002). Maize contains about 730g/kg DM starch, 90-140g/kg CP, 220-572g/kg NDF, low CF and high ME (McDonald *et al*., 2002).

2.6.3 Fats and Oils

Fats and oils are described as a non-carbohydrate energy source containing about 2.25 times more calories than carbohydrates (McDonald *et al*., 2002; Duane *et al*., 2000).

The energy content of feedstuffs and energy requirements of pigs are commonly expressed as metabolizable energy (ME) (Duane *et al*., 2000). Animal fat and soybean oil are the most common fat sources used in pig diets which will improve pig performance more when provided in the dry season than in the rainy season (wet season) (Duane *et al*., 2000). According to Duane *et al*. (2000), less heat is produced by pigs as they ingest and digest fat compared with starch or fiber. This allows pigs fed diets with added fat to consume large amounts of energy during hot weather when feed intake is normally reduced. Although fats are used primarily as energy sources, it has been known that the pig has a requirement for one essential fatty acid; linolenic acid. However, the requirement is so small that it can be met in normal rations formulated to meet required energy standards are generally more expensive.

2.6.4 Proteins

These feeds are high in amino acids and can be classified into plant (soya bean meal, leaf meal and legume seed meals (e.g *mucuna*) and animal sources (fishmeal, blood meal and meat scraps) which promote growth and high production (Koney, 1993; Ayivor and Hellins, 1986). According to Duane and Gretchen (2006), pigs of all ages and stages of their life cycle require amino acids to enable them to grow and reproduce. Amino acids are the structural units of protein. During digestion, proteins are broken down into amino acids and peptides. The amino acids and peptides are absorbed into the body and are used to build new proteins, such as muscle. Diets that are "balanced" with respect to amino acids contain a desirable level and ratio of the 10 essential amino acids required by pigs for maintenance, growth, reproduction and lactation. Those 10 essential amino acids for pigs are arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.

2.6.5 Minerals

Duane and Gretchen (2006) stated that minerals serve many important functions in pig nutrition. These range from structural functions in bone to a wide variety of chemical reactions essential for maintenance, growth, reproduction and lactation. Pigs require at least 13 minerals of which calcium, chloride, copper, iodine, iron, manganese, phosphorus, selenium, sodium and zinc should routinely be added to the diet. Some minerals are found in relatively large amounts while others are found in minute or trace quantities.

Ten mineral elements are regularly added to pig diets because the natural ingredients commonly used in swine diets (cereal grain, soybean meal, etc.) are deficient or the minerals are not available to the pig. These minerals can be divided into two groups, macro- and micro or trace-minerals, based on the amounts added to the diet Duane and Gretchen (2006). The requirements for, and dietary concentrations of the macro-minerals are generally expressed as a percentage of the diet, whereas the micro or trace minerals are expressed as parts per million (ppm or mg/kg) or milligrams (mg) of diet (Duane and Gretchen, 2006).

2.6.6 Vitamins

Vitamins are another class of nutrients required in very small amounts for normal metabolic functions, maintenance, growth, reproduction and lactation in the body (Duane and Gretchen, 2006). Vitamins are generally required as co-factors in metabolic reactions. Good decisions must be made concerning the mineral and vitamin nutrition of pigs when formulating diets, because feeding excess can be costly and dangerous while not providing enough of these required nutrients can result in a deficiency and reduced productivity (Duane and Gretchen, 2006). Eleven vitamins are regularly added to pig diets because the natural ingredients commonly used in pig diets (cereal grain, soybean meal, etc.) are deficient. These vitamins can be divided into two groups, fat soluble (vitamins A, D, E and K) and water soluble (riboflavin, niacin, pantothenic acid, choline, biotin, vitamin B12, and folic acid) Duane and Gretchen (2006).

2.7 Fish Meal (FM)

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). Fish meal is the most important fish product used in pig feeding (Pond and Maner, 1974). It is the main source of protein of fish origin with crude protein (CP) content of about 60% (Okai and Bonsi, 1989) According to Ousterhout (1968) as cited by Pond and Maner (1974) fish meals are basically of two types: those made from whole fish and those made from waste from human food fishery.

Payne (1990) reported that, many tropical countries have two types of fish meals on the market; sun-dried and artificial dried. Sun-dried meal usually has lower protein and higher oil contents and may be dangerously contaminated with bacteria. According to Serres (1992), 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. Locally produced fish meal can be obtained. Some are very valuable with CP levels reaching 60%.

2.8 Feed and Feeding

Feed accounts for 55-85% of the cost of commercial pig production depending on the level of intensification of the production system. Feed is therefore the major operational cost item in a pig enterprise. Pigs require feed to meet biological needs for maintenance, growth and reproduction. The feed supplies nutrients which are extracted through the digestive system of the pig and converted into the metabolites (products) that are used to meet these biological needs.

In order to reduce feed cost and reduce scarcity of feed there is the need to look for alternative and available feed resources that will serve this purpose. The non-conventional feeds could partly fill this gap.

2.9 Non-Conventional Feed Resources (NCFR):

According to Umesh *et al., (*2014) non-conventional feed resources (NCFR) refer to all those feeds that have not been traditionally used in animal feeding and or are not normally used in commercially produced rations for livestock. NCFR include commonly, a variety of feeds from perennial crops and feeds of animal and industrial origin.

The term NCFR has been frequently used to describe such new sources of feedstuffs as palet oil, mill effluent and palm press fiber (oil palm by-products), single cell proteins, and feed material derived from agro industrial by-products of plant and animal origin.

Poor-quality cellulosic roughages from farm residues such as stubbles, haulms, vines and from other agro-industrial by-products such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption also come under the category of NCFR.

2.9.1 Need for Non-Conventional Feed Resources

There are shortages in animal feeds of the conventional type. Grains are barely enough for human consumption especially in developing countries. With increasing demand for livestock products as a result of rapid growth in the world economies and increasing population while the land area is "shrinking", future hopes of feeding animals and safeguarding their food security will depend on better utilization of non-conventional feed resources which humans do not compete for. The availability of feed resources and their rational utilization for livestock possibly is the most compelling task facing planners, livestock producers and scientists in the world. The situation is acute in numerous developing countries where chronic annual feed deficits and increasing animal populations are common, thus making the problem a continuing saga.

Thus non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self-sufficiency in nutrients from locally available feed sources. It is therefore imperative to search for cheaper non-conventional feed resources that can improve intake and digestibility of low quality forages. Feedstuffs such as fish offal, duckweed and kitchen leftovers such as, potato peel, carrot peel, yam and cassava peels, plantain peels, and cabbage leftover, other non-conventional resources include: poultry litter, algae/Spirulina, Leucaena leaf, local brewery and distillery by-products, sisal waste, cactus, coffee parchment and coffee pulp are commonly used, and could be useful feed resources for small and medium size livestock holdings. Umesh *et al*., 2014

2.9.2 Advantages of NCFR: Umesh *et al.*, (2014) outlined the following advantages of NCFR;

a) These are end products of production and consumption that have not been used.

b) They are mainly organic and can be in a solid, slurry or liquid form. Their economic value is often very low.

c) Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are useful in providing energy.

d) The feed crops which generate valuable NCFR are excellent sources of fermentable carbohydrates e.g Cassava and sweet potato and this is an advantage to ruminants because of their ability to utilize inorganic nitrogen.

e) Concerning the feeds of crop origin, the majority are bulky poor-quality cellulotic roughages with a high crude fibre and low nitrogen content, suitable for feeding to ruminants.

f) They have considerable potential as feed materials and their value can be increased if they are converted into some usable products.

Table 2.3 Major by-product Feeds from various Sources

	Crop	**Scientific name**	**By-product feed**
Tree crops	Cocoa	*Theobroma cocoa*	Cocoa bean waste Cocoa pod husk
	Coconuts	*Cocos nucifera L*	Coconut meal
	Oil Palm	*Elaeis uineensis*	Oil palm sludge (dry) Palm press fibre Palm kernel meal
	Rubber	*Hevea brasiliensis*	Rubber seed meal
	Sago	*Metroxylon _ selo*	Sago refuse
Field crops	Castro	*Ricinus communis L.*	Castro meal
	Cotton	*Grossypium spp*	Cotton seed meal
	Maize	*Zea mays*	Maize bran Maize germ meal
	Rice	*Oryza sativa*	Broken rice Rice bran Rice husk Rice straw
	Sugar cane	*Saccharum officinarum*	Bagasse Green tops Molasses
	Cassava	*Manihot esculenta Crantz*	Tapioca waste
	Wheat	*Triticum aestivum L.*	Wheat bran Wheat straw

Source; Umesh et al., (2014)

Table 2.4 Minor by-product Feeds from various Sources

	Crop/Animal	Scientific name	By-product feed
Plants	Cassava	*Manihot esculenta*	Cassava leaves
	Dbupa	*Veteria indica*	Dhupa meal
	Groundnut	*Arachis hypogaea*	Groundnut vines Groundnut meal
	Guar	*Cyampsis psonaloides DC*	Guar meal
	Kakan	*Salvadoza oleoides*	Kakan meal
	Karaj	*Pohogomia pinnata*	Karaj meal
	Kakum	*Garcinia indica chois*	Kakum meal
	Kasum	*Schleichara oleosa*	Kusum meal
	Mahura	*Madhuka indica*	Mahua meal
	Mango	*Mangifera indica*	Mango kernel
	Nahor	*Mesua ferrca linnn*	Nahor meal
	Neem	*Azadirachta indica*	Neem meal
	Oak	*Obercus dilatata*	Oak meal
	Pineapple	*Annanas comosus*	Pineapple waste
	Pisa	*Actinedaphne hooberi*	Pisa meal
	Sal	*Shorea robusta Gaerth*	Sal seed meal
	Sesame	*Sesammum indicum L.*	Sesame cake
	Soyabean	*Glycine soya*	Soya bean
	Sweet potatoes	*Ipomoea batatas*	Sweet potato vine
	Tamarind	*Tamarindus indica*	Tamarind seed hull Tamarind seed kernels
Animals	Poultry		Poultry litter (dry)
	Ruminant		Blood meal, Meat and bone meal (dry), Rumen content (wet)

Source; Umesh et al., (2014)

Concerns over preserving the welfare and health of non-ruminant livestock in modern, commercial production systems and tight profit margins have prompted livestock producers to seek alternative approaches to feeding their animals. In addition, steady increases in the world's human population will increase the competition between non-ruminant livestock and people for grains with high nutrient density (CAST, 1999). It is estimated that around 80% of the total pig production of 26 million is found in rural areas and most are raised in small- scale semi- intensive and extensive systems *(*Lapar *et al*., 2003).It is important with respect to the economic efficiency and sustainability of these smallholder systems to utilize locally available feeds, such as rice bran, cassava residue, and sweet potato vines (Rodriguez and Preston, 1997), which are cheap, but usually contain high levels of dietary fiber.

Several reports have indicated that indigenous pig breeds can utilize fiber better than exotic breed (Fevrier *et al*., 1992; Ndindana *et al*., 2002), especially with diets that are very high in fiber. This has been attributed to the fact that indigenous pigs have higher digestive capacity and higher microbial activity in the hindgut than improved pigs.

2.10 Fiber

Fiber is the indigestible material and is made up mostly of cellulose. It is not actually a major feed ingredient for pigs but small amounts of it is required to stimulate the gut muscles to contract properly to ensure free movement of food through the gut and thereby facilitates free bowel movement and prevents constipation.

Feeding fibrous diet results in a number of advantages, such as improved well- being of animals, and reduction of stomach ulcers (Low, 1993).However, when included in monogastrics diets, the high fiber content result in decreased diet digestibility

(Nongyao *et al.*, 1991; Wang *et al.*, 2006) and dilution of dietary nutrients (Schulze *et al.*, 1994; Noblet and Le Goff, 2001).

The enzyme in the pig's digestive tract cannot digest fiber, however, the bacteria in the caecum can break down a small amount of fiber into fatty acids such as acetic, propionic and lactic acid which are then available as sources of energy. In general, a high level of fiber in the diet will reduce the availability of other energy sources, particularly if the feedstuff is not ground.

2.10.1 Characterization of Fiber

The most widely accepted definition of fiber states that fiber is the sum of lignin and polysaccharides that are not digested by endogenous secretions of the digestive tract (Trowell *et al.*, 1976). This definition segregates dietary polysaccharides into starch and non-starch polysaccharides (NSP) since starch is almost completely digested in the mammalian digestive tract. The definition proposed by these authors seems simple and easily applied to practical animal nutrition. Weende Crude Fiber, Van Soest Fiber, and Total Dietary Fiber (TDF) are the three predominant methods of fiber characterization that can be applied to non-ruminant diets.

2.10.2 Nutritional Effects of Fiber

The quantity and character of dietary NSP greatly influence the site and degree to which dietary polysaccharides are digested. It is difficult to describe with certainty the effects of various fiber components (SDF or IDF) on digestibility because they are not a homogenous substance. Fibrous feeds may contain predominantly one type of fiber or another type but they are not pure. Consequently, conclusions are drawn from a given fiber source that is predominantly one type of fiber and those conclusions are used to generalize the effects of that fiber component. Starch is almost completely digested (90 to 100%) by the time digesta reaches the ileal-cecal junction (Bach Knudsen and Hansen, 1991; Le Goff and Noblet, 2001). In contrast, lignin is not digested by pigs nor is there any significant fermentation by resident microbes in the gut (Graham *et al.*, 1986; Shi and Noblet, 1993). In addition to being indigestible, lignin influences the digestibility of other fibrous components of the diet. As a plant matures, cellulose becomes intertwined with lignin to increase the rigidity of the plant structure. In this process, cellulose becomes less accessible to microbes in the hindgut, which depresses the rate and extent of fermentation. Diet digestibility is inversely proportional to lignin concentration (Lee *et al.*, 2003), Pectins, fructans, β-glucans, and other components of SDF increase viscosity of the digesta (Mosenthin *et al.*, 2001; Noblet and Le Goff, 2001). Increased viscosity in the small intestine might slow gut transit time due to suppressed intestinal contractions (Cherbut *et al.*, 1990) which in turn leads to less mixing of dietary components with endogenous digestive enzymes. The end result is that SDF may interfere with complete digestion of dietary components (fibrous and non-fibrous) in the small intestine. However, the swelling associated with increased viscosity creates a much greater surface area for microbial attack in the hindgut. This partly explains the relatively high total tract digestibility of soluble fiber (Noblet and Le Goff, 2001).

Insoluble dietary fiber is digested primarily in the hindgut as a result of fermentation (Noblet and Shi, 1993; Shi and Noblet, 1993). Pigs do not secrete enzymes in the small intestine that attack components of IDF so they pass through relatively untouched to the large intestine (Shi and Noblet, 1993; Varel and Yen, 1997). Insoluble dietary fiber can negatively affect total tract digestibility of dietary nitrogen and ether extract (Shi and Noblet, 1993; Le Goff and Noblet, 2001). Pigs fed high fiber diets have proportionally heavier gastro-intestinal tracts than pigs fed low fiber diets which contribute to slight increases in maintenance energy requirements (Rijnen *et al*., 2001; Yen, 2001). Fermentation of NSP in the hindgut of pigs yields short chain fatty acids (SCFA) and lactic acid (Bach Knudsen and Jorgensen, 2001). This hindgut fermentation can generate 17% of the total digestible energy derived from the diet in growing pigs and 25% in sows (Shi and Noblet, 1993). These end-products of fermentation can supply 24 to 30% of the energy needs for growing pigs (Rerat *et al*., 1987; Yen *et al*., 1991). In sows, the contribution to daily energy requirements is likely to be greater than that for growing pigs because of the sow's greater ability to digest fibrous feed ingredients.

Total tract digestibility of NSP increases as the pig matures (Cunningham *et al.*, 1962). For most types of NSP, sows possess higher digestibility coefficients than growing pigs (Fernandez *et al.,* 1986; Noblet and Shi, 1993; Le Goff and Noblet, 2001). The improvement with age is particularly noticeable with feedstuffs that are high in IDF, which is digested mainly in the hindgut (Noblet and Le Goff, 2001;) Improved digestibility of NSP with age results from a more voluminous large intestine and cecum (Kass *et al.,* 1980; Pekas, 1991) that contain a more extensive microbial population and fermentation (Yen, 2001). Furthermore, sows generally receive a much smaller quantity of feed relative to their body size compared with growing pigs. This practice allows slower transit time of digesta and greater contact of endogenous enzymes and microbial populations with feed in the gut which should improve digestibility.

In vivo digestibility of fibrous feed ingredients is usually determined in young growing pigs. However, it is clear that sows have a greater capacity to extract energy from fibrous feedstuff compared with growing pigs. Diet containing very high levels of fibrous feed ingredients can be just as digestible as high starch diets. The degree of digestibility is dependent on the character of fiber.

2.11 Growth and Development of Pigs

According to Whittemore (1987), growth in animals relates to gain in weight, brought about by cell multiplication (as in pre-natal cleavage), cell enlargement (as in post–natal growth of muscles) and incorporation of materials directly in cells (as in lipid inclusions in fatty tissues). Pond and Maner (1974) identified three phases of growth in the post-natal period in pigs and these are commonly based on live weight of the pigs. The phases include the weaner or starter phases (5 – 20 kg live weight), grower phase (20 – 45 kg live weight) and the finisher or fattening phase (45 – 90 kg live weight). The rate of growth varies with breed. English *et al*. (1988) reported that pigs with a live weight range of 20 – 50 kg are capable of growing at a rate of 900 g per day. For improved breeds of pigs, Serres (1992) identified rates of 400 g following weaning, 500 g at 30 kg and over 600 g per day up to 40kg. Development occurs as pigs grow from infant stage to maturity. The body of a young pig is estimated to be 80% water, which is reduced to 40% at 150 kg live weight (English *et al*., 1988).

The factors which influence the ability of an animal to grow and the ultimate attainment of maximum size are fixed by heredity. Other factors which affect growth and performance of pigs are feed, sex, environmental temperature, management and stockmanship (English *et al*. 1988). According to Maynard and Loosli (1969), nutrition is an essential factor determining whether the optimum growth will be reached, and an optimum nutritional regime is one which enables the organism to take full advantage of its heredity.

2.11.1 Feed and Growth Performance of Pigs

Feed is defined as the material which after ingestion by animal is capable of being digested, absorbed and utilized while growth may be explained to mean an increase in weight and size, associated with changes in shape, until the pig reaches maturity (McDonald *et al*. 1998). According to Mavromichalis, (2006) the most important measurement of growth in growing pigs is gain in body weight, usually expressed as mean weight gain per day (g/day). Other ways of expressing growth of pigs is weight gain as a percentage of initial weight, which eliminates the effects of initial weight as heavier pigs tend to gain more weight than lighter pigs of the same age.

Feed is the most important factor, which plays an important role in the animal in exhibiting its genetic potential in growth. The composition, timing and feeding regimes all affect the growth performance of individual animals. Armah *et al*. (2008) fed Dried Cashew Pulp (DCP) diets to starter-grower pigs and observed that live weight gain of pigs fed the O, 50 and 100g/kg, DCP diets were significantly (P< 0.05) better than those fed the diet containing the highest amount of DCP (150g/kg). It was explained that the inferior live weight gain of pigs fed the 150g/kg DCP diet was due to high crude fiber level of the diet. (Fanimo *et al*., 2003 and Graham *et al*., 1987) reported that addition of fiber to the diet can lead to lower apparent digestibility of starch, fat, crude protein and peptides and withhold them from absorption. Varying levels of African Locust Bean fruit pulp (ALBP) to growing pigs and observed that pigs on the Control diet had a significantly (P< 0.05) lower average daily weight gain (ADWG) than the ALBP -5 group. The ADWG values were a reflection of the values for the ADFI and TFI. Usually a higher feed intake of a well-balanced diet would lead to a higher growth rate. (Tengan *et al.* 2012)

2.11.2 Feed Intake of Pigs

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). Muys, 1984 stated that, 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. Grower pigs get adapted to straw or high crude fiber in their diet by the second month of the introduction and intake will increase (Holness 1999). 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 social (space allocation, group size, regrouping etc) factors and environmental (temperature, humidity, air circulation etc), hot temperatures reduce feed intake whiles Cold temperatures increase feed intake when compared to temperature in the thermal-neutral zone (Revell and Williams, 1993) grower-finisher pigs eat about 40g per day less for each 10^{o}C above the comfort zone, when the room temperature is too hot. Pigs eat about 30g more per day for each 10^{o}C below the comfort zone, under cold temperatures (Revell and Williams, 1993). For social factors, space restriction reduces feed intake. For example, a 55% reduction from 0.56 to 0.25m2/ pig reduced feed intake by 8% (Hyun *et al*., 1997), whereas 37% reduction in space allowance from 0.55 to 0.35m2/ pig for grower pigs reduced feed intake by 11% (Edmond *et al*., 1998). different group size alters the feed intake pattern of pigs, mixing unfamiliar pigs reduces feed intake, and these changes alter overall daily feed intake, immunological stress or activation of the immune system results in reduced feed intake of grower-finisher pigs (Johnson,1997). An important determinant of feed intake is feed composition in terms of nutrient content and nutrient balance. In general, pigs try to eat to meet the requirement of the most –limiting nutrient, which in most cases is energy (Manu *et al*., 2015). Therefore, the current assumption is that dietary energy content mainly determines voluntary feed intake of grower-finisher pigs from 15 to 110kg (NRC, 1998). The presentation of feed can influence voluntary feed intake (Hancock, 1999) According to Gonyou and Lou (1999), 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% (Manu *et al*., 2015). Alenyorege and Dziwornu (2014) reported that, average daily feed intake was generally similar among 0%, 5% and 10% inclusion levels of groundnut vines in grower diet in the first three weeks of their study.

2.11.3 Weight Gain

According to Okai and Bonsi, (1989) average daily weight gain (ADWG) is the amount of weight the pig puts on each day over a certain period of its life cycle. Pond and Maner, (1974) stated that increase in body weight gain is the most meaningful and useful measure of growth in practical pig production. The ADWG 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) Higher weight gains in pigs though not statistically different might be due to presence of growth ability in the pigs fixed by heredity which awaits favorable environment like good nutrition to be expressed (English *et al*., 1988). Alenyorege and Dziwornu 2014, reported that,the final life weight for pigs on 5 and 10 % groundnut vines did not differ (P>0.05), but were higher than that of 0 %. It suggests that, inclusion of groundnut vines beyond 5% and exclusion of it all together tended to reduce weight gain in sows. Pigs on 5 % groundnut vines had the highest total life weight gain of 13.41 Kg followed by those under 10 % groundnut vines with 12.27 Kg and both treatments did not differ significantly (P>0.05). The life weight gain of pigs on 0%, (10.5 Kg) was significantly lower than those of 5% and 10% levels of groundnut vines.

Groundnut vines are rich in fibre that slows down digestion making pigs feel satisfied and full up for longer thereby increasing weight**.** The implication of this is that, groundnut vines have the potential to contribute to grower weight gain. This can facilitate puberty or fast growth. Soluble fibre slows down digestion hence providing energy to the pigs. The lower weight of pigs under 10% than 5% might probably be as a result of higher level and bulkiness of the fibre. This agrees with Kass *et al.* (1980) who stated that diet containing more than 7-10% fibre result in decrease growth rate. This could be observed that an increase in the dietary level beyond 5% decrease protein digestibility. Most probably, groundnut vines promote the growth of certain microbes that ferment and make waste materials soft and less bulky. Fibre keeps the digestive system healthy and functioning properly**.** Higher gut fill can also be seen as a reason for the higher weight gain

2.11.4 Feed Conversion Ratio

Feed-conversion ratio (the ratio of feed disappearance to live weight gain) is an important determinant of profitability for swine producers (Edwards *et al.*, 1989). Because feed costs represent approximately two-thirds of the total cost of pork production, small increments in the feed-conversion ratio can have a major impact on the profitability of an operation. Therefore, improving the feed-conversion ratio is a major goal in pork production (Henry, 1992). Genetic selection (which has concentrated on increased growth and reduced fat) is an important factor that has had an impact on improving the feed-conversion ratio (Henry, 1992). Diet and use of antibiotics can influence the feed-conversion ratio in pigs (Henry, 1992; NRC, 1968; Tribble *et al.*, 1956). Lopez *et al*. (1991) reported poorer feed conversion ratios among cold-stressed pigs. Overcrowding of pigs may have a detrimental impact on the feed-conversion ratio (Brumm and Miller, 1996). In addition, some diseases can result in an inferior feed-conversion ratio in pigs (Muirhead, 1989; Straw *et al*., 1989). According to Alenyorege and Dziwornu (2014), the weekly FCRs in their study indicate an increasing ability of the pigs to digest the test diets (inclusion of groundnut vines). Alenyorege and Dziwornu (2014) again stated that, feed was poorly utilized at the beginning of their experiment, but with time there was improvement in utilization. Less feed was consumed for a kilogram of live weight gain. Multiplication of bacteria in the intestinal tract increase as fermentable fibrous material continues to be fed to the pigs. High population of these in the intestinal tract facilitates digestion of the diets. Generally, the FCR for all diets were a bit poor, but since these were indigenous pigs and the diets comprised mainly of agro by-products, it can be said that utilizations was good.

2.11.5 Economics of Gain

Ayivi (2008) indicated that, feeding pigs with agro- industrial by-product-based diet is less economically compared to feeding pigs on standard diet (control diet- pito mash, cassava peels and cassava leaf meal). Alenyorege and Dziwornu (2014) stated that, cost per kilogram diet in monetary terms decrease as the levels of groundnut vines increased.

2.12 The Groundnut Plant

2.12.1 Origin and Botany of Groundnut

Groundnut, or peanut, is commonly called the poor man's nut. Today it is an important oilseed and food crop. This crop was grown widely by native peoples of the New World at the time of European expansion in the sixteenth century and was subsequently taken to Europe, Africa, Asia, and the Pacific Islands. Peanut was introduced to the present southeastern United States during colonial times. The botanical name for groundnut, Arachis *hypogaea* Linn, is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground, referring to the formation of pods in the soil. Contrary to popular opinion, however, the peanut is not really a nut such as a pecan or walnut. It is actually a close relative of the black eyed pea in the family Leguminosae. Legumes are plants in which the roots contain nodules of nitrogen fixing bacteria which return remarkable amounts of nitrogen to the soil. Groundnut is an upright or prostrate annual plant. It is generally distributed in the tropical, sub-tropical and warm temperate zones. The peanut plant is a sparsely hairy, tap rooted, annual bush about 45 cm tall when mature. The four main botanical varieties are Virginia, Spanish, Valencia, and Peruvian Runner. They are distinguished from each other by branching habit, branch length, and hairiness. Peanut is a self-pollinating, indeterminate, annual, herbaceous legume. Natural cross pollination occurs at rates of less than 1% to greater than 6% due to atypical flowers or action of bees (Coffelt, 1989). The fruit is a pod with one to five seeds that develops underground.

2.12.2 Uses of Groundnut

All parts of the peanut plant can be used. The peanut, grown primarily for human consumption, has several uses as whole seeds or is processed to make peanut butter, oil, and other products. The seed contains 25 to 32% protein (average of 25% digestible protein) and 42 to 52% oil. A pound of peanuts is high in food energy and provides approximately the same energy value as 2 pounds of beef, 1.5 pounds of Cheddar cheese, 9 pints of milk, or 36 medium-size eggs (Woodroof, 1983). Nonfood products such as soaps, medicines, cosmetics, and lubricants can be made from peanuts. The vines with leaves are excellent high protein hay for livestock. The pods or shells serve as high fiber roughage in livestock feed, mulch, and are used in manufacturing particle fertilizer.

2.12.3 Groundnut Vine

The groundnut vines include root, stem, leaves and flowers. Recent works have highlighted the role of functional compounds of the peanut kernel, skin and hull, while the functional components of peanut root, stem, leaves and flowers has been neglected for a variety of reasons. The yield of groundnut vine generated annually worldwide as a by-product of the groundnut industry is much more than the peanut kernel, skin and hull. The production of groundnut vine from harvested peanut has been estimated to be 60–65% of the groundnut production. Groundnut vines are rich in diety fibers and flavonoid compounds (Du and Fu 2008). Groundnut leaves are often lost at the time of harvest for the nuts and in addition during handling and storage. Essentially the haulms forms the major feed component by the time of feeding them to animals. Parts of the groundnut can be utilized for different purposes, such as groundnut leaves, which provide good quality roughage after the crop has been harvested. Groundnut haulms constitute approximately 45% of the total biomass and provide excellent forage for livestock including pigs.

Haulms are rich in protein and more palatable than many other fodder (Yasar *et al*., 2013)**.** Groundnut haulm is a nutritious feed for livestock and it contains protein (8-15%), lipids (1-3%) minerals (9-17%) and carbohydrates (38-45%).

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY

3.1 Study Area

The research was conducted at Samboligo in the Bongo district of the Upper East region of Ghana. Somboligo, is one of the Geo-tagged communities of Africa Rising project in the Bongo district, and was selected for possible assistance for intensification of pig production. This on- farm feeding trial was conducted to find out whether the use of groundnut vines as a feed ingredient would reduce feed cost, support intensification and improve production of pigs.

The Bongo district is found in the arid north of the country and with a total population of about 80,000 of which many are subsistence farmers. The District shares boundaries with Burkina Faso to the north, Kassena-Nankana East to the west Bolgatanga Municipal to the south west and Nabdam District to the south east and lies within the Onchocerciasis freed zone.

The district lies between longitudes 0.45^{o}W and latitude 10.50^{o}N to 11.09 and has a total land area of 459.5 Km^{2}, which is generally flat with occasional outcrops of rocks to an altitude of about 200 m. The landscape has little vegetation and borders to the Sudan Savannah zone although technically in the Guinea Savannah zone. The district is in danger of desertification with an annual average of 70 rainy days giving between 600-1,400 mm of rain.

3.2 Methodology of Research

The study started with the administering of a questionnaire to 114 respondents that will enable an assessment of rural pig production in the three regions of Northern

Ghana in particular, how it operates and the weak points especially in relation to integration and intensification of crop and livestock production. Five (5) most important constraints to pig production were revealed. These were cost of feeding, poor pig housing due to high cost of building materials, diseases, lack of veterinary services and inadequate water especially in the dry season. These problems were ranked and a pair wise comparison was completed, with cost of feeding rated as the most important by farmers.

Plate.3.1: Pig House for Experimental Pigs

3.3 Experimental Housing and Unit

A local breed was used, because these are better adapted to the current feeds, feeding systems and physical environment. Under our condition the ABP features prominently as a local breed. However, the ABPs normally found are not uniform in genetic make-up due to some crossing with other breeds. Therefore, ABPs of the Babile MoFA station origin, raised in a farm in Bolgatanga were used. This farm keeps the pigs intensively and pure. The ABP is the most popular indigenous breed of pig in Ghana which varies in colour but is generally black and of the Mediterranean type

(Tweneboa, 2000). It has a small body size, short body, relatively narrow head and a prolonged snout (Devendra and Fuller, 1979).

According to Blench, (2000) the breed was introduced into the Mediterranean regions by the Portuguese but those that tolerate trypanosomiasis are likely to have had more ancient ancestry in West Africa. It originated from Ghana and is used for meat though a poor producer of meat with yield ranging between 35-40 Kg of meat at maturity (Gopalakrishan and Lal, 1996).In all, 25 female grower pigs were used for the study with 5 pigs for each replication and a pig for each unit.

Plate 3.2: An experimental unit

Source: Alenyorege et al., 2015

Plate.3.3 Ashanti Black Pig under Extensive System

3.4 Experimental Design and Treatments

A total of 5 farmers (5 replications) were considered with each assigned to 5 treatments consisting of different diets (, T0-0% of Groundnut vine , FD- farmer diet, T4- 4% of Groundnut vine , T8- 8% of Groundnut vine, T12- 12% of Groundnut vine). The experimental treatments were randomly assigned within each replication to a pig as a unit. Initial weights of pigs were taken before assigning treatments. A Randomized Complete Block Design (RCBD) was used to conduct the experiment with each farmer representing a replicate. Discussions on the experiment were held with pig keepers and consequently these pig keepers selected five among themselves that were willing to use their farms for the study. The farmers were trained on the processes involved in the experiment and feed mixing.

Table 3.1 Composition of Treatment Diet for Grower Pigs (Ashanti Black)

Feed Ingredients	Treatment				
	0 %	4 %	8 %	12%	Farmer's diet
Groundnut vines	0	4	8	12	0
Dusa *(corn chaff)*	40	37	35	35	30
Fish Chaff	20	20	20	20	0
Millers flour	26	25	23	20	33
Yam peels	8	8	8	7	25
Oyster shell	2	2	2	2	0
Vitamin Premix	1	1	1	1	0
Rice bran	2	2	2	2	2
Salt	1	1	1	1	1
Kitchen waste	0	0	0	0	9
Total (kg)	**100**	**100**	**100**	**100**	**100**

Formulation of the farmers' diet; it was done by asking farmers to select and quantify the ingredients they used in preparing pig diets.

3.5 Chemical Composition of Groundnut Vines and Fish Meal

A sample of the groundnut vines that were used in the trial was milled for analysis. The fish meal used for the formulations of the experimental diet was derived from broken pieces of fish including bones and scales from herring. As market women handle and sell herring from baskets, some break into pieces and this product is cheaper than the main herring and manufactured fish meal. These rejects were milled at the Savannah Agriculture Research Institute Laboratory (SARI) into a meal and nutritional analyses were made at the Spanish laboratory of University for development studies. Chemical composition of these two feedstuffs are indicated in Table 3.2.

Table 3.2 Chemical Composition of the Groundnut Vines and Fish Meal that were used in the Diet Formulations (%Dry matter basis)

Sample	Fat	Fiber	Ash	Carbohydrate	Protein
GV	1.48±0.06	46.95±14.30	1.36±1.02	36.05	13.85±0.49
FM	4.54±0.06	29.75±1.10	4.76±1.18	13.46	47.49±1.64

GV-Groundnut Vine, FM- Fish Meal.

3.6 Chemical Composition of Treatment Diets

It was observed from the chemical analysis (Table 3.3) that T0 had the highest content of fat and carbohydrates. Meanwhile, T12 had the highest fiber content and the least in ash and carbohydrates. The highest protein was obtained by T8 though similar to T12.

Table 3.3 Chemical Composition of Treatment Diets (%DM basis)

Diet	Fat	Crude Fiber	Ash	carbohydrates	Protein
T0	3.27±0.01	29.61±1.10	3.35±0.97	46.89	16.88±0.35
FD	2.19±0.07	34.9±1.60	3.73±1.07	46.75	12.43±0.09
T4	3.13±0.07	34.85±2.60	1.35±0.49	43.00	17.67±0.11
T8	2.59±0.01	34.9±1.50	2.36±0.48	41.34	18.81±0.14
T12	3.11±0.11	41.11±12.50	1.02±0.57	36.73	18.03±0.63

T0-0% of groundnut vine, FD- farmer diet and also 0% groundnut vine, T4- 4% of groundnut vine, T8- 8% of groundnut vine, T12- 12% of groundnut vine DM – Dry Matter.

Carbohydrates was calculated using the formula; Carbohydrates = 100- (fat+ crude fiber+ Ash+ protein) for each of the treatments (AOAC 1999)

3.7 Housing of Experimental Pigs

Five houses (figure 3.1) were constructed with hollow cement blocks and roofed with galvanized sheets for five selected farmers to house experimental pigs. Each house consisted of six rooms or compartments, a Pig per room and the sixth served as a feed room. The doors had wire netting and there were ventilation gaps at the back of the building as well as between the roof and the wall to enhance aeration and heat dissipation. Pigs were fed with known weight of feed two times daily and leftover feed swept, collected, dried and weighed.

Plate 3.4: Feed Ingredients used in the Experiment



Vitamin premix **Rice bran** **corn chaff**



Fish chaff **Groundnut vines** **common Salt**

Miller's flour

3.8 Proximate Analysis of the Treatment Diets

The proximate compositions of the various treatments were conducted in accordance with the AOAC (1999) method except fiber and ash.

3.8.1 Crude Fiber Determination using Filter Bag Technique

This method determines crude fiber which is the organic residue remaining after digesting with 0.255N H_2SO_4 and 0.313N NaOH. The compounds removed are predominately protein, sugar, starch, lipids and portions of both the structural carbohydrates and lignin.

An empty filter bag was weighed (W1) and while still on, the scale was balanced to zero, so that weight of bag was taken care of. Some 0.95-1.00g of prepared sample (W_2) was weighed into the filter bag, and the upper edge of the filter bag within 4mm of the top was completely sealed with a heat sealer. One blank bag was weighed and included in the run to determine blank bag correction factor (C_1). Fat was extracted from the samples by placing all bags into a 250 ml container and petroleum ether was added to cover bags and soaked for 10 minutes. The solvent was poured off and bags allowed to air dry. Samples were spread uniformly inside the filter bag by shaking and flicking the bag to eliminate clumping.24 bags were placed into the bag suspender, with each tray taking three (3) of the bags. The bag suspender with the bags was inserted into the ANKOM ^{2000} fiber analyzer vessel and the weight of the bag suspender was placed on top of the empty 9^{th} tray to keep it submerged.

A quantity of 1900-2000ml of ambient temperature acid (0.255N H_2SO_4) solution was poured into the ANKOM ^{2000} fiber analyzer vessel and agitate and heat switched on. Samples were extracted after 40 minutes, at the end of extraction the heat and agitate were turned off. The drain valve was opened (slowly at first) to exhaust hot solution before opening lid. After the solution has been exhausted, the exhaust valve and open lid were closed. 1900ml of (50-90^{o}C) rinse water was added and agitated for 5 minutes, hot water rinse was repeated twice.

Another, 1900-2000ml of ambient temperature base (0.313N NaOH) solution was added over the bag suspender in the vessel, samples were extracted after 40 minutes. At the end of extraction, heat and agitate were turn off, after the solution was exhausted, the exhaust valve was closed and the lid opened.1900 ml of (50.90^{o}C) rinse water was added and agitated for 5 minutes, hot water rinse was repeated for a total of three rinses, after the rinsing process, samples were removed and placed in a 250ml beaker, and acetone was added and soaked for 3-5 minutes. Bags were removed from acetone and placed on a wire screen to air dry and were completely dried in an oven at 102^{o}C for 2-4 hours. Bags were oven dried when acetone had completely evaporated. After oven drying, bags were placed into a desiccator and flattened to remove air. Bags were cooled to ambient temperature and weighed. The entire bag/sample was ashed in a pre-weighed crucible for 2 hours at 550^{o}C, it was cooled in a desiccator and weighed to calculate loss of weight of organic matter (W_3).

Calculations

$$\%\boldsymbol{CRUDE\ FIBER} = \frac{\mathbf{100} * [\boldsymbol{W_3} - (\boldsymbol{W_1} - \boldsymbol{C_1})]}{\boldsymbol{W_2}}$$

W_1= Bag tare weight

W_2= sample weight

W_3=weight of organic matter (loss of weight on ignition of bag and fiber)

C_1=Ash corrected blank bag factor (loss of weight on ignition of blank bag/original blank bag)

3.8.2 Ash Determination

Ash is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600^{o}C in a muffle furnace for 4 hours.2 grams (W_1) of samples previously dried at 150^{o}C for 2 hours was weighed into a known weight of pre dried crucibles (W_2) at 550 ^{o}C for 2 hours or until whitish-grey ash is obtained.

The crucible containing the 2 gram samples, were placed in a muffle furnace and ashed for 4 hours at 550^{o}C. The crucibles were then cooled in a desiccator and weighed (W_3).

Percentage Ash was calculated using the formula below:

$$\% \, Ash = \frac{(W3 - W2)}{W1} \times 100$$

Where

W_1 =weight of sample

W_2= Weight of crucible

W_3=Weight of crucible plus ash after ignition

3.8.3 Nitrogen Free Extract (NFE)

NFE represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substance in feed. NFE is determined by mathematical calculation. It is obtained by subtracting the sum of percentage of the entire nutrient already determined from 100.

% NFE = 100-(%CF+%CP+%Fat+%Ash)

Where

CF= Crude Fiber

CP=crude protein

3.9 Chemical Analysis and Procedure of the Treatment Diets

Proximate analysis of the various treatments were carried out using the standard procedure of the association of official analytical chemist (1990). Fiber was analyzed using the filter bag technique forA200, A2001 method 7 and ash was analyzed using the Muffle furnace at 550^{o}c overnight. For fiber analysis**,** samples had no trace of moisture in it. It was milled and passed through2 and 1 millimeter sieve, between 0.45g to 0.50g of sample was weighed and sealed with a sealer, placed in acetone and air-dry and used for analysis.

1 gram of the milled sampled was weighed and oven dried at 80^{o}c for 12 hours and the tree stage of protein carried out (Digestion, Distillation and Titration)

Fat was also extracted using the soxtec apparatus, Between 3- 3.5grams of sample is weighed into the thimble, 50mls of petroleum ether (solvent) is added into the extraction cup and the three stages of fat extraction carried out. (30min boiling, 45 mins rinsing and 15mins ether recovery).

Chemical analysis of fiber and Ash was conducted at the Forage Evaluation Unit (FEU) of the Agricultural Services Sector Investment Project (AgSSIP) laboratory protein and fat was conducted at the Spanish Laboratories of the University for Development Studies, Nyankpala campus, Tamale.

3.10 Weighing of Pigs

Initial weights of pigs were taken before the start of the experiment. Weights of individual pigs were taken weekly before feeding, using a portable spring balance weighing scale. The scale is calibrated and hanged on a tree branch to a height such that during weighing pigs hang above the ground. Each pig was put in a jute sack and hanged on the scale and the weight recorded in kilograms.

3.11 Management of Pigs

Pigs were intensively housed and pens swept daily, while feeding was twice daily (morning 6:00am and evening 5:30 – 6:00pm). They were fed 2kg of feed per day (over 8% of their live body weight) and water was provided ad Libitum.

3.12 Weighing of Leftover Feed

Leftover feed was gathered separately according to treatments before feeding the pigs each morning (6:00 am) on each of the five farms, and weighed biweekly using the portable spring balance weighing scale.

3.13 Data Collection

The parameters considered during the experiment were; Average feed intake, average daily weight gain, feed conversion efficiency and final body weight gain. General observations were made on the health of the animals. Animals were conditioned to feed for three days before data collection started. The experiment lasted for eight (8) weeks (May- June). Data on feed intake had to end at week four because, due to size increase of the pigs, space became limited and pigs could no longer zone the floor space for feeding, resting and defecating. Left over feed frequently got mixed with faeces due to the limited space.

3.13.1 Average Daily Feed Intake (kg)

Feed intake for each pig was measured by subtracting the weight of leftover feed from the quantity fed or supplied. Daily feed intake for each week was measured by dividing feed consumed in a week by seven (7) days. It is represented in kilogram (kg)/day.

3.13.2 Average Daily Weight Gain (kg)

The initial weights of pigs were taken, weekly and at terminating day of data collection as final weight. Daily average weight is the final weight minus the initial weight divided by the number of days of data collection. It is represented in kilogram (kg)/day.

3.13.3 Feed Conversion Ratio

Feed conversion ratio (FCR) was calculated as the weight of the feed eaten divided by weight gain by each pig for that same period. The feed conversion ratio (FCR) is computed with the equation below;

$$FCR = \frac{FI\ (kg)}{WG\ (kg)}$$

Where: FI is feed intake for a period and

WG is weight gain for the same period.

3.14 Animal Health Management

Daily observations were made on pigs by the farmers to ascertain their health status for prompt attention. There was also a weekly visit by the researcher for, examination of animals and to act on any health concerns raised by farmers. Farmers were asked to notify the researcher or the vet or both during emergency health conditions.

Generally all pigs remained healthy for a period of two weeks until signs of ill health were realized. However, three of the pigs that showed signs of ill health were brought under control by deworming all pigs, administering of stress Aid, and antibiotic injections. A herb locally called (sigra) was chopped, soaked and its water used to mix with feed and also given in water for the sick pigs to drink. The signs and symptoms of ill health observed were: reduced feed intake, red eyes, bruises on the tail and diarrhea.

3.15 Processing of the Groundnut Vines

Groundnut vines were collected and dried to a low moisture content to prevent moldiness. It was pounded in a mortar to a coarse texture, stored in sacks and used during feed mixing.

Plate 3.5 Processing of Groundnut Vines By A Female Participant

3.16 Economics of Gain

Economics of production was calculated based on the cost per Kg of each diet and feed cost per Kg live weight gain. Feed cost per Kg live weight gain was calculated for individual dietary treatment as a product of feed cost and the feed conversion ratio.

3.17 Cost per Kg Live Weight Gain

Feed cost per Kg for each of the experimental diet was first calculated based on the price of the ingredients at the time of the experiment. This was calculated as cost of feed consumed by pigs under each treatments for 1Kg live weight gain.

3.18 Data Analysis

Data gathered after the experiment was subjected to analysis of variance (ANOVA) for a Randomized complete block design using GenStat 12th edition. Means were separated with fisher's protected LSD at $P \leq 0.05$. Correlation between growth parameters and chemical composition of the experimental diet and regression analysis between fat and protein to mean feed intake and weight gain were performed. Results are presented in tables and graphs.

CHAPTER FOUR

4.0 RESULTS

4.1 Average Daily Feed Intake

The results of the effect of groundnut vines on feed intake of Ashanti black pigs are presented in Table 4.1. No significant difference exists between all parameters across treatments, though numerical differences existed between them.

Table 4.1: Analysis of variance (ANOVA) table for Average Daily Feed Intake (Kg) for a Feeding Period of Four Weeks

Weeks	T0	T4	T8	T12	FD	SED	P.value
1	1.16	1.08	1.18	1.26	1.02	0.127	0.400
2	1.14	1.30	1.32	1.24	0.92	0.160	0.121
3	1.28	1.20	1.32	1.26	1.10	0.108	0.324
4	1.47	1.19	1.68	1.25	1.01	0.131	0.281

SED - Standard Error of difference, P- Probability(GV-Groundnut vine, T0-0% of GV, FD- farmer diet, T4- 4% of GV, T8- 8% of GV, T12- 12% of GV).

Data on feed intake had to end at week four, due to size increase of the pigs, space became limited and pigs could no longer zone the floor space for feeding, resting and defecating. Left over feed frequently got mixed with faeces due to the limited space.

4.2 Average Daily Weight Gain

The average daily weight gain of the Ashanti black pigs under the treatment diets are presented in Table 4.2.

Significant difference (P< 0.05) existed in week one for average daily weight gain. No differences were recorded among all treatment in week two to week eight. However, there were fluctuations in numerical difference from week two to eight

Table 4.2 Analysis of variance (ANOVA) table for The Effect of Groundnut Vines on Average Daily Weight Gain. (ADWG) (Kg) of Treatment Pigs

Weeks	T0	T4	T8	T12	FD	SED	P. value
1	0.346[a]	0.469[a]	0.332[a]	0.357[a]	0.171[b]	0.066	0.005
2	0.369	0.460	0.326	0.326	0.257	0.069	0.097
3	0.611	0.374	0.400	0.371	0.354	0.143	0.354
4	0.629	0.419	0.589	0.471	0.314	0.151	0.280
5	0.203	0.136	0.268	0.186	0.107	0.075	0.323
6	0.246	0.137	0.279	0.186	0.100	0.079	0.216
7	0.114	0.054	0.071	0.160	0.176	0.136	0.872
8	0.286	0.077	0.411	-0.020	0.157	0.235	0.386
Mean	0.351	0.266	0.336	0.205	0.205		

SED- Standard Error of difference, T0-0% of groundnut vine, FD- farmer diet, T4-4% of groundnut vine, T8- 8% of groundnut vine, T12- 12% of groundnut vine. Means with the same superscript are not significantly different. Wt – weight

In week 3 and 4 the ADWG of T0 were two times those of FD but there were no significant differences. This is because of some wide variations in the data which led to higher SED.

4.3 Mean Weekly Weight Gains of the Experimental Pigs

From the table, T4 picked up weight actively from week 1 and maintained it throughout the eight week period of the experiment. The gain was appreciable higher in first three weeks of the experiment but became marginal or gradual in the rest of the experimental weeks. All other treatments showed good weekly weight gain, but however experienced differently some falls in the weight gain in at least one of the weeks. However, the differences in weekly weight gains of the various experiments across all weeks cannot be describe as significant since they were numerical (table 4.3)

Table 4.3 Mean Weekly Weights Gains of the Experimental Pigs

WEEKS	T0	T4	T8	T12	FD
0	18.6	17.2	22.7	24.2	19.0
1	21.0	24.1	25.0	26.8	20.2
2	23.4	27.3	27.3	29.3	21.7
3	27.7	29.9	23.8	31.9	24.4
4	28.6	32.9	33.9	33.8	21
5	31.8	33.8	35.8	38.4	21.5
6	28	34.8	37.8	37.8	22
7	29.0	35.2	38.0	38.9	24.2
8	29.2	35.7	40.9	38.8	38.8
Mean wt. gain	10.6	18.5	18.2	14.6	19.8

NB; pigs were distributed taking care of dam effects.
(GV-Groundnut vine T0-0% of GV, FD- farmer diet, T4- 4% of GV, T8- 8% of GV, T12- 12% of GV).

4.4 Graphical representation of Mean Weekly Weight gains of Pigs

The trend of mean weekly weight gains of the experimental pigs in the experiment is presented in Figure 4.1. Generally, there are sudden rise and fall in weight of pigs regarding all treatments across weeks except T0, T4, and T12.These treatments showed steady weekly weight gain throughout the experiment, though T0 and T12 experienced one week fall (week 5 – week 6) before retaining steady increase in weight gain again. T8 having started with steady increase in weight gain, dropped suddenly from week 2 to week 3 and rose sharply from week 3 to week 4 before retaining its steady rise.

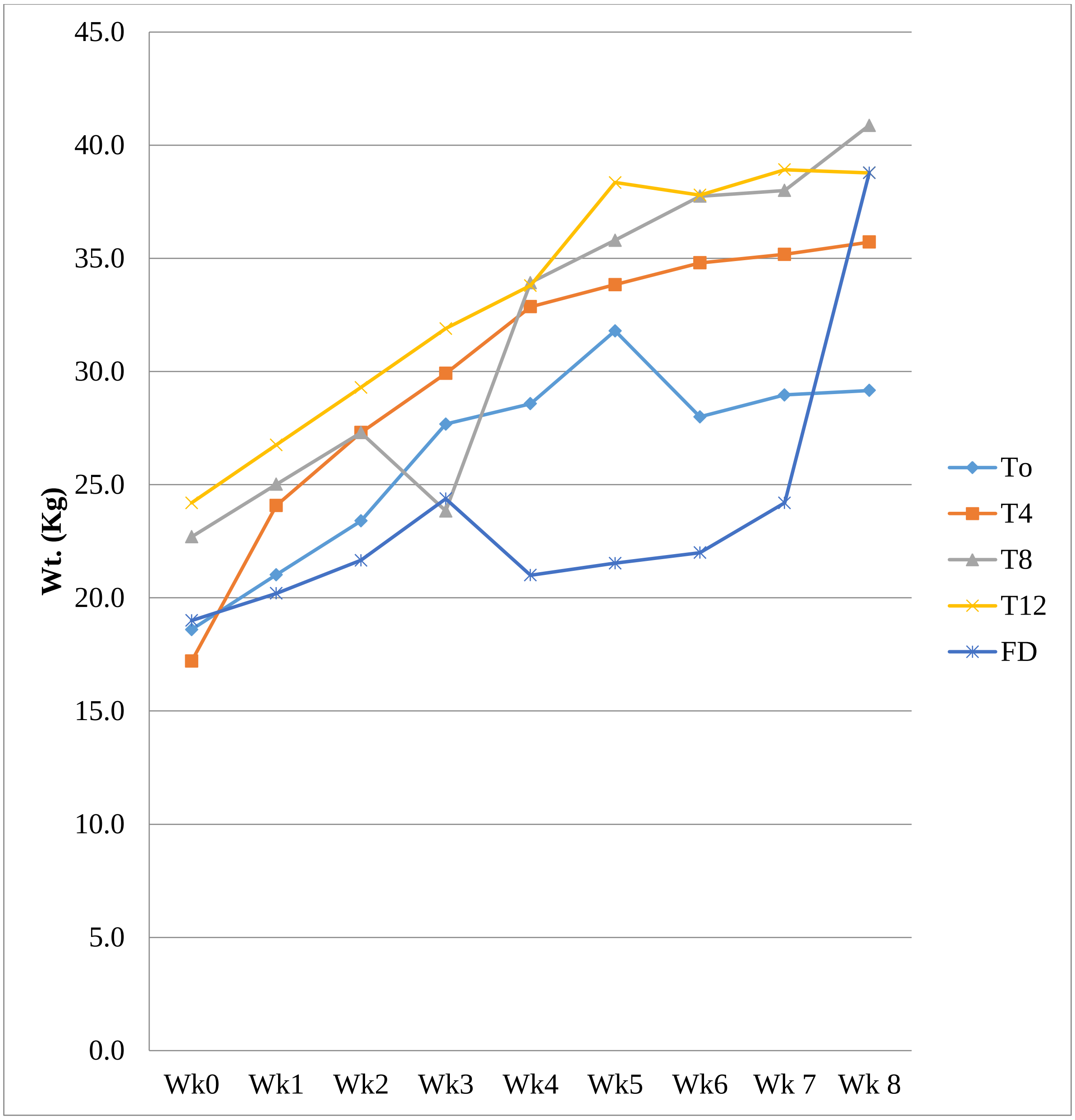


Figure 4.1 Mean Weekly Weight gains of Pigs

NB; the figure above will give a quick overview of the weight gains of the pigs. (GV-Groundnut vine, T0-0% of GV, FD- farmer diet, T4- 4% of GV, T8- 8% of GV, T12-12% of GV).

4.5 Feed Conversion Ratio (FCR)

The result of the FCR for all the treatments are presented in Table 4.4. Significant difference (P<0.05) exist between Farmer Diet and the rest of the diet (T0, T4, T8 and T12) in the first week. No difference was recorded among treatments after week one.

Table 4.5 Analysis of variance (ANOVA) table for Feed Conversion Ratio

Weeks	T0	T4	T8	T12	FD	SED	P. value
1	3.64[a]	2.41[a]	3.82[a]	3.78[a]	9.38[b]	2.24	0.045
2	3.26	2.98	4.50	3.64	6.83	2.67	0.613
3	2.21	7.32	2.61	5.05	3.81	3.57	0.599
4	1.47	3.19	1.68	2.72	7.08	2.03	0.092
Mean	**2.65**	**3.98**	**3.15**	**3.79**	**6.78**		

SED - Standard Error of difference, P- Probability, T0 - 0% of groundnut vine, FD - farmer diet, T4 - 4% of groundnut vine, T8 - 8% of groundnut vine, T12 - 12% of groundnut vine. Means with the same superscript are not significantly different.

4.6 Economics of Gain for the Experimental Diets at (GH₵ 0.68)

The cost per kilogram of Farmer diet was lowest (GH₵ 0.48) whereas T12 was the highest (GH₵ 0.99). The resulting diet cost per kilogram of live weight gain are presented in the Table 4.6.

Table 4.6 Economics of Gain for the Experimental Diets at (GH₵ 0.68) per kilogram of Groundnut vine

Parameters	T0	T4	T8	T12	FD
Cost/kg of Diet	0.96	0.97	0.98	0.99	0.48
Cost per kg LWG	2.65	3.98	3.15	3.79	6.78
Feed Cost per kg Live Weight.	2.54	3.86	3.08	3.75	3.25

T0-0% of groundnut vine, FD- farmer diet, T4- 4% of groundnut vine, T8- 8% of groundnut vine, T12- 12% of groundnut vine, kg-kilogram ,GH₵- Ghana cedi, LWG-Live Weight Gain.

4.7 Economics of Gain for the Experimental Diets at (GH₵ 0.25)

The cost of Farmer diet was lowest (GH₵ 0.48) whereas T4 was the highest (GH₵ 0.96). The resulting diet cost per kilogram of live weight gain are presented in the Table 4.7.

Table 4.7 Economics of Gain for the Experimental Diets at (GH₵ 0.25) per kilogram of Groundnut vine

Parameters	T0	T4	T8	T12	FD
Cost/kg of Diet	0.96	0.96	0.95	0.94	0.48
Cost per kg LWG	2.65	3.98	3.15	3.79	6.78
Feed Cost per kg Live Weight.	2.54	3.82	2.99	3.60	3.25

T0-0% of groundnut vine, FD- farmer diet, T4- 4% of groundnut vine, T8- 8% of groundnut vine, T12- 12% of groundnut vine, kg-kilogram ,GH₵- Ghana cedi, LWG-Live Weight Gain.

The cost of groundnut vines varies seasonally. In the early dry season, 1Kg could be bought at GH₵ 0.25 pesewas whereas in the late dry season 1Kg could be bought at GH₵ 0.68 pesewas. At harvest farmers gather it free from their own harvested fields.

4.8: Pearson Correlation between Growth Parameters or Predicted Variables and Chemical Composition of the Experimental Diet.

The mean feed intake and weight gain were significantly affected by protein and fat respectively at ($p<0.05$) (Table 4.7). The protein content of the diet correlated positively to weight gain but it was not significant at ($p>0.05$) as presented. However in Table 4.8, feed conversion efficiency was negatively correlated with protein.

Table 4.8 Pearson Correlation between Growth Parameters and Chemical Composition of Experimental Diet

Parameters	Mean FI	Wt. gain	FCE	Fat	Fiber	Ash	Carbohydrate	Protein
Mean FI	-							
Wt. gain	0.69	-						
FCE	-0.71	-0.82	-					
Fat	0.45	0.92*	-0.55	-				
Fiber	0.46	-0.11	0.14	-0.09	-			
Ash	-0.70	-0.47	0.12	-0.52	-0.71	-		
Carbohydrate	-0.83	-0.37	0.31	-0.27	-0.87	0.87	-	
Protein	0.90*	0.82	-0.67	0.65	0.18	-0.70	-0.64	-

*Mean feed intake (Mean FI), Weight gain (wt, gain) and FCE Feed conversion efficiency. *means significant at p<0.05*

4.9 Regression Analysis between Fat and Protein to Mean Feed Intake and Weight Gain.

The tested parameters (fig. 4.2-4.4) shows a positive linear regression between weight gain, fat and weight gain and protein at p<0.01.

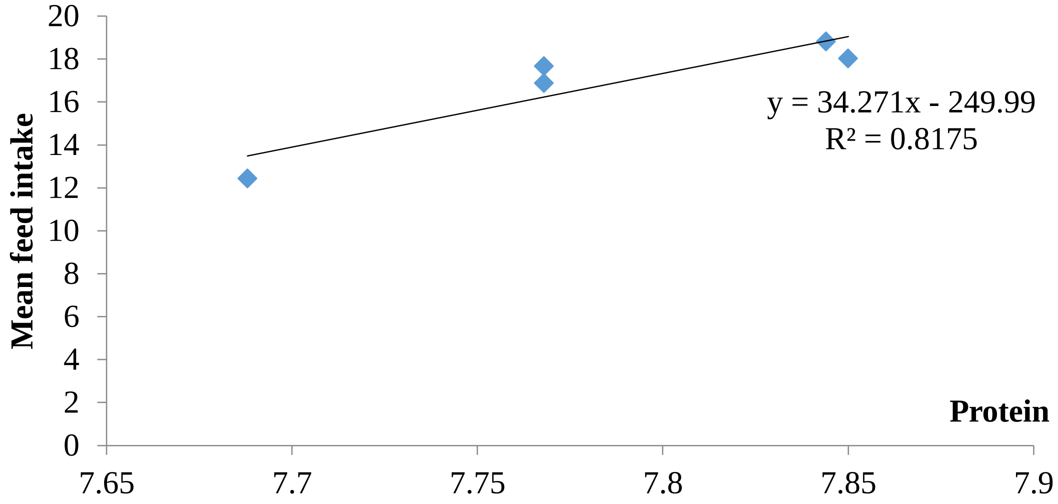


Figure 4.2: Relationship between Protein Content and Feed Intake

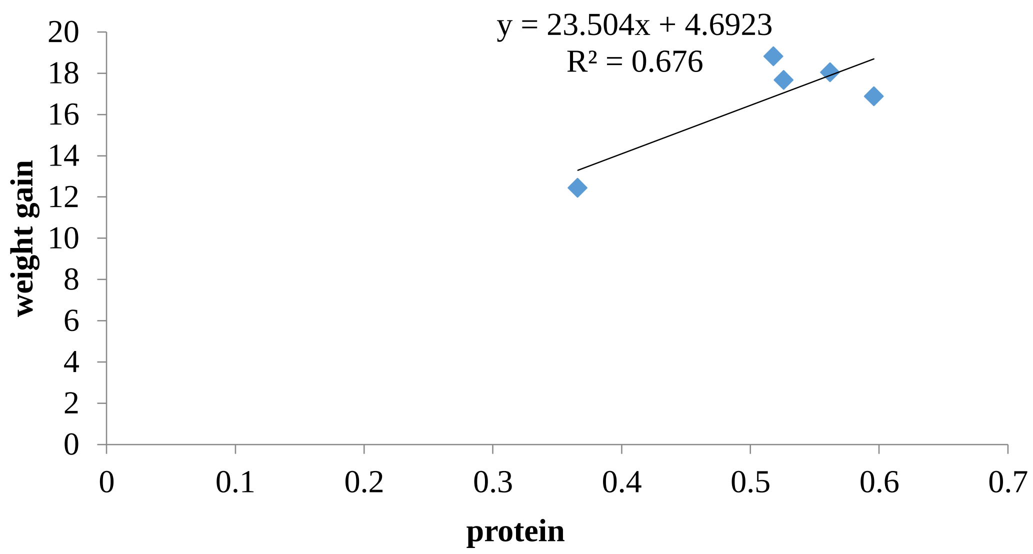


Figure 4.3 Relationship between Protein Content and Animal Weight Gain

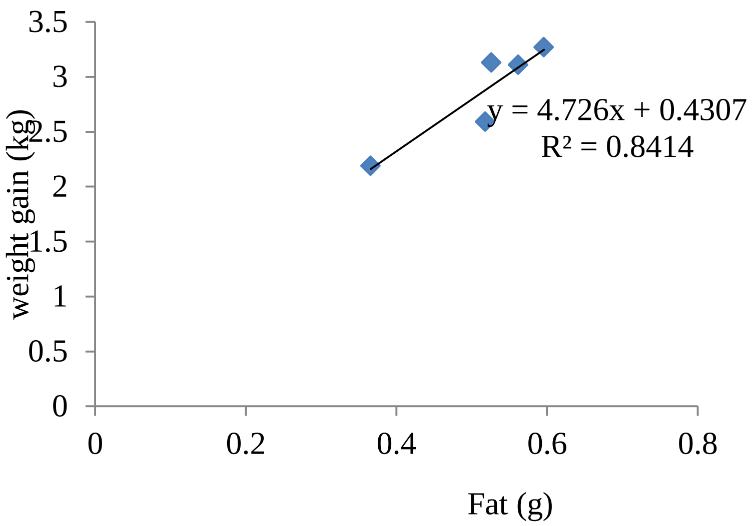


Figure 4.4: Relationship between Fat Content and Animal Weight Gain

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Chemical Composition of Experimental Diets and Feed Ingredients on DM Basis.

Based on the chemical analysis of the groundnut vines, the high fiber content with relatively low fat and protein contents indicate that, groundnut vines are not very good for feeding pigs, especially growers. The high fiber content may be due to the age of the plant, since the vines were obtained after harvesting the nuts hence, the lignin content, which is indigestible might be high. This might not be applicable to young and fresh groundnut vines, which are not yet lignified. Unfortunately farmers will harvest only upon maturity.

According to Mosenthin *et al*., (2001) and Noblet and Le Goff (2001), as a plant matures, cellulose becomes intertwined with lignin to increase the rigidity of the plant structure. By this, cellulose becomes less accessible to microbes in the hindgut which depresses the rate and extent of fermentation. Thus diet digestibility is inversely proportional to lignin concentration. Groundnut vines can however be used for grower pigs but in small amounts to enhance adequate gut muscle ion for free movement of ingester and in particular digester. The moderate carbohydrate levels of the groundnut vines could be utilized by pigs when included in the diets in small amounts.

The fish meal was high in protein and appreciable level of fat with relatively low carbohydrate content. These made the fish meal an important ingredient in the diet of the pigs. This is because high fat content supports the energy sources of pigs, whiles the protein facilitates growth and development.

The high fiber levels of the fish meal than other types might be due to the source, and handling of the fish meal. The fish meal was derived from the broken pieces of fish including bones and scales from herring sold by fish mongers. As market women handle and sell herring from baskets, some pieces of the baskets break into the fish and increases the fiber content of the fish meal before it gets to the livestock user. This is because even though the level of the fiber or the nutrient content depends on the type of fish meal used, the fiber should not be as high as 29.75 % as in this case. The fibre value recorded in this study, was different from the values of (Len *et al.,* 2003) who recorded as low as 1.30 % as crude fiber in fish meal specifically prepared for livestock use. The packaging of the fish which is made from jute sacks, baskets and paper could have introduced additional fibre into the fish.

The high carbohydrate content and low protein level of the farmer diet suggest that farmers do not give attention to balancing their pig diets. This might be due to the fact that, farmers usually have easy access to carbohydrate based ingredients such as trimming of vegetables, fruit and peels of tubers which they feed to pigs rather than protein sources.

The low protein content of the Farmer diet might be due to the expensive nature of the protein based ingredients which farmers cannot afford for their pigs. It is also possible that, the nutrient imbalance in the farmer diet is due to the ignorance of farmers on feed formulation and nutrient requirements of pigs. Fish meal and other expensive feed stuffs were not within the financial means of farmers.

The farmer diet had a fibre content of 34.9 %, this is moderately high. Peels of root and tubers served as ingredients. These are meant to protect the tuber and hence are not easily digestible and will increase the fibre levels. These materials are usually lignified and are quite indigestible by pigs. This might be the reason why rural pigs are usually emaciated with poor production and reproduction performances especially those that are kept mainly on by- products with no or little supplementation from standard feeds.

The diet without groundnut vines, (T0) obtained the highest fat and carbohydrate content which had a positive influence on the weight gain Mc Donald *et al*., (2002) and Dune *et al*., *(*2000) reported that, fats and oils are described as non-carbohydrate energy sources containing about 2.25 times more calories than carbohydrates and there is no doubt that weight gain is an indication of good performance in growing pigs.

5.2 Feed Intake

The inclusion of groundnut vines (at the various levels) did not significantly influence feed intake from week 1 to 4 where data was collected on intake, perhaps due to the processing method of the groundnut vines. This is because, it was observed that, the groundnut vines were processed into finer particle size for the first four weeks, than the later stages when the farmers were asked to try processing it as a learning process. The vines processed by the farmers were fairly of bigger particle sizes. The processing was improved thereafter. In an earlier study, Alenyorege and Dziwornu (2014), reported that average daily feed intake was generally similar among 0%, 5% and 10% inclusion levels of groundnut vines in growing sow diet in the first three weeks of their study. However, they recorded significant difference in feed intake between 5% and 10% inclusion levels of groundnut vines in the fourth week only, which is quite different from the values recorded for the fourth week of the present study.

However, there was steady numerical increase in feed intake across treatments in the four weeks in this current study was probably due to gradual transition of the pigs to adapt to the high crude fiber of the experimental material. Grower pigs get adapted to straw or high crude fiber in their diet by the second month of the introduction and intake will increase (Holness 1999). This did not happen in this current study. Pigs poorly digest high levels of fiber in their diet particularly if the feedstuff is not milled. Where low digestibility existed, space in the stomach for the animal to consume more, will be reduced hence low intake.

Mean feed intake which was not influenced by the groundnut vines, might probably be due to high dietary fiber content in the groundnut vines especially the stems. Meanwhile, the report by Du and Fu (2008) stated that, high dietary fiber content in pig diet reduces feed intake. Low feed intake may also be due to the presence of flavonoids compounds in the groundnut vines (Du and Fu 2008), this leads to poor digestibility. Low digestibility of the high fibre content in the diet owing to the young age of the pigs could also be factors that hinder the feed intake and subsequent utilization of the high fibre content in the diets with groundnut vines. This is because growing pigs have limited number of cellulotic bacteria (that aid in fibre digestion) in their gut compared with mature pigs, Varel and Pond (1985) found that there were 6.7 times more cellulolytic bacteria in the large intestines of mature sows compared to growing pigs. These bacteria facilitate digestion of roughage.

The marginal difference on feed intake might be due to increasing groundnut vine levels. The likelihood is that, as more fibre is added into the diet because of increasing levels of groundnut vines, the feed does not stay long in the GIT for good digestion. This is because, added fibre agitates muscular movement in the GIT, increase fibre induces more water intake and as there is increased water intake the bowel opens up and ejects its content at the lower intestines, but it needs to slow down for good digestibility and reabsorption into the system. However, increasing fibre is not making it to slow down hence the animals are not able to digest these feed very well. In T0 where there is no groundnut vine and where Cp is 16% whiles the other Cp is around 18%, the higher Cp would have induced feed intake and weight gain. However, it was not so because, the lower Cp in the T0 probably stayed longer in the gut for better digestion and absorption.

Therefore, the effect of the groundnut vine is not lowering nutrient content, but is lowering digestibility hence the difference. Digestibility will reduce because, bowel emptying is faster and there is less time for enzyme action on feed and nutrient extraction. These animals are young and cannot digest groundnut vines very effectively and absorb nutrients from it. Also if the fibre induces more water intake, then there will be less space for additional food to be added, hence the difference in the feed intake would not be that high.

Some of the experimental pigs showed signs of ill health in the fifth week. This might have reduced feed intake and possibly lowered feed digestibility as well. Prior to this, feed intake was generally increasing.

Nongyao *et al*., (1991); Schulze *et al*., (1994); Wang *et al*., (2006); Noblet and Le Goff, (2001) reported that, fibrous diets decrease diet digestibility and dilution of nutrient. While dilution of nutrient was marginally observed for fat and digestible energy these observation did not hold for this current study (Table 4.2).

Fiber is not a feed ingredient for pigs, but small amounts of it is required to stimulate the gut muscle to contract properly to ensure free movement of food through the gut and thereby facilitates free bowel movement to prevent constipation (Abora, 2013)

However, previous studies by, Fevrier *et al*. (1992) and Ndindina *et al*. (2002) indicated that, indigenous pig breeds can utilize fiber based diets better than exotic breed. This has been attributed to the fact that indigenous pigs have higher digestive capacity and higher microbial activity in the hindgut than improved pigs (Freire *et al.*, 2000; Jorgensen *et al.*, 1996).

5.3 Effect of Groundnut Vines on ADWG and Mean Weekly Weight of Ashanti Black Pigs

The final average weekly weight of the experimental pigs across all treatment is an indication that groundnut vine is good to be used as feedstuff for pigs. The differences in final average weekly weights of pigs in 8th week prove that T0 does not improve final weights as compared to the treatment diets. Considering the positive control diet (T0) in the experiment, exclusion of groundnut vines lower weight gain of grower pigs whiles its addition up to 12% has no adverse effects on the weekly weight gains of the grower pigs. This is contrary to the findings of Alenyorege and Dziwornu (2014) which stated that inclusion of groundnut vines beyond 5% and exclusion of it all together tended to reduce weight gains in sows. Pigs on 4% and 8% of groundnut vines recorded highest total live weight gain of 18.5kg and 18.2kg respectively, followed by those under 12% groundnut vines (14.6kg). The weekly live weight gain of pigs on 0% groundnut vines (10.6kg) was lower than those of 4%, 8% and 12% levels of groundnut vines. The value for 0% groundnut vines (10.6kg) is battered by the 10.5kg weekly weight gain obtained for 0% inclusion of groundnut vines by Alenyorege and Dziwornu (2014). The effect of exclusion of groundnut vines on weekly weight gain of the grower pigs is however questionable. While the T0 (positive control) had the lowest weekly weight gain, FD (negative control) had highest weekly weight gain even above the experimental treatment (T4, T8 and T12).

Meanwhile, the farmers do not use groundnut vines in feeding their pigs. The results suggest that, the non-usage of groundnut vines by farmers might be replaced with other fibre source ingredients which contain similar fibre level as the groundnut vines. Groundnut vines are rich in fibre that slows down digestion making the pigs feel satisfied and full up for longer thereby increasing weight. The implication is that, groundnut vines have the potential to contribute to grower weight gain. This can facilitate puberty or fast maturity. Soluble fibre slows down digestion hence providing energy to the pigs. The lower weight (14.6kg) of pigs at 12% might probably be as a result of higher level and bulkiness of the fibre. This agrees with Kass *et al.* (1980) who stated that, diet containing more than 7-10% fibre result in decrease growth rate.

All treatments showed a steady weight gain from 1st week of the experiment to the fourth week as presented in Table 4.2. The control diet (T0), gave higher weight gains though not statistically different. This might be due to the presence of genetic potential for growth in the pigs which was only awaiting favorable environment like good nutrition to be expressed (English *et al*., 1988). It could also mean that the control diet without groundnut vines was better. Most probably groundnut vines promote the growth of certain microbes that ferment and make waste materials soft and less bulky. Fibre keeps the digestive system healthy and functioning properly. Higher gut fill can also be seen as a reason for the higher weight gain.

Some pigs showed signs of ill-health in the fifth week. This might have reduced feed intake and possibly lowered feed digestibility as well. Prior to this, ADG was generally increasing. These conditions were treated with a combination of orthodox medicines and a local herb (siriga). Some nutrients would have been used for body repairs and this could have accounted for the reduced ADG.

5.4 Feed Conversion Ratio

The significant difference (P<0.05) that exist between the Farmer diet and the rest of the experimental diets (T0, T4, T8 and T12) in the first week of the experiment could be attributed to the unbalanced nature of the Farmer diet. The Farmer diet was poorly utilized probably due to the disparity in the nutrient level of the diet compared to levels required by the pigs. For instance the protein content of the farmer diet was 12.43 % which is far less than the protein content of 20-22% Cp required by grower pigs (ABP) for proper utilization.

Even though there was no significant difference in feed utilization among all the experimental diets after week one, the farmer diet was numerically poorer in terms of utilization compared to other experimental diets, probably due to the same reasons given for week one.

According to Alenyorege and Dziwornu (2014), the weekly FCRs indicated an increasing ability of pigs to digest the test diets (inclusion of groundnut vines) which this study supports, though the values in the current study were fluctuating. These findings however failed to support the findings of the previous study that, feed was poorly utilized at the beginning of the experiment, but improved with time. Less feed was consumed for a kilogram of live weight gain. However, the earlier experiment was with sows. According to the researchers, multiplication of bacteria in the intestinal tract increase as fermentable fibrous material continues to be fed to pigs. High population of bacteria in the intestinal tract facilitates digestion of the diets.

5.5 Economics of Gains

Cost per kilogram per diet in monetary terms increased as the level of groundnut vines increased. This finding is contrary to the report of Alenyorege and Dziwornu (2014) that, cost per kilogram of diet in monetary terms decreased as the level of groundnut vines increased. The resultant effect was a high cost of production of a kilogram live weight of pig. The non-replacement of more expensive fish meal, maize, miller's flour, and corn chaff, with the low cost groundnut vines rather than mere addition of groundnut vines led to addition of cost of feed and the fish meal not increasing growth. The Farmer Diet however, was cheapest probably due to availability and abundance of the feed material in the farmers' locality but could not lead to cheaper production of a kilogram of live weight of pig compared to T0 which was more expensive than FD. This could be due to the poor nutrient levels of the Farmer diet, therefore more of the diet was eaten to produce a kilogram live weight of pig, hence an increase in overall cost. The result of this work agrees with the finding of Ayivi (2008) which indicated that, feeding pigs with agro-industrial by-product-based diet is less economical (more expensive) compared to feeding pigs on standard diet (Maize, fish meal, wheat bran, oyster shell, premix, soya bean meal, fat, vitamins).

5.6 Pearson Correlation of Growth Parameters with Chemical Composition of Experimental Diets.

Fat and weight gain had a positive coefficient of 0.917, this is an indication that increase in fat content of pig diets would lead to appreciable weight gains in pigs.

Reports of Mc Donld *et al*., (2002) and Dune *et al* (2000), showed a similar trend. They indicated that, fats and oils which are non-carbohydrate energy sources contain about 2.25 times more fine calories than carbohydrates. Weight gain is an indication of good performance in pigs. This implies that, increased fat content in pig diets leads to improved performance in pigs. Fats are easier to digest and assimilate by growing pigs than carbohydrates, especially if they are of low chain fatty acids.

There is a, positive (0.65) correlation between fat and protein, though this is not very strong, it implies that, for protein to be utilized well, a fairly high energy is required. However, energy will be deposited as fat, whether protein is high or low. In the absence of adequate fat, excess protein would be deaminated and discharged from the body. So for bigger animals adequate fat will be needed. To get a quality growing animal, the relationship between protein and fat is important. So the increased protein in T4, T8 and T12 did not necessarily result into bigger pigs than the T0 which had 16% Cp while the rest had around 18% Cp. So it is likely that, some of the protein was deaminated and excreted, because, there was no corresponding high fat for it to be utilized. When food is eaten, fat is digested at the upper GIT, and much of the carbohydrates would also be digested there, but most of the protein would be digested at the mid portion of the GIT, so if the feed exits fast, protein will have a shorter time for digestion from the middle to the lower point, as such some of the protein would be lost. High crude fibre makes feed utilization poorer and will imply that feed is exiting fast, hence digestibility is lowered.

The GIT is more alkaline at the upper part and that facilitates fat absorption from the middle portion GIT, down it is acidic and this facilitates protein absorption. On the other hand, if excess protein is to be deaminated, energy will be drawn for this, thus resulting in reduced growth.

Also, the positive correlation between protein and mean feed intake (0.904) suggests that protein makes feed more palatable to pigs and for that matter enhancing feed intake. However, Peter *et al.*, (2007) were rather of the view that, feed intake is determined by the nutrient concentration of the diet. There was a weak and negative correlation coefficient between protein intake and feed conversion efficiency (-0.673), an indication that, despite the high intake of (expensive) protein, the feed conversion efficiency was low. Some protein could have been used for body tissue repair and sexual development. While some was lost in faeces.

This is further confirmed by the positive relationship between protein and weight gain (0.822). This implies that, the protein is used for cell and tissue multiplication hence subsequent increase in weight. This result agrees with the findings of Ayivor and Hellins (1986) and Konney (1993), that diets which are high in amino acid promote growth and production. These results were also confirmed by the finding of Peter *et al*., (2007) that sufficient amino acids must be present in the diet to support muscle growth at the level of feed consumed. However, not all the protein consumed by the animal is transfered into weight gain. This is because the correlation co efficient between protein and mean feed intake was good (R^2= 0.904) and the correlation between protein and weight gain was low (R^2=0.822). This is further suggesting that, some of the protein is lost due to deamination and some could have been used in body repair and development.

5.7 Regression Analysis between Fat and Weight Gain.

The linear association between fat and weight shows that increase in the quantity of fat in pig diets leads to an increase in weight gain. This might be due to the fact that, fat is energy based. Fat provides dense source of energy that is readily utilized as energy by pigs especially when the fat is of animal origin such as from fish meal. It has low fatty acid chains and higher in quality for the animal to absorb faster and better. Fat provides 2.25 times more energy than carbohydrates (Peter *et al*., 2007). This may be the reason why pig weight increased with increasing fat levels in the diets.

5.8 Regression between Protein and Weight Gain

From the regression equation, increasing protein levels in the diet, leads to an increase in weight gain. This might be due to the function of the protein in increasing body mass of the animal, thus the role of protein in growth and muscle tissue building would undoubtedly increase the weight of the pig. Some protein will also be used to repair body tissues, immune system development, and enzyme components and for sexual development since the pigs were becoming gilts.

5.9 Regression Analysis between Protein and Mean Feed Intake

Increasing protein levels in the diet leads to an increase in feed intake, this suggests that when protein content is high in pig diets, palatability is enhanced and consequently intake is increased. This is particularly good for grower pigs.

CHAPTER SIX

6.0. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

- The addition of different levels of groundnut vines in the diets of Ashanti black pig did not affect their feed intake levels, feed conversion efficiencies and the cost of feed.

- Proximate analysis of groundnut vines revealed appreciable levels of carbohydrate and protein suggesting that, groundnut vine is a potential feed ingredient for pigs

- Though, there was weight gain of pigs fed with the inclusion of groundnut vines but not statistically significant.

6.2 Recommendations

- Analysis should be carried on the digestibility of groundnut vine.

- Assessment on higher inclusion levels of groundnut vines in the diet of pigs to ascertain optimum levels of response.

- This study should be conducted **on-station and on- farm concurrently to detect possible errors and make timely corrections.**

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