GROWTH PERFORMANCE, BLOOD PROFILE AND CARCASS CHARACTERISTICS OF GROWING PIGS FED DIETS CONTAINING VARYING LEVELS OF SOYBEAN MILK RESIDUE (SBMR)

BY

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DECLARATION

I, Nsoh Abora, hereby declare that the work herein submitted as a thesis for the Master of Philosophy (Animal Nutrition) degree is entirely my own conducted research and has neither been presented nor is being presented concurrently for any other degree elsewhere.

However, works of other researchers and authors which served as sources of information were duly acknowledged.

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DEDICATION

This work is dedicated to my son Shaddrack Atiah

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ABSTRACT

Scarcity of and high cost of conventional feed ingredients have necessitated the identification and exploitation of nonconventional feed resources (NCFRs) for livestock especially monogastric livestock production. Soybean milk residue (SBMR) is one of such nonconventional feed ingredients. An experiment was therefore carried out to determine the nutrient composition and nutritive value of dried SBMR. The SBMR was collected in the fresh or wet form from Wiamoase, Agona, Mampong and some surrounding villages mostly from women who produce soybean milk and khebab. The fresh SBMR was then sun-dried to a moisture content of about 15%. Analysis of the dried SBMR showed that the crude protein, fat, ash and crude fibre levels were 20.1%, 8.0%, 1.75%,and 19.34% respectively. The metabolisable energy value was estimated to be 2157Kcal/kg. In a subsequent feeding trial, four diets were formulated to contain varying levels of the dried SBMR; the levels were 0.0kg, 5.0kg, 10.0kg and 15.0kg/100kg diet. These 4 dietary treatments were labelledT1, T2, T3, and T4, respectively. A total of twenty Large White growing pigs comprising of eight males and twelve females with a mean initial weight of 11.88kg were allocated to the 4 dietary treatments in a randomized complete block design (RCBD). Each treatment consisted of five replicates comprising of two males and three females and each replicate consisted of one pig. Feed and water were supplied *ad libitum* during the 91-day feeding trial. There were no significant (P>0.05) differences in the growth performance parameters, i.e. final weight, mean daily feed intake, mean total feed intake, total weight gain, daily weight gain and feed conversion ratio. There were no health-related problems that could be attributable to the inclusion of the varying level of the SBMR. There was however a marginal decrease in the feed cost per kg live weight gain (1.87, 1.77, 1.71 and 1.76 GH¢), with increasing levels of the SBMR. Carcass parameters that were measured did not show significant (P > 0.05%) differences among treatment means except for loin weight which was significantly (P<

0.05%) different among treatment means, with the 10% SBMR giving the highest value. Furthermore, the dietary treatments did not have any significant (P>0.05%) impact on the various blood biochemical indices. The haematological parameters examined were also similar (P>0.05%).It was concluded that the SBMR has some potential for use as a dietary ingredient in pig diets without compromising health and growth performance and carcass and blood traits.

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LIST OF ABBREVIATIONS

AA	Amino acids
ADFI	Average daily feed intake
AIBP	Agro-industrial by-products
ADWG	Average daily weight gain
ANF	Anti-nutritional factors
ATP	Adenosine triphosphate
CP	Crude protein
cm	Centimeter
dl	Deciliter ($1l \times 10^{-1}$)
DE	Digestible Energy
DM	Dry matter
EAA	Essential amino acids
EDTA	Ethylene diamine tetra acetate
EE	Ether extract
eg	example
FAO	Food and Agricultural Organization
FCE	Feed conversion efficiency
FCR	Feed conversion ratio
fig	Figure
fl	femtoliter ($1l \times 10^{-15}$)
GE	Gross Energy
GIT	Gastro-intestinal tract
g	Gramme
g/dL	Gramme per deciliter

GH¢	Ghana Cedis
g/l	gramme per liter
Hb	Haemoglobin
HDL	High density lipoprotein
HCT	Haematocrit
i.e.	That is
Kcal	Kilocalories
LDL	Low density lipoprotein
LWG	Live weight gain
kg	Kilogramme
ml	millilitre
MCH	Mean cell haemoglobin
MCHC	Mean cell haemoglobin concentration
MCV	Mean cell volume
ME	Metabolisable energy
NCFR	Non-conventional feed resources
NE	Net Energy
NFE	Nitrogen free extract
NRC	National Research Council
pg	picogramme
PCV	Packed cell volume
RBC	Red blood cell
RCBD	Randomized complete block design
SBM	Soybean meal
SBMR	Soybean milk residue

TDN	Total Digestible Nutrients
TFC	Total feed cost
TFI	Total feed intake
TWG	Total weight gain
VFA	Volatile fatty acids
WBC	White blood cells
WFI	Weekly feed intake
WWG	Weekly weight gain

CHAPTER ONE

1.0 INTRODUCTION

The need to provide feed is basic to any livestock enterprise including pigs. however, making the feed cheaply available is more compelling to profitability and sustainable livestock development (Ayuk *et al.,* 2009). One approach to feed cost reduction is the use of the cheap sources of nutrients. The energy and protein component of a feed are usually high and a reduction in the cost of the energy and protein sources could translate to reduced cost of feeding livestock.

Some of the major conventional sources of energy and protein in monogastric animal feeding may also serve as the bulk of raw material for the brewery and flour milling industries, apart from being sources of food for human consumption (Adesehinwa *et al*., 1998; Adesehinwa and Ogunmodede, 2004). Their high demand has resulted in scarcity and high cost; thus, pushing the prices of animal products far beyond the reach of an average consumer. As a result of this, research efforts have been directed towards the increased use of agro-industrial by-products (AIBP) and farm residues as alternative feed resources (Longe and Fagbenro-Byron, 1990). These are cheaper and less competitive sources of livestock feed and some have been reported to play an important role in the maintenance of normal structure and function of intestinal mucosa because of the high fibre content of most of these products (Adesehinwa, 2007). Livestock, especially pigs, are prolific and fast growing animals that can convert food waste to valuable products (Eusebio, 1984).Pido and Adeyanju (1980) and Okai (1998) reported that the use of non-conventional feedstuffs often reduce feed cost. Most recently, the growth of the animal feed industry has allowed considerable use to be made of agricultural by-products and wastes, some of which may contain toxic elements but can be safely included in compounded feeds in relatively low proportions. Various AIBP and other

non-conventional feedstuffs (NCFRs) have been evaluated in Ghana as potential feed ingredients for non-ruminant farm animals. Studies have been conducted on brewers spent grains, cocoa pod husk, dried coffee pulp, mango kernel meal, oil palm slurry, among others (Okai, 1995). In many developing countries, there exists a largely untapped potential for utilizing NCFR for feeding pigs. Soybean milk residue (SBMR) is one of the unexploited feed resources that have potential as a feed ingredient in pig feeding. It is a by-product obtained from the processing of soybeans into soymilk. In Ghana the wet SBMR is usually discarded as waste and at a drying price of at most Gh¢ 0.16/kg it is relatively cheaper than most of the conventional energy and protein sources. Its inclusion in pig diets therefore could help to reduce feed cost drastically and reduce or eliminate the problems associated with its disposal. However, there is a dearth of information on the nutritional value of SBMR, even though a few farmers in Ghana use the wet form as feed. This study was set up to investigate the chemical composition of dried locally produced SBMR and further assess the effects of graded levels of the dried SBMR in diets on growth performance, carcass and hematological characteristics of growing pigs.

CHAPTER TWO

2.0.LITERATURE REVIEW

2.1.Pig Production in Ghana

The pig industry in Ghana has responded well in recent years after the pork show was organized to give more publicity on pig production and pork consumption (Awuku *et al*., 1991). The religious taboos and other sanitation problems which have put people off pork have mostly been overcome by the high level of meat hygiene and husbandry practices in the pig industry. Pork and pig-rearing are gaining popularity in many communities in Ghana Koney (2004).

Pig farming is important in many parts of the world as it produces cheap tasty meat and other secondary products like pigskin, bristles, lard, bone and blood meals, and manure over a short period. In the tropics, pigs are kept primarily for the production of pork (Anthony *et al*., 1990), but pork may also be processed into various forms such as ham, bacon, and sausages.

The pig is omnivorous i.e. it can eat all types of food although it likes to graze or chew forage, it cannot digest too much fibre and unlike domestic ruminants it cannot live entirely on roughage (Williamson and Payne, 1989). They thrive under less than optimal conditions but just like all other animals, they require adequate and balanced diets, good management including housing and adequate veterinary care. The use of improved breeds and improvement in feeding and management practices and disease control measures are important factors in developing a pig industry (Koney, 2004).

2.1.2. Ghana's Pig Population and Distribution

The pig population in Ghana increased from 139,453 in 1973 to 224,487 in 1980. By 1990 the pig population had reached 473,946. This figure however decreased to 354,690 by 1996 due to increasing feed cost, inadequate veterinary services, outbreak of diseases, for example African swine fever, lack of interest on the part of most farmers and religious barriers. A map of Ghana showing population and distribution of pigs per kilometer square in the country in 1996 is shown in Table 1 and Figure 1 (Koney 2004).

Distribution of pigs country-wide and their percentage of the national stock is showed in Table 1.Out of the 354,690 pigs in the country in 1996, 19.4% were in Upper West Region; 13.5% in the Volta Region, 12.9% in the Northern Region and 12.3% in the Western Region. The rest are: 10.4% each in the Brong Ahafo and Upper East Regions with 5.8, 5.4, 5.7 and 4.6% in the Greater Accra, Ashanti, Eastern and Central Regions in that order.

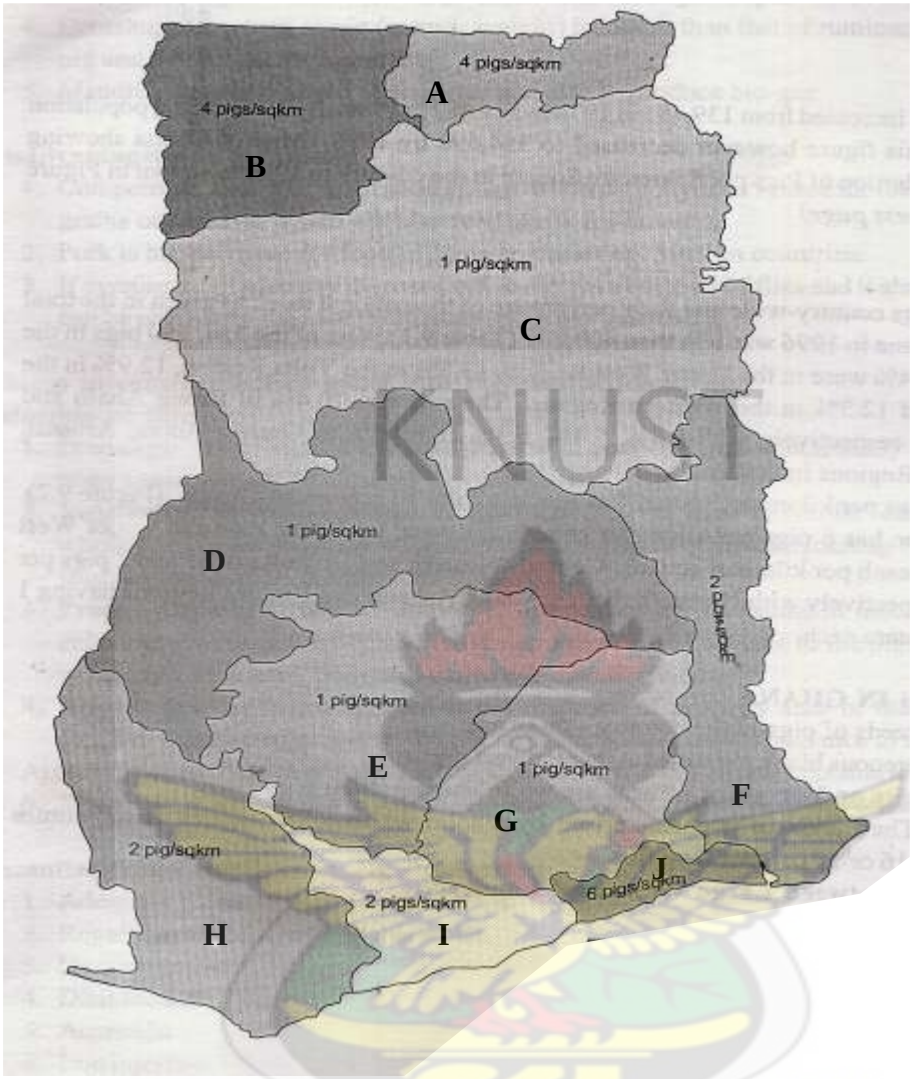
The number of pigs per kilometer square (km^2) was low in all the 10 regions of Ghana (Figure 1). Greater Accra had more pigs per kilometer square, followed by Upper East and Upper West Regions with 4 pigs each per kilometer square, while Volta, Western and Central Regions had 2 pigs per kilometer square, respectively with Northern, Brong Ahafo, Ashanti and Eastern Regions having 1 pig per kilometer square each. The estimated pig population for 2007/2008 was 1,289,000. Table 2 shows the distribution of pigs by ecological zones and percentage of the national total.

Table 1 Distribution of pigs country- wide and percentage of the national stock

Region	Pigs	Land Area	Density	%
Ashanti	19,019	24,390.00	1	5.4
Brong Ahafo	36,756	39,560.00	1	10.4
Central	16,461	9,830.00	2	4.6
Eastern	18,972	19,320.00	1	5.7
Greater Accra	20,657	3,240.00	6	5.8
Northern	45,727	70,380.00	1	12.6
Upper East	36,776	8,840.00	4	10.4
Upper West	68,886	18,480	4	19.4
Volta	47,795	20,570.00	2	13.5
Western	43,641	23,920.00	2	12.3

Source: MOFA (1996)

Fig. Map of Ghana showing density of pigs per kilometer square (1996)



Source: Koney (2004)

KEYS

A- Upper East Region
B- Upper West Region
C- Northern Region
D- Brong Ahafo Region
E- Ashanti Region
F- Volta Region
G- Eastern Region
H- Western Region
I- Central Region
J- Greater Accra

Table 2. Estimated pig population by ecological zones.

Ecological zone	Pig population	Percentage of the national stock (%)
Sudan savannah	18,217	6.3
Guinea savannah	523,854	40.6
Derived Savannah	105,176	8.2
Forest Zone	320,547	24.9
Coastal savannah	258,801	20.1
Total	1,289,595	100

Source: computations from livestock growth trend study field survey (2007/08) and several other studies in the various ecological zones. The computed figures may be approximated to thousands.

2.1.2. The Potentials of Pig Production in Ghana

When compared with ruminants, pigs have major potential merits, namely:

a. They are more efficient in converting concentrated food to meat as compared to ruminants.

b.They are highly prolific. A sow produces on the average 9 – 10 piglets per farrowing after 114 days of pregnancy. Thus, if she raises 20 piglets in a year; in view of the fact that they attain market weight fast, they will provide animal protein faster (Koney, 2004; Awuku *et al*., 1991).

c. They produce meat without causing the deterioration of natural grazing lands. This is of major importance in relation to the current steady rate of desertification, soil erosion and loss of productive land in the tropics.

d. The pig has also contributed a great deal in medical research as it has been used to investigate certain diseases which are common in humans.

e. If confined, maximum use can be made of their manure and effluent.

f. Pigs require a small space in which to live. For example, a mature sow or boar requires 3 – 4 Metre square of living space.

g. Pig production has been found to have a quicker turnover rate on investment compared with cattle and other ruminants (Koney, 2004).

2.1.3.Constraints to Pig Production in Ghana.

Apart from the socio-cultural and religious problems, other constraints are:

a. Pigs compete directly with humans for food especially the staple cereal grains and oil seeds (legume grains). This could lead to increasing cost of grains and scarcity. However, this problem can be partly overcome by making use of a crop by- products and waste foods and grains unsuitable for human consumption (Holness, 1995).

b. They cannot provide a source of draught power for farming operations.

c. Because pigs and human are co-hosts to a number of parasites, they can cause health problems if they are not confined.

d. If manure is not properly disposed off, it creates a buildup of flies and it also smells. Manure can be profitably used as fertilizer or in bio-gas plants to solve this problem.

2.2.0.Nutrient Requirements 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).

2.2.1. Energy Sources and Energy Requirements of Pigs

Apart from water, energy is the most important nutrient required by the pig and will most rapidly influence its survival if withdrawn. Energy can be defined as the capacity to do work and it occurs in various inter-convertible forms such as chemical, thermal or radiant energy. Dietary energy is provided by carbohydrates, protein, lipids and some fermentable fibre (Mavromichalis, 2006). The main precursor of energy is carbohydrates. Cereals (maize, sorghum, millet) and root and tubers (e.g. cassava, cocoyam, sweet potato and yam) are the main sources of carbohydrates (Awuku *et al*., 1991).in Africa and other developing countries. Lipids (fats and oils), which contain about 2.25 times more energy than most carbohydrates and protein, also provide much energy compared to carbohydrates but when used for energy, it leads to negative balance. Fibre is fermented by the intestinal microflora to produce volatile fatty acids (VFAs) which are absorbed and used as energy. Other sources of energy include by- products of cereals (e.g. wheat bran, rice bran, brewer's spent grains, etc) and by - products of root and tubers (e.g. yam, cassava, cocoyam peels, etc) (Awuku *et al*., 1991).

Energy is normally measured in heat units (traditionally the calorie) and in modern livestock nutrition, the Mega joule (MJ) is the most commonly used unit (1MJ = 0.239 Mcal) (Holness,

1995). Energy in feeds is described as Gross (GE), Digestible (DE), Metabolisable (ME) or Net Energy (NE).The energy released when a feed is completely burnt in a calorimeter constitutes the gross energy (GE), the component of the feed digestible by the animal forms the DE; while the ME is DE minus gaseous and urinary energy and the NE on the other hand, is a further refinement of ME to express the energy value of a feed (Anthony-Youdeowei, *et al*., 1990; Kellems and Church, 2002). An alternative system of assessing the energy value of pig feeds is the Total Digestible Nutrients (TDN) system, which was widely used in the USA. The TDN is calculated as the sum of the digestible components of the diet; i.e. TDN is the summation of Digestible crude protein + digestible crude fibre + nitrogen free extract + ether extract x 2.25) (Holness, 1995). One kg of TDN is equivalent to 18.49 KJ DE (Farrell, 1978). Morgan and Whittemore (1982) suggested that DE is more preferable in describing the energy content of pig feed, because DE is more easily and precisely determined.

The energy requirement of pigs is variable depending on the age of the pig, reproductive stage, health status and type of ingredients fed (Holness, 1995). According to Serres (1992), basal metabolism and maintenance requirements are proportional to live weight and growth rate, as a result, energy needs increase with increasing body weight (Table 2). Awuku *et al*.(1991) suggested that it is normal to feed pigs according to their body weight and the energy value of the feed. Generally, the energy density controls the amount of feed consumed (*ad libitum)* daily (Cole, 1984; and English *et al*., 1988), and pigs will increase feed intake in situations of low energy diets and decrease the intake where the energy density of the diet is high. Table 3.is a summary of the nutrients required at different stages of growth as recommended by NRC.

Table 3: **NUTRIENT REQUIREMENTS AT DIFFERENT STAGES OF GROWTH AND PRODUCTION IN PIGS**

NUTRIENTS	LIVE WEIGHT OF PIG/kg						GESTATION	LACTATION
	3-5	5-10	10-20	20-50	50-80	80-120		
Estimated ME intake (Kcal/kg)	820	1620	3265	6050	8410	10030	6040	17135
Estimated DE intake (Kcal/kg)	855	1690	3400	6305	8760	10450	6290	17,850
Estimated feed intake (g/day)	250	500	1.000	1.855	2,575	3,075	1,850	5,250
Crude Protein CP(%)	26.0	23.7	20.9	18.0	15.5	13.2	14.0	19.2
Mineral elements	**Requirement**							
Calcium (g)	0.90	0.80	0.70	0.60	0.50	13.84	0.75	0.75
Phosphorus available (g)	0.55	0.40	0.32	0.19	0.15		0.35	0.35
Sodium (g)	0.25	0.20	0.15	0.10	0.10	0.10	0.15	0.20
Chlorine (g)	0.25	0.20	0.15	0.08	0.08	0.08	0.12	0.16
Magnesium (g)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Potassium (g)	0.30	0.28	0.26	0.23	0.19	0.17	0.20	0.20
Copper (mg/kg)	6.00	6.00	5.00	4.00	3.50	3.00	5.00	5.00
Iron (mg/kg)	100	100	80	60	50	40	80	80
Iodine (mg/kg)	0.14	0.14	0.14	0.14	0.14	0.14	5.0	5.0
Selenium (mg/kg)	0.30	0.30	0.25	0.15	0.15	0.15	0.15	0.15
Manganese (mg/kg)	4.00	4.00	3.00	2.00	2.00	2.00	20	20
AMINO ACID	**REQUIREMENT (g/day)**							
Methionine cystine	1.9	3.4	5.8	8.8	10.0	9.5	6.1	0.34
Lysine	3.4	5.9	10.1	15.3	17.1	15.8	8.5	0.90
Histidine	1.1	1.9	3.2	4.9	5.5	5.1	2.7	0.36
Arginine	1.4	2.4	4.2	6.1	6.2	4.8	00	0.50
Isoleucine	1.8	3.2	5.5	8.4	9.4	8.8	5.0	0.50
Leucine	3.4	6.0	10.3	15.5	7.2	15.8	8.1	1.03
Methionine	0.9	1.6	2.7	4.1	4.6	4.3	2.7	9.7
Threonine	2.1	3.7	6.3	9.7	11.0	10.5	7.0	0.56
Phenylalanine + tyrosine	3.2	5.5	9.5	14.4	16.1	15.1	8.5	1.02
Valine	2.3	4.0	6.9	10.4	11.6	10.8	5.8	0.77
VITAMINS	**REQUIREMENT**							
Vitamin A (IU)	2.200	2.200	1750	1.300	1.300	1.300	4000	2000
Vitamin D (IU)	220	220	200	150	150	150	200	200
Vitamin E (IU)	16	16	11	11	11	11	44	44
Vitamin K (mg/kg)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Biotin (mg/kg)	0.08	0.05	0.05	0.05	0.05	0.05	0.20	0.20
Vitamin B (mg/kg)	2.50	1.50	2.00	1.50	1.50	1.00	1.00	1.00
Vitamin B_{12} (mg/kg)	20.0	17.50	15.00	10.00	5.00	5.00	15	15
Choline (g/kg)	0.60	0.50	0.60	0.50	0.40	0.30	1.25	1.00
Folacin (mg/kg)	0.30	0.30	0.30	0.30	0.30	0.30	1.30	1.30
Niacin available (mg/kg)	20	15.00	12.50	10.00	7.00	7.00	10	10
Pantothenic acid (mg/kg)	12.00	10.00	9.00	8.00	7.00	7.00	12	12
Riboflavin (mg/kg)	4.00	3.50	3.00	2.50	2.00	2.00	3.75	3.75
Thiamine (mg/kg)	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Sources: - NRC (1998)

2.2.2. Protein Requirements of Pigs

Proteins are organic compounds which always contain the elements carbon, hydrogen, oxygen and nitrogen. Some proteins also contain sulphur and phosphorus. The basic unit of

protein is the amino acid (AA) and 22 of these occur naturally in living organisms even though chemically many others exist. Out of these, ten are essential and 12 non – essential. The essential amino acids (EAA) must be present in the feed since the body itself cannot synthesize them. These are arginine, methionine, histidine, leucine, lysine, valine, threonine, isoleucine, tryptophan and phenylalanine (Gillespie, 1992). The most limiting AA in pig diets are lysine and methionine (Koney, 2004; Kellems and Church, 2002), due to their low content in most feedstuffs and also the relative high level of requirement for them in the muscle of pigs.

Protein is the most plentiful substance in the animal's body, next to water, and it is essential in the building up of muscles and other body tissues. In addition, many of the hormones that regulate the metabolic processes in the animal's body, the antibodies which provide immunity against diseases and the catalytic enzymes which speed up chemical reactions inside the body, are also proteins. Insufficient protein intake in young animals results in reduced appetite, with resultant poor growth rate. There is also lack of muscle development and a prolonged time to reach puberty. Protein deficiency in older animals leads to muscle deterioration, particularly in the hind quarters. In addition, deficiency of protein generally accompanies a deficiency of energy (Lewis *et al*., 2002). Excessive intake of protein leads to separation and excretion of nitrogen in the urine and the material left is converted into energy or body fat by the animal. Sources of protein include; fishmeal, soybean meal, blood meal, cotton seed meal, copra cake, palm kernel cake and groundnut cake.

In pig nutrition, a good quality protein source is one that provides all the ten EAA required for normal growth and development in amounts and proportions necessary for the particular needs of the pigs. Fishmeal is an excellent animal protein source; however, it is expensive and the tendency of causing fishy flavor in pork reduces its use. Soybean meal has an excellent balance of amino acids and is specifically high in the amino acids lacking in most

cereals. It is also very palatable (FAO, 2004;Koney, 2004). One major problem with the use of soybean meal as a source of protein is the presence of anti-nutritional factors such as trypsin inhibitor, haemagglutimins and digosaacharides especially when there is no heating. Fortunately, these can be removed by heating for 20 to 40 minutes (Mangala and Mauria, 2006). According to Kellems and Church (2002), the AA requirements of pigs is usually expressed as a percentage of the diet and this decreases as the pig becomes older, for example, the requirements are higher from weaning to 30kg body weight, however, pig diets are generally formulated on the basis of crude protein which refers to nitrogen content of the feedstuffs. The protein levels are established for the different weight groups of pigs so that the most limiting EAA, lysine will be present in adequate amounts (Adesehinwa and Ogunmodede, 1995). Protein and AA requirement of pigs in the tropics is higher than the NRC recommended levels for the temperate zones (Babatunde *et al*., 1972).

2.2.3.Protein: Energy Ratio

Efficient utilization of protein depends on the amount of energy available. Thus the amount of protein per unit of DE is more important than the absolute concentration of protein (Table 2). Protein to energy ratio is guided by two factors:

i) The age of the pig: The energy : protein ratio changes steadily as the pig grows, being highest in the young animal and lower in the older pig, where protein requirements per kg live weight are less, and

ii) Genotype: Generally, exotic breeds of pigs, for example, require a higher protein to energy ratio than local unimproved pigs because they have higher lean to fat ratio in their bodies (Holness, 2005).

2.2.4. Vitamins

Vitamins are organic nutrients that are essential for normal growth and development but are required in much smaller quantities than the EAAs (Neil *et al*., 2000). Most vitamins serve as coenzymes or part of coenzymes; they have catalytic function and are used over and over in metabolic reactions. Even though needed in only tiny amounts, these substances are absolutely necessary and deficiencies can cause serious problems; on the other hand, vitamins in excess can be dangerous. Fourteen vitamins are required by pigs and these are either fat-soluble (can dissolve in fat) or water- soluble (can dissolve in water). Examples of fat soluble vitamins are; A (retinol), E (tocopherol), D and K. The water-soluble vitamins include C (ascorbic acid) and the B – complex vitamins which include niacin, pantothetic acid, folic acid, cyanocobalamin, choline, inositol, thiamin, riboflavin and pyridoxine (Table 2).

Vitamins B_1, B_6, B_{12},folic acid and biotin are coenzymes used in the metabolism of sugars, amino acids and fats. Vitamin B_2, macro pantothenic acid form part of coenzymes central to cellular respiration. According to Gillespie (1992), some of the other vitamins and their functions are:

i. Vitamin K is essential for blood clotting.

ii. Vitamin D regulates the absorption and use of calcium and phosphorus in bone and teeth formation.

iii. Vitamin A promotes growth and health of teeth, protects lining of the eye and is important for the normal functioning of the eye.

iv. Vitamin E is necessary for normal reproduction and normal metabolism.

v. Vitamin C helps in teeth and bone formation and prevention of infections.

2.2.5. Fibre

Fibre is the indigestible fibrous 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 prevent constipation. The enzyme in the pig's digestive tract cannot digest fibre, which occurs to some extent in all plants material. However, the bacterial in the caecum can break down a small amount of fibre into fatty acids such as acetic, propionic and lactic acid which are then available as sources of energy. In general, a high level of fibre in the diet will reduce the availability of other energy sources, particularly if the feedstuff is not ground.

2.2.6. Minerals

In the area of nutrition, minerals are chemical elements other than carbon, hydrogen, oxygen and nitrogen, the staples of organic compounds (Neil *et al.*, 2000). Dietary minerals are grouped into major/macro minerals and micro/minor/trace minerals based on the amount required by the animal for normal growth and development. The macro minerals include Ca, P, K. Cl, Mg, Na and S and the minor minerals include Zn, Si, Mn, Mo, I, Fe, Cu, Ni, Se and F. Calcium and P are needed in relatively larger amount by pigs to construct and maintain the skeleton (bones). Calcium is also necessary for the normal functioning of nerves and muscles and phosphorus is a component of ATP and nucleic acids. Sulfur is a necessary component of several electron carrier molecules that function in cellular respiration. It is also a component of haemoglobin. The oxygen carrying protein of red blood cells is iron. A small amount of F helps maintain bones and teeth. Magnesium, manganese, zinc copper, cobalt, selenium and molybdenum are components of various enzymes.

Iodine is required to make a hormone called thyroxin, which regulates metabolic rate while

Na, K and Cl are important in nerve function and help maintain the osmotic balance of cells. Common Salt is the main source of Na and Cl but is limited in a natural environment and must be added to pig diets (Table 2).

2.2.7. Water

Water is one of the most vital of all nutrients. In fact, animals can survive for a longer period without feed than they can without water. Fortunately, under most conditions, it can be readily provided in abundance and at little cost. Sources of water for animals are:

i. Drinking water

ii. Water in feed and body tissues and

iii. Metabolic water which is water provided by the combustion of foodstuffs such as carbohydrates, protein, and fat in the cells (Koney, 2004).

Water is one of the largest single constituents of the animal body, varying in amount from 40% in fat hogs to 80% in newborn pigs. Water also constitutes 90% of blood. Water performs the following functions in the animal body:

i. It acts as a carrier of various substances, serving as a medium in which nourishment is carried to the cells and waste products are removed there- from (McDonald *et al*., 1988).

ii. It assists with temperature regulation in the body, e.g. cooling the animal by evaporation from the skin as perspiration.

iii. It acts as a solvent for a number of chemicals which can subsequently be detected by taste buds.

iv. It aids in gas exchange during respiration by keeping the alveoli of the lungs moist.

v. It is necessary to the life and shape of every cell and is a constituent of every fluid in the body, for example, blood and milk.

vi. It is necessary for many important chemical reactions of digestion and metabolism.

Water restrictions or deficiency leads to reduction in growth rate, reduced feed intake, poor metabolic rate and utilization of feed and reduced milk production in lactating sows.

2.3.0. 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 the pigs grow from the 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. However, English *et al*. (1988) identified other factors which affect growth and performance of pigs as feed, sex, environmental temperature, management and stockmanship. 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.

2.4. Feed and Growth Performance of Pigs

According to McDonald *et al*. (1998), 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 increased in weight and size, associated with changes in shape, until they pig reaches maturity. 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 (Mavromichalis, 2006).

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 feed the diets 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 fibre level of the diet. (Graham *et al*.1987 and Fanimo *et al*.2003) reported that addition of fibre to the diet can lead to lower apparent digestibility of starch, fat, crude protein and peptides and withhold them from absorption.

Tengan *et al.* (2012) fed 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.

2.5.0. BLOOD AND ITS COMPOSITION

According to Bone (1988), blood is a circulating tissue composed of fluid (plasma) and cells [erythrocytes or red blood cells (RBC), leukocytes or white blood cells (WBC) and platelets]. Lewis *et al*. (1998) described blood as a complex mixture that has a number of functions in the body.

Plasma

The matrix of blood is liquid plasma that contains many suspended or dissolved biochemical substances. Blood plasma, which comprises more than half of the blood's volume, is 90-92% water, 1% dissolved molecules including salt, nutrients, hormones, metabolic waste and gases. Plasma also contains 7 – 8% dissolved proteins of more than 70 different types. Lewis *et al*. (1998) stipulated that the concentration of protein in the plasma at a given time is a function of hormonal balance, nutritional status, water balance and state of health.

Blood Cells

Erythrocytes (RBC) are by far the most numerous of the formed elements (about 5 million RBC(×10/L). Their precursor forms are within red bone marrow at a rate of 2 to 3 million per second (Frandson and Spurgeon, 1992; Lewis *et al*. 2000). A matured RBC has no nucleus and therefore cannot divide or carry out metabolism.

Matured RBCs are biconcave, disc-shaped and packed with heamaglobin. RBC carries oxygen to the tissues and carbon dioxide away from the tissues due to the presence of heamoglobin. They also maintain normal pH of body fluid, and help maintain the viscosity and specific gravity of blood (Bone, 1988).

Leukocytes (WBC) are less numerous in numbers than RBC in the circulating blood (Swenson, 1970). Five types of WBC cells exist in order of abundance in normal organisms. They are; neutrophils, lymphocytes (B cells and T cells), monocytes, eosinophils and basophils. These cells offer protection against toxins, infectious organisms, and to some extent, cancer. WBCs are larger than red blood cells and retain their nuclei. They originate in the bone marrow and lymph system. (Lewis *et al*., 1998).

Thrombocytes or Platelets

In mammals, platelets are small, colourless cell fragments that live about 1 week and initiate blood clotting. Platelets originate as part of a huge bone marrow cell called a megakaeryocyte (Lewis *et al*. 1998). They secrete factors that increase local platelets aggregation, enhance vasoconstriction and promote blood coagulation.

Haematological parameters often studied are; RBC and WBC counts which deal with the number of RBC and WBC in a given blood sample, others are packed cell volume (Haematocrit) referring to the volume of packed RBC in the sample, mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC) which gives the average percentage of the mean cell size(MCV) occupied by the Hb (Swenson, 1970).

2.5.1. FEED AND BLOOD CHEMISTRY/PROFILE

The physiological responsiveness of the animal to its internal and external environments is the function of the haematological constituents. In other words, haematological parameters reflect the way and manner the animal responds to its internal and external environment,

which include feed and feeding (Esonu *et al*., 2001). According to Madubuike and Ekenyem (2006), haematological and serum biochemical assay of livestock indicate the physiological disposition of the animal to their nutrients. Hence, it is always possible to collect samples of blood from animals and analyze to find out if a non-conventional feed ingredient has had any negative effect on the blood profile or physiology of the animal.

Otsyina *et al*. (2007) fed dried cassava pulp to West African Dwarf sheep and observed that the blood parameters (PCV, Hb, RBC, WBC) of the animals fed the test diet compared with the control diets were similar (P> 0.05). The results indicated that sun dried cassava pulp has no deleterious effect on blood profile of sheep.

Ekenyem and Madubuike (2007) fed varying levels (0, 5, 10 and 15%) of *Ipomoea asarifolia* leaf meal (IALM) to grower pigs and reported that IALM had an influence on the haematological parameters such as PCV, RBC, Hb, MCV, MCH, MCHC, WBC; specifically blood clotting time as well aseosinophil, basophil and monocyte contents. The values for WBC and blood clotting time increased with increasing levels of IALM, which suggest that the leaf meal contained a substance or substances which interfered with clotting. The PCV, Hb, MCV, MCH, MCHC, levels also showed that the addition of IALM in pigs' diets reduced the values of these indices. However, the overall conclusion was that inclusion of IALM up to 15% had no deleterious impact on the haematology and serum biochemistry of growing pigs.

2.6. FEED AND CARCASS CHARACTERISTICS

The state of nutrition and the type of ingredients used in feeding livestock have effects on their carcass characteristics. Aberle *et al*. (2001) reported that pigs fully fed a concentrate

diet, tend to produce more carcass fat and eventually are less efficient in converting feed to lean meat than pigs fed slightly below *ad libitum* energy intake. Also, Attoh-Kotoku *et al*. (2007) fed maize bran to starter-grower pigs and observed that, the warm and chilled dressing percentages as well as the carcass length, the back fat thickness and loin eye area were not significantly ($P > 0.05$) different among pigs on the 4 dietary treatments. They also observed that pigs on 200 gkg^{-1} maize bran diet had slightly lower chilled dressed percentage, warm dressing percentage and loin eye area as well as slightly lower back fat thickness compared with those on 0 and 100 g maize bran kg^{-1} diet. They concluded that maize bran (MB) has no adverse effect on the growth performance and carcass characteristics of growing pigs. Armah *et al*., (2008) fed Dried Cashew Pulp (DCP) at varying levels to growing pigs and reported that carcass parameters were not significantly ($p>0.05$) different among the animals on the various diets.

2.7.0. NON-CONVENTIONAL FEED RESOURCES (NCFR) USED IN THE ANIMAL FEED INDUSTRY

Non-conventional feed resources are those feed ingredients that have not been used traditionally in animal feeding or are not normally used in commercially produced rations for animals (Devendra, 1992). A large number of agro-industrial by-products, forest wastes, aquatic wastes, crop wastes and animal wastes which have been identified, processed and used for feeding livestock are described as unconventional or non-conventional feed ingredients. Examples include; rice bran, blood meal, maize bran, cassava peel, cassava chips, discarded biscuits, cocoa pod husk and coffee pulp. Others are oil palm slurry, pito mash, groundnut skins, brewer's spent grains, bone meal, molasses, citrus pulp, yeast, copra cake and wheat bran (Rhule *et al*., 2007).

Leaves of shrubs such as *Leaucaena spp*, aquatic plants, fruits (palm fruits, pawpaw, guava, etc) and small animals such as earth worms can be used in poultry feed production (Sonaiya, 1990)

2.7.1. Need for Alternative/Non-conventional Feed Stuffs

The increasing cost of feed ingredients especially energy and protein sources has been a serious constraint to the survival of the livestock industries in developing countries including Ghana at the time of serious global economic meltdown (Olomu, 1995). The situation calls for more attention to be shifted towards the use of alternative feed ingredients or non-conventional feedstuffs that maybe locally available and many constitute waste or considered relatively cheaper as compared to conventional feed ingredients.

The village pig is observed scavenging on a wide range of items, from herbage to discarded agro-by-products. Agro-Industrial by-products (AIBP) and other edible waste materials used as total or partial replacement for important feed ingredients is seen as a way of solving the high cost of conventional feed ingredients which are scarce and thereby sustaining the livestock industry. However, their usage must be done with care. Myer and Hall (2004) reported that the following should be considered when using a by-product or edible waste as an alternative feed source:

i. It must be available and in constant supply.

ii. It should be free from potential health hazards, such as aflatoxins.

iii. It must be palatable to the animal

iv. Information on the nutrient content must be established.

v. It should not have adverse effect on the end products of the animals.

vi. Handling, processing and storage should not require extra cost.

Some impressive results have been achieved with the use of alternative or unconventional feed ingredients for feeding pigs. Armah *et al*. (2008) fed twelve Large White starter-grower pigs four different levels of dried cashew pulp (DCP) i.e. (0, 50, 100 and 150g DCP kg^{-1}) and recorded positive and significant effects on weight gain. Okai (1998) indicated that rice bran could be used as a substitute for wheat bran and also as a partial replacement for the cereal component of the diet. There had been however conflicting reports on ideal inclusion levels, which could be attributed to the extent of adulteration with the husk/hull. However, a 20% or lower inclusion level for young pigs was indicated to be satisfactory. Attoh-Kotoku *et al.* (2007) fed nine 8week-oldLarge White entire male pigs on three different levels of maize bran (MB) i.e. 0, 10 and 20kg MB /100kg diets and reported no adverse effect on growth parameters and the various carcass measurements. They concluded that MB could be included in pig starter diets up to 200g/kg^{-1} without any adverse effects on growth performance and carcass characteristics. These diets were found to be cheaper than the control diet. Similarly Okai *et al*. (1984) had earlier replaced 25% of maize with same level of cocoa pod husk (CPH) without adverse effect on pig performance and carcass characteristics but at a cheaper cost. Tengan *et al*. (2012) fed twenty Large White starter pigs five different levels of African Locust Bean fruit pulp (ALBP) (0, 5, 10, 15 and 20 kg ALBP /100 kg) and observed that the inclusion of the ALBP in the diets did not impact negatively on the growth parameters of pigs as well as the carcass characteristics except the liver, spleen and respiratory tract weights. Other NCFRs include brewer's spent grains, groundnut skin meal (GSM), cotton seed cake, sorghum spent grain (pito mash),palm kernel cake (PKK) and rubber seed cake (Okai, 1998). There are a lot more AIBP and edible wastes yet to be assessed and used for feeding livestock. Soybean milk residue (SBMR) is one of such unexploited by-products available in Ghana. This material is often discarded after the production of soybean milk and khebah. The problem in some communities is how to dispose

of the soybean milk residue. There is scanty nutritional information on the SBMR, especially on its value for pigs. Also, it is envisaged that if the nutritive potentials of SBMR and other more by-products are established, more NFCRs will be available and at a reduced cost. It will also eliminate the disposal problems of most of these by-products. Because of the low cost of these by-products, farmers will be encouraged to use them and thereby reduce the cost of pig production in Ghana and other developing countries.

2.8. Constraints in the use of Non-conventional Feedstuffs

The slow growth rate of livestock when fed some by-products has been attributed to poor feed intake and digestibility. This is so because of the high fibre content of most of these by-products which reduced intake because of their bulkiness. Some animals, especially the monogastric animals, cannot digest fibre. The low feed intake experienced with non-conventional feedstuffs, could also be attributed to low palatability of most of these by-products. Farm animals generally will eat more of a palatable diet than unpalatable feed.

Another major constraint in the use of non-conventional feedstuffs is the anti-nutritional factors (ANF) contained in most of them. Anti-nutritional factors may be defined as the chemical constituent of a feedstuff, which interferes in the normal digestion, absorption and metabolism of feeds, some of which may have deleterious effects on the animal's digestive system. Some inherent chemical compounds present in some feedstuffs interfere in the optimum utilization of nutrients especially proteins and carbohydrates and are also toxic in higher concentration. Anti-nutritional factors can be found in some conventional feedstuffs but they abound in non-conventional feedstuffs (Pathak, 1997). To make these feedstuffs safe for use, the anti-nutritional factors need to be removed or inactivated by various procedures (Korte *et al*., 1972). Some seeds often contain factors such as lectins, which are deleterious or

toxic to animals or man (Liener, 1989). Seed lectins present major problems as they are resistant to heat treatment and some seeds such as kidney bean, have to be heated for several hours at temperatures above 80^0C or boiled for 10 – 12 minutes to ensure the elimination of their lectin activity. One must therefore be extra careful in the use of these seeds as dietary materials. This is of particular importance because recent research suggests that long-term exposure to relatively low levels of some anti-nutritional or toxic factors may have serious effects on body metabolism (Grant, 1989).

Anti-nutritional factors could be classified on the basis of their chemical nature into nitrogenous compounds, saponins, tannins, acids, glucosinolate and phenolic compounds (Pathak, 1997). Others are trypsin or protease inhibitors and haemagglutinins. Soybean contains several anti-nutritional factors which include trypsin inhibitors, haemagglutinin and goitrogenic factors, all of which can be inactivated by 20 to 40 minutes of heat treatment.

2.9.0. THE SOYABEAN PLANT

2.9.1. Origin and Botany of Soybean

The soybean is a legume and belongs to the family, *Leguminosae.* It is botanically called *Glycine max.* The cultivated soybean originated from China during 2800BC. The eastern half of northern China is believed to be the primary centre and Manchuria the secondary centre of origin. From there, it had spread to Korea and Japan. It was cultivated in Europe in the 17^{th}century. Soybean production reached Africa in the late 1800s, although little is known of the countries to which it was first introduced (Onwuene and Sinha, 1991).

The cultivated soybean is an annual generally exhibiting erect, sparsely branched, bush type growth habit with pinnately trifoliate leaves; purple or white flowers are borne on short axillaries racemes on reduced peduncles. The pods are either straight or slightly curved,

usually hirsute. The one to three seeds per pod are usually ovoid to sub-spherical in shape. Seed coat colour ranges from light yellow, olive green and brown to reddish black. It is a self-pollinated species propagated commercially by seed. It has a complete flower with 10 stamens arranged around the pistil. The stigma is receptive to pollen one day before pollen is shed from anthers of the same flower.

2.9.2. Adaptation/Climatic and Soil Requirements

Soybean cultivation now extends from 52^0N to the high elevation in the tropics. Soybean is a warm – season crop and its climatic requirements are about the same as those for maize. For germination and early plant development, there is the need for a moderate moisture supply. The period of germination is the most critical stage and an excess or deficiency of soil moisture at this time could be harmful soil temperatures of 15^0C or more favour rapid germination and vigorous seedling growth which are essential for successful drought resistance after the plants are well-established. Growing temperatures of between 20^0 and 28^0C appear to be optimum. Soybean seeds produced beyond temperatures of about 32^0C tend to be low in oil quantity and quality.

Soybean plants are sensitive to light duration (photoperiod). They are short-day plants but cultivars differ markedly with respect to the minimum dark period required to induce flowering. Soybean plants need high light intensity for vigorous growth and they suffer from shading and competition for light from tall growing weeds.

Soybean can be grown on a wide range of soil types; but thrive best on sandy or clayey loams and alluvial soils of good fertility. The optimum soil pH ranges from 6.0 – 6.5. Inoculation is desirable if the crop is taken to a new area. The strain, *Rhizobium japonicum*, the nitrogen fixing bacteria in the root nodules is specific to soybeans. An annual rainfall of 850mm is recommended (Romain, 2001).

2.9.3. Distribution of Soybean

Soybean is grown on 83.69million hectares in the world to produce 189.34million tonnes (Romain, 2001). The USA tops the list in acreage and production. The other major production countries are Brazil, China, Argentina, Indonesia, Canada, Paraguay and Italy. India was fifth in 2004 with 6.50 million hectares under soybean cultivation.

2.9.4 Yield Potentials of Soybean

Soybean yields vary considerably according to the genotype, cropping system, level of agricultural intensification and environment (Romain, 2001). Throughout the world, the average soybean grain yields range from 550 to 2,200kg/ha (Mangala and Mauria, 2006; Romain, 2001). Adapted high yielding cultivators can yield from 3,500 to 5000kg/ha with good management. Work in Australia has indicated that even higher yields > 5000kg/ha can be obtained if soil moisture is kept at water holding capacity throughout the crop cycle (Mangala and Mauria, 2006). In the high input, well managed irrigated wheat-soybean rotation schemes in Zimbabwe and Zambia, yields of 5 – 6 tonnes/ha of wheat and 3 – 4tonnes/ha of soybean have been reported.

2.9.5. Nutrient Composition of Soybean

The grain of *Glycine max* contains (per 100g approximately) 59Kcal of energy, 10 g water, 40 g protein, 20 g fat (oil), 30 g carbohydrates, 220 mg Ca, 558 mg P, 3.8mg Fe, 0.4 mg thiamine, 0.17 mg riboflavin 1.5 mg niacin and 27 mg ascorbic acids. It is prominent among the grain legumes due to its high quality protein and oil. Like others grain legumes, its grain is relatively rich in lysine (5.9 – 6 – 9% of total amino acids), which makes it suitable for blending with cereals, but it is low in methionine (Romain, 2001). Most cultivars contain 18 – 22% oil with about 85% of unsaturated fatty acids which in order of importance are linoleic,

oleic and linolenic acids. Some palmatic acid, a saturated fatty acid, is also present. However, it contains several anti-nutritional factors (ANF) such as trypsin inhibitors, haemagglutin and goitrogenic factors, all of which fortunately, can be deactivated by 20 to 40 minutes of heat treatment.

2.9.6. Uses of Soybean

The soybean is a versatile crop that can be used for many purposes. Soybean is primarily utilized as the source of protein and oil. The seed contains 20% oil and 40 to 42% quality protein. Soybean oil is the most important source of fats and oil in the world market. In the USA, most of the soybean oil (90%) goes to the edible oil market and the rest is used in animal feed and industrial products. The oil is consumed as salad oil, shortening and margarine. The oil is also used for frozen desserts, cooking, shortenings, confections, icings, ice cream coating, whipped toppings and coffee whiteners. Industrial uses include soap making, paints, resins, lubricants, fuel, printing ink, lacquers and drying oil. A number of protein rich products such as soybean milk, soya saurce, and soya flour can be produced from the seed (Mangala and Mauria, 2006). After harvesting, the vegetative parts of the plants can be used for silage, hay and fodder for livestock feeding or ploughed into the soil as green manure.

Soybean meal (SBM) is another product of importance as far as the animal feed industry is concern. The SBM is one of the best and most widely-used protein supplements in animal feeding but it is highly priced in most tropical and sub-tropical countries, probably only slightly cheaper than groundnut cake among the oil-seed protein supplements. Soybean protein contains all the essential amino acids but amounts of cystine and methionine are sub-optimal and a number of toxic stimulatory and inhibitory substances including allergic, goitrogenic and anticoagulant factors may also be found (McDonald *et al*., 1992).

Toasting inactivates the inhibitors, especially for simple stomached animals. It is, however, a poor source of B vitamins which must therefore be provided if soybean meal is used consistently as a major protein supplement for monogastrict animals. Soybean meal contains 45% crude protein, 2% fat and 3.5% cellulose. The cellulose content of this cake is partly digested by monogastric animals. The SBM is adequate in magnesium, a good source of potassium and supplies a fair amount of trace elements (Ralph, 1987). Furthermore, an important by-product of soybean milk production is the SBMR, which is the material obtained after the milk is extracted, has the potential of being included in animal feed as source of protein.

2.9.7. Feeding Value of the Soybean Milk Residue (SBMR)

Odeyinka *et al*. (2007) studied growth performance and carcass characteristics of weaner rabbits comprising of New Zealand White, Chinchilla and California breeds fed four different diets; the control maize groundnut cake (CD) diet, soybean milk residue (SMRD), corn starch residue (CSRD) and cowpea testa (CTD) based diets. It was observed that there were no significant (P>0.05%) differences in the mean dry matter intakes of animals on the four diets. The mean dry matter intake (48.36g/day/animal) on the control diet (CD) was slightly lower than mean values of 48.84, 48, 80 and 49.5g/day/animal obtained from the SMRD, CSRD and CTD-based diets, respectively. Differences in the weight gains of animals on the four diets were not significant (P>0.05). Feed conversion ratio values were 4.12, 4.08, 4.35 and 4.69 for animals fed the CD, SMRD, CSRD and CTD diets, respectively. There were no significant (p>0.05) differences in the corresponding hot dressing percentage, i.e., 52.5, 52.9, 53.3 and 51.3% and the weights of the other carcass components were not significantly different (P>0.05).

Similarly, when 24 West African dwarf goats were fed four different diets comprising of a control groundnut cake-corn (GNC- C), soybean milk residue (SMRD), cornstarch residue (CSRD) and Cowpea seed waste (CSWD) diets, it was observed that the rates of live weight gains and feed conversion were similar on all diets. Digestibility of feed values were significantly ($P<0.05$) higher (i.e. 61.5, 64.3, 52.0, 55.4%) for GNC – C, SMRD, CSWD and CSRD diets, respectively. TDN was highest on the SMRD diet mainly because of higher values for digestibility of the ether extract. In an experiment to determine the effects of feeding soybean milk residue (SBMR), Cowpea seed wastes (CSW), corn starch residue (CSR) and groundnut cake-corn bran (GNC – C) on the blood parameters, temperature and carcass characteristics of West African Dwarf goats, Olubunmi *et al*. (2005) reported that there were no significant ($P>0.05$) impact on blood profiles (RBC, WBC and PCV) of animals on the various diets. They also observed that there were no significant ($P>0.05$) differences in their body temperatures and the various carcass traits among the experimental animals.

2.9.8. INFERENCES FROM THE LITERATURE REVIEWED

Pig production is highly influenced by feed cost and level of nutrition to satisfy the requirement of the animal. Feed cost constitutes 70 – 80% of the pig's production cost (Okai, 1989). For maximum growth and development, pigs must be supplied with the following nutrients in their correct proportion and quantities; carbohydrates, fat and oils; protein, minerals, vitamins and clean and fresh water.

These nutrients are present in plant leaves, legumes and some AIBPs and serve as important sources of feed for monogastric animals such as pigs and poultry. However, due to the presence of anti-nutritive factors and high moisture content as well as presence of toxins and

low palatability in some of them, care must be taken in their usage in order to minimize the adverse effects on the animal. From the literature, it is possible to formulate pig diets to achieve the required nutrients levels using non-conventional feed ingredients to either totally or partially replace some of the conventional feedstuffs and at a reduced cost. Two important factors need to be considered before the use of these NCFR. One has to do with the establishment of their nutrient composition, and the other has to do with the optimum inclusion levels. Furthermore, further treatments are required to render them safe and palatable for consumption. Several studies have suggested that the use of non-conventional feedstuffs is aimed at reducing feed cost and consequently reduce production cost. More research is on going with other AIBPs not yet used in animal feeding trials and SBMR is one of such unexploited non-conventional feed ingredients. This experiment was carried out to determine the potential yield, evaluate the nutrient composition of SBMR and the effect of graded levels of SBMR on the growth performance, carcass characteristics and blood traits of growing pigs.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1.1 Location of experiment and duration

The experiment was conducted at the Livestock Section of the Department of Animal Science Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, from 4th of October, 2011 to 3rd January, 2012.

The study area or site is located on Longitude $01^0$33 West and Latitude $06^0$11North. (Agrometeorological Division, Station no. 0601-050-17, Kumasi) and lies in the semi-deciduous forest zone. The climate is hot and humid with mean temperatures varying from 24.5^0C in August to $34.^0$C in February with an annual mean of 26.3^0C. The mean minimum monthly temperature of28^0C is recorded in December while the maximum monthly temperature (34^0C) occurs in February.

Rainfall is bimodal with major rains occurring between March and July with peak rainfall in June. After a relatively short dry spell in August, the minor season begins in September and tails off in November. This is followed by the December – February dry season. The mean annual rainfall is about 1300mm and about 55% of the rains occur between March and July.

The mean monthly minimum relative humidity maybe as low as 36% in January and as high as 96% in May. The daily relative humidity varies from 36% in January to 96% in May with an annual mean of 75%.

3.1.2. *Weather Report at the site during the period of the experiment.*

The average temperatures for October to December, 2011 were 31.20^{0}C (maximum) and 22.2^{0}C (minimum) at 09.00 hours GMT and 30.3^{0}C (maximum) and 24.70^{0}C (minimum) at 15.00 hours GMT. Average relative humidity (RH) of 84% and 58.8% were recorded for the two different times. The highest monthly total rainfall were 247.0mm and 44.9mm respectively (Agrometeorology Division, Station No. 0601-050-17, Kumasi)

3.2.2 *Feed Ingredients*

Two hundred and fifty kilogrammes (250 kg) of the dried test ingredient, SBMR, was obtained from Wiamoase, Agona, Mampong and surrounding villages in Ashanti region mainly from women who produce soybean milk and soykhebab. The processing methods used by the women involved sorting out bad seeds and other extraneous materials, soaking the beans in water for about 4 – 6hours, milling, adding water, filtering or sieving to obtain the soybean milk and finally the by-product, i.e., wet SBMR. The wet material was collected and sun-dried for about 2 – 3 days depending on the intensity of sunlight to a moisture content of about 15%. The dried SBMR was then packaged in polythene sacks and transported to the experimental site for storage until it was used for compounding diets. Fig.2. is a flow chart on the processing of soybean into soymilk. The extraction rate of the wet SBMR is 0.3 kg per every 2 kg of soybean seed processed into soymilk. With this extraction rate, it is possible to produce 1500 tonnes of SBMR from 10,000 tonnes of soybean seed processed. The collection and drying of the SBMR started on the 26th of September, 2010 and ended on 30th of August, 2011.

The rest of the ingredients; i.e. maize, wheat bran, soybean meal, fishmeal, as well as the micro ingredients; i.e. oyster shells, dicalcium phosphate, common salt and vitamin and trace

and mineral premix were purchased from shops within the Kumasi Metropolis. Fig. 2 is a flow chart on the production of soybean milk residue.

3.2.0. Processing and Procurement of Feed Ingredients

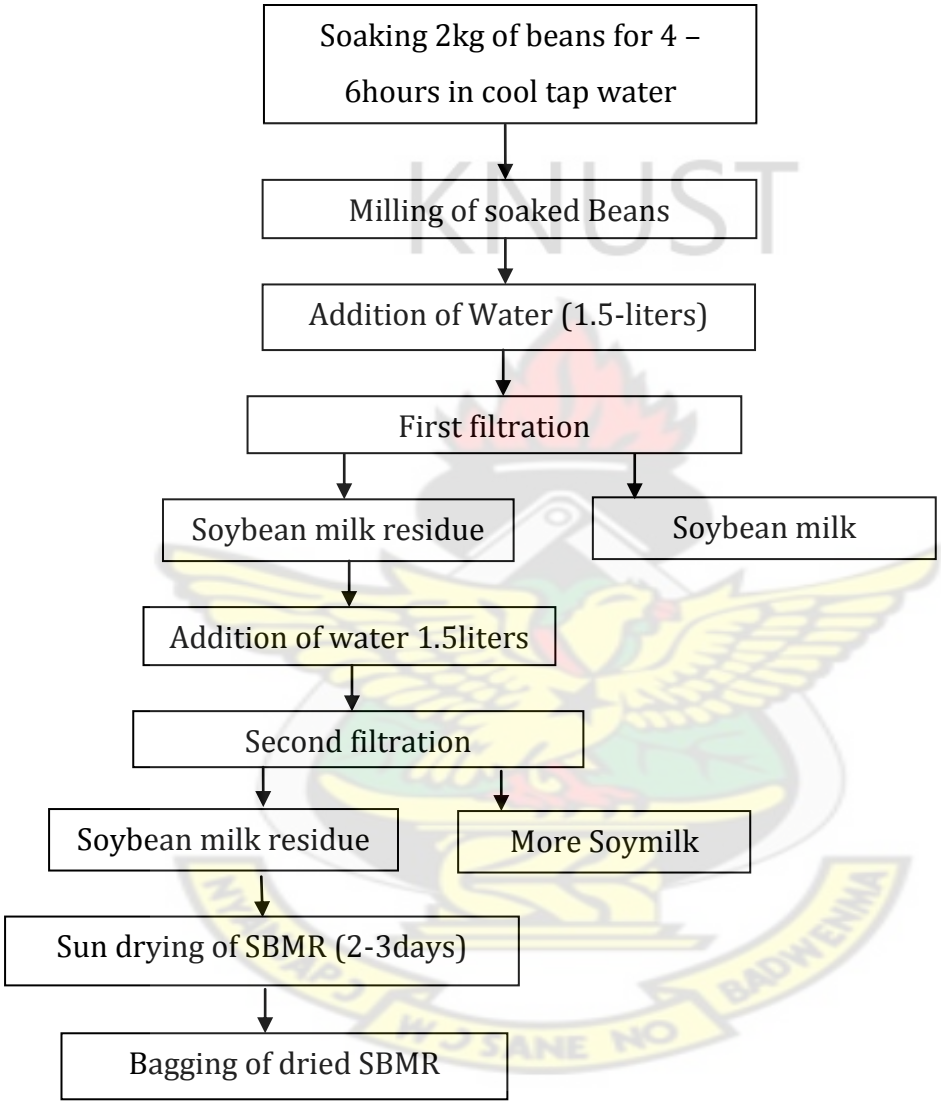


Fig. 2. A flow chart on the production of soybean milk residue.

3.3. Experimental Diets

3.3.1. *Diet Formulation and Feed Compounding.*

Four (4) isonitrogenous (18% CP) diets were formulated (Table 4) to contain 0, 5, 10 and 15% SBMR. These were labelled T1, T2, T3, and T4, respectively SBMR replacing some of the wheat bran and soybean meal. The control contains 0% SBMR. The micro-ingredients i.e. oyster shell, dicalcium, phosphate, common salt and vitamin and trace-minerals premix were added in the same amounts for the four experimental diets.

Batches of the diets were compounded to last for at least 10 days. The maize and the SBMR were ground using a hammer mill[1]with a 2mm diameter sieve. The rest of the feed ingredients were not ground. The Soybean meal, wheat bran, milled maize, SBMR and fishmeal were weighed out using a hanging scale[2], while the oyster shell, dicalcium phosphate, common salt and the vitamin and trace mineral premix were weighed using an electronic scale[3]. Compounding of the diets was carried out using a Carmen machine mixer[4]. Each compounded diet was then put in sacks and labeled appropriately.

3.3.2. Chemical Analysis of SBMR and Experimental Diets

Twenty grames of the experimental material and representative samples of the four experimental diets were taken to the Nutritional Laboratory of the Department of Animal Science KNUST, Kumasi for chemical analysis to ascertain the nutrient compositions of SBMR and the four experimental diets by the procedures of the AOAC (1990).The metabolisable energy (M.E.) was calculated using the equation of Pauzenga (1985).

Table 4: Percentage Composition of Experimental Diets

Ingredient	Dietary Treatments			
	T1(SBMR– 0)	T2 (SBMR – 5)	T3 (SBMR- 10)	T4(SBMR- 15)
Maize	59	59	59	59
Wheat bran	18	13.5	9	3
Soybean meal	13	12.5	12	11.5
SBMR	0	5.0	10	15
Fishmeal	8	8.0	8	8.5
Oyster shell	1.25	1.25	1.25	1.25
Dicalciumphosphate	0.25	0.25	0.25	0.25
Vitamin-trace mineral premix[2]	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**
CALCULATED COMPOSITION %				
Crude Protein	18.12	18.18	18.24	18.36
Crude Fibre	5.37	5.91	5.34	5.68
Ether Extract	5.47	5.59	5.72	5.83
Calcium	0.97	0.96	0.95	0.96
Phosphorus	0.97	0.72	0.79	0.61
Metabolisable Energy Kcal/kg	2,881.6	3,023.6	3,038.8	3,033.0
ANALYSED COMPOSITION %				
Crude Protein	20.7	20.5	20.1	21.0
Crude Fibre	2.31	4.09	3.95	4.57
Ash	5.50	5.00	5.00	7.00
Ether Extract	1.00	1.50	2.00	2.00

[2]Provided the following/kg diet vit. A. 12.00 iu; vitD 200iu vit E10iu vitK 0.002mg vitB1 0.002mg; vit. B2 0.0045mg;vit.B6 0.004mg;vit B120.01mg; pantothenic acid 0.012; nicotinic acid 0.003mg; folic acid 0.001mg; biotin 0.015mg; manganese 0.06mg; iodine 0.001mg; iron 0.025mg; zinc 0.05mg; copper 0.005mg; selenium 0.001 BUTYLATEDHYDROXYTOLUENE (BHT)(antioxidant)

3.3.3. *Feeding*

The pigs were watered and fed *ad libitum* throughout the experimental period. Six kg of each of the four diets was weighed into well-labeled plastic buckets placed in front of each cage and from these allowances of different quantities of feed were made to the pigs in the feeding troughs as and where the feed was depleted. The buckets were refilled when they were empty. Spilt feed was collected back into the feeding trough while wet feed was air-dried and added to the leftover feed at the end of the week to determine the weekly feed intake.

3.4.1. Experimental Animals, Design and Treatment

Twenty (20) Large White starter pigs with an overall mean initial weight of 11.88 kg and consisting of 12 females and 8 entire males were randomly selected at the Swine Unit of the Department of Animal Science, KNUST, Kumasi for the feeding trial. The randomized complete block design (RCBD) was used to assign the four experimental diets to the 20 pigs. Each treatment consisted of 3 females and 2 entire males and there was one pig per replicate and five (5) replicates per treatment. All animals were dewormed with Levamisole[5] prior to the start of the experiment.

3.4.2. Management of experimental animals.

The pigs were housed in individual160 x 66 x 104cm welded mesh, concrete- floored cages, located in an aluminium – roofed building (Plates1 and 2). A total of twenty (20) of such cages located within pens measuring 3.6 x 3.1 and1m were used. Each cage contained a concrete watering trough measuring 46 x 22 x 14cm and shallow feeding troughs measuring 46 x 23 x 13 cm; these feed troughs were used for the first two weeks and were later replaced by deeper heavier feeding troughs measuring 55 x 25 x 27cm (plate 3).

Cages, feeding and watering troughs were also washed with Denzel[4] before the start of the feeding trial. All the experimental animals were washed with Gammatox[5]during the 8th week of the feeding trial to control mange mite infestation. On the day of the start of the feeding trial the experimental pigs were weighed individually with a Gascoigne weighing scale[8] to obtain the initial weights. Other management practices such as provision of clean water and feed and regular washing of pens and cages were strictly followed.

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[4]10mg of Ivermectin per ml solution. Dosage: 1ml per 33kg bodyweight. KEPRO B.V. Holland

[1]Designed and built by Department of Agric Engineering UST, Kumasi Feb. 1986

[3]GASCOIGNE, GUSH & DENT,150kg capacity, made by precision Weighters, Reading,England

[5]Gammatox:Fenvalerate (A.I) Tech + inert ingredients100% wv. Aimco pesticides Ltd. Akandjyoti Road Santacruz (E) Mumbai, India.

[4]Denzel (Highly concentrated germicide). Contains phenols 27% w/v. Dosage: 1in 200 solution (3 table spoonfuls Dental to bucketful of water). Made by Damsu Industries Ltd. Accra Ghana.

Plate 1 Aluminum roofed pens containing cages used for the pigs' experiment

Plate 2. Metal Cages Used in Housing the Experimental Animals

plate 3 : Feed and water troughs (*left to right: Deep and heavy wooden trough, shallow feed trough and concrete water trough*)

3.5.0. PARAMETERS MEASURED

3.5.1. Feed intake

The determination of weekly feed intake (WFI) was done every Tuesday throughout the period of the experiment. The WFI was obtained by weighing back the leftover feed in the buckets, trough as well as any dried (wet) feed during the week under review for each animal and the sum was subtracted from the total weight of feed allocated to each pig. This was done using a table top weighing scale[6]. The summation of WFI for the period a particular pig stayed on the experiment was described as the total feed intake (TFI) for that pig. Mean daily feed intake (MDFI) was determined by dividing TFI by the number of days the pig remained on the experiment.

3.5.2. Live weights and live weight gains.

The initial weight of each replicate was taken at the beginning of the experiment. Subsequently, pigs were weighed every week specifically on Tuesday before feeding to determine body weight changes for the week using the Gascoigne[8] weighing scale described earlier. The mean daily weight gain (MDWG) was then calculated by dividing the weekly gain by seven (days).The live weight gained (LWG) for the week was the differences between the previous week's recorded weight and the current weight. The difference between the final weight (65± 2.5kg) and the initial weight of each pig was the total weight gain (TWG)

3.5.3. Feed conversion ratio, feed cost, and feed cost per kg gain.

Feed conversion ratio, defined as the quantity of feed (kg) consumed to gain a unit of live weight (kg), was computed as a ratio of total feed consumed to total weight gain for each pig. The cost of feed was the sum total of the cost of each ingredient used in compounding 100 kg of a diet; from this the cost per kg was calculated. The cost of transporting SBMR (from point

of drying to site of the experiment) was factored into the calculation of the SBMR cost. Labour cost was not considered as it was the same labour used for compounding all the diet. The economy of gain for each pig was calculated as the feed cost/kg live weight gain, i.e. the cost of feed required to produce a kg of weight and was computed as the product of feed cost (per kg) and the feed conversion ratio.

3.6.0. HAEMATOLOGICAL AND SERUM BIOCHEMICAL STUDIES.

3.6.1. Sample collection

All the 20 experimental animals, i.e., five pigs per treatment were bled through the anterior vena cava to collect about 7ml of blood into two labeled sterile vacutainer tubes. One contained 1.0mg/ml of ethylene diamine tetra acetic acid (EDTA) and 0.1mg/ml heparin and was used for haematological analysis, while serum from the blood from the other vacutainer tube without the EDTA (anticoagulant) was used for blood biochemical studies.

3.6.2. Haematological Examination

The SysmexHaematological Auto-Analyser[7] was used for the haematological analysis. The following parameters were measured: Haemoglobin (Hb), Haematocrit (HCT) or Packed Cell Value (PCV), Red (RBC) and White Blood Cells (WBC) counts as well as Mean Cell Haemoglobin Concentration (MCHC) and Platelets (PLTS) number.

3.6.3. Serum biochemical indices

The serum biochemical analysis was aimed at determining the levels of cholesterol, total protein, albumin and globulin. The sample of blood for the serum biochemical assay was allowed to clot at room temperature. The clotted samples were spun in the centrifuge to separate the blood cells from the serum. The serum was then used for the analysis as follows;

the total protein (TP) was determined using Biuret method as described by Kohn and Allen (1995). Albumin was determined using the Bromocresol Green (BCG) method. Total cholesterol (TC) was estimated using the CHOP-PAP method as described by Peter *et al.* (1982). The globulin content was determined by subtracting albumin from the total protein. Other parameters measured were, Low Density Lipoprotein (LDL) and High Density (HDL) cholesterol and Triglycerides.

[6]CAMRY Scale of 441bs x 202/20kg x 50g capacity made in China.

[7]Mindray, Auto HaematologyAnalyser.ShenzhenMindray Bio-medical Electronics Co. Ltd. Mindray Building, Kej. 12th Road South, Hi-tech IindustriesPark Nanshan, Shenzhen, 5780, 57. P – R China.

3.7.0 CARCASS EVALUATION

3.7.1. Slaughtering of Pigs

Each experimental pig was slaughtered when it attained the target weight of 65 ±2.5kg on a weighing day. The slaughtering was done at the Meat Processing Unit of the Department of Animal Science, KNUST. The electric stunner was used to stun the pigs and a sharp knife was then used to slit the anterior vena cava and bicarotid trunk and the pigs allowed to bleed. Pigs were scalded with hot water (80^0C) immediately after bleeding and the remaining hairs were singed with a gas burner. The carcasses were then hung, washed and eviscerated.

3.7.2. Warm Carcass Parameters

(i) Dressed Weight: Warm dressed weight was determined as the whole carcass weight after the removal of the viscera, head and trotters using a hanging scale. Each head and set of trotters were weighed separately. The viscera (internal organs) were collected into a bucket and after washing off the clots of blood and fluids, the weight was determined and recorded. The liver, kidneys, heart, spleen, as well as the respiratory tract were separated and weighed individually using a table top scale.

The weights of the full GIT plus its content and then the empty GIT were taken after which the empty stomach when emptied of its content was weighed.

(ii) Relative weights of viscera, GIT (full and empty), heart, liver, kidney, respiratory tract and spleen were determined. The relative weight of the above components of the carcass was defined as the weight of the component expressed as a percentage of the live weight at slaughter.

3.7.3. Chilled carcass parameters

The following parameters were taken after the overnight chilling of each carcass in a cold room (4^0C):

(i) Chilled dressed carcass weight was the weight of the whole carcass (without the head viscera and trotters). Each chilled carcass was then split into two equal halves along the vertebral column and the right half was then used to determine the following parameters:

(a) Carcass length-this was taken from the right half of a hanging carcass and was the distance between the anterior edge of the first rib and the anterior edge of the aitch bone (Os pubis)

(b) Absolute weights of loin, thigh, shoulder, belly, fillet and leaf fat. The leaf fat was detached and weighed and each chilled carcass was then portioned into the shoulder, belly, loin, thigh and filet. The absolute weights were measured on a table top scale and subsequently, the relative weights were computed as the weight of a particular body component expressed as a percentage of live- weight at slaughter.

(ii) Back fat thickness

The average of the thickness of the back-fat measured from three points, viz, the first rib, the last rib and rump described as the back-fat thickness.

(iii) The P_2 value was estimated by measuring the back-fat depth at the P_2 position which was taken 6.5cm from the dorsal midline and at the head of the last rib.

3.8. STATISTICAL ANALYSIS

All data collected were subjected to analysis of variance (ANOVA) using Genstat Statistical software (Discovery Edition 3) and comparison among treatment means were made by the Duncan's New Multiple Range test (Steel and Torrie, 1980). The 5% probability level was used for determining significance among treatments.

CHARTER FOUR

4.0 RESULTS AND DISCUSSION

4.1. Chemical Composition of Dried SBMR

The chemical composition of the SBMR is shown in Table 3. The crude protein and ether extract values of 20.1% and 8%, respectively were slightly lower than those recorded by Desmond (1999) who recorded25% crude protein and 10% ether extract. The differences in the values could be attributed to differences in processing methods, variety of soybean used and harvesting time and probably drying methods employed. The crude fibre content of 19.34% is slightly higher as compared to that of maize 9.3%

Table 5. Chemical Composition of Dried SBMR

Crude protein	20.1%
Crude fibre	19.34%
Ether extract	8%
Nitrogen free extract	53%
Ash	1.75%

4.1.1. *Proximate Composition of Experimental Diets*

Table 5 summarizes the calculated and analyzed chemical composition of the experimental diets. The analyzed crude protein (CP) values of the diets on DM basis were higher than the calculated values. The variation in values could be attributed to the differences between the nutrient compositions of the ingredients used in compounding the diets and values given by the nutrient composition tables. There were no consistent trends in the analyzed values for CP, CF, EE, and NFE as the level of SMBR increased. There were, however, a consistent

trend in the calculated values for the CP, CF, EE and ME. The extraction rate is 15% per every 2kg of soybean seed processed in to soya milk. With this extraction rate it is possible to produced 1500tonnes of SBMR from 100000tonnes of soybean produced.

4.2.0. PERFORMANCE CHARACTERISTICS

4.2.1. Health of pigs.

All the animals were generally healthy throughout the experimental period and readily consumed their allowances of the experimental diets. However, three pigs, one on the control diet (T1) and two on diet T2 had mange infestation. This condition was observed during the 8th week of the experiment. To reduce the rate and the intensity of the mange infestation, all pigs were treated with an acaricide called Gammatox. No mortalities were recorded in the study. This is consistent with the findings of Odeyinka *et al* (2007) who recorded no mortality when they fed weaner rabbits with diet containing up to 25% SBMR.

4.2.2. Growth Performance of Pigs

A summary of the growth performance data of the pigs fed the varying levels of SBMR is presented in Table 6. Average daily feed intake (ADFI), total feed intake (TFI), average daily weight gain (ADWG), feed conversion ratio (FCR) and the duration of feeding did not manifest dietary influences.

Table 6: Growth performance of starter- grower pigs fed SBMR-based diets

	Dietary Treatments					
Item	**0%SBMR**	**5%SBMR**	**10%SBMR**	**15%SBMR**	**LSD**	**SIG**
No of pigs	5	5	5	5		
Initial weight, kg.	11.80	11.90	11.90	11.90	2.027	NS
Final weight, kg.	63.80	64.20	65.10	63.70	1.881	NS
Mean daily feed intake, kg/pig.	1.754	1.744	1.780	1.778	0.195	NS
Mean total feed Intake, kg/pig	139.1	135.9	136.7	139.0	12.19	NS
Total weight gain, kg.	52.00	52.30	53.20	51.80	2.795	NS
Daily weight gain, kg.	0.656	0.676	0.694	0.664	0.063	NS
Feed conversion ratio (feed/gain)	2.678	2.598	2.570	2.686	0.219	NS
Feed cost,GH ¢/kg.	0.698	0.682	0.665	0.654		
Feedcost/kg live weight gain, GH¢.	1.870	1.770	1.710	1.756	0.151	NS
Duration, days.	79.8	78.4	77.0	78.4	8.58	NS

LSD – Lest Significant Difference

SIG – Significance Level. **NS** – Not significant

Total Feed Intake

The mean total intake of the pigs on the four diets did not show any significant (P>0.05) differences (Table 6). The test material SBMR had a very good aroma as well as the fish meal and the soybean meal. This could have rendered the diets more palatable and possibly enticed the pigs to eat more of the diets. This assertion agrees with that of Anyika *et al*. (2009) who had earlier stated that feed intake can be influenced by level of palatability, source of nitrogen and the level of essential amino acids.

Mean daily feed intake

The different dietary treatments did not impact significantly (P>0.05) on the daily feed intake suggesting that pigs will readily consume diets containing up 15% SBMR. Pigs on the four treatment consumed similar amounts of feed on daily basis. Table 4 indicates that the energy content of the experimental diets were similar. Pigs, like other monogastric animals, generally eat to satisfy an inner metabolic need for energy and will therefore eat similar amount of diets containing similar levels of energy.

Live weight changes

The mean initial weight (MIW), final weights (FW) and the total weights gain (TWG) did not indicate any statistical(P >0.05) differences among treatment means. Based on the termination criteria, a pig was slaughtered when it attained a live weight of 65±2.5kg hence non-significant (P>0.05)differences in the TWG of 52.0, 52.30, 53.20 and 51.80 for treatments T1, T2, T3, and T4, respectively. The ADWG values were 0.65, 0.67, 0.69 and 0.66 for the corresponding treatments T1, T2, T3 and T4. Treatment T3 had the highest ADWG value of 0.69 as compared to other treatments.

Feed conversion ratio (FCR) and feed cost

The FCR values obtained i.e. T1: 2.68, T2: 2.60, T3: 2.57and T4: 2.58 were statistically (P>0.05) not significant. However, the figures obtained for T3 and T4 were better than those for the control diet (T1) and T2. Feed cost per/ kg decreased with increasing levels of SBMR for the dietary treatments (i.e.GH¢0.698>GH¢0.682> GH¢0.665>GH¢0.654 for treatments T1, T2, T3 and T4, respectively. The total feed cost (TFC) values of 97, 93, 91 and 91 for T1, T2, T3 and T4, respectively shown in fig 3 were similar and did not show a reducing order numerically. Based solely on the TFC, it is evident that the control diet (T1) was the most

expensive diet to feed. The cost of feed to produce 1kg of pork was lowest for pigs on T3 due to a slightly better feed conversion ratio and the highest for the pigs fed the control diet(¢1.87/kg.)

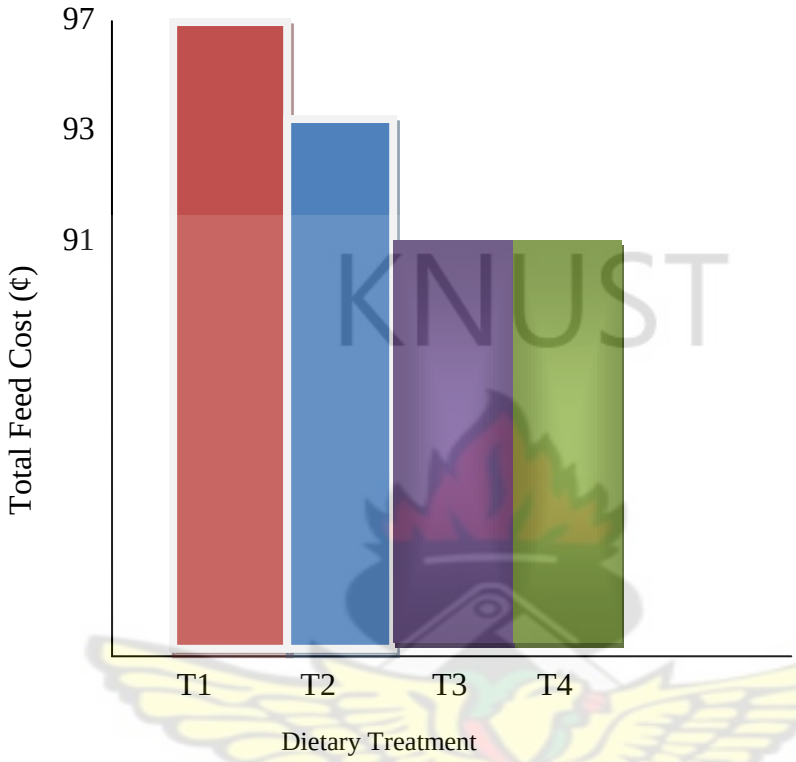

Fig. 3. A Histogram showing Total Feed Cost

4.3.0. CARCASS CHARACTERISTICS

Absolute carcass parameters

Table 7 shows that the values for the carcass parameters measured; Live weight at slaughter, warm carcass weight, chilled carcass weight, dressing percentages as well as the carcass length were statistically (P>0.05) similar. The values were 63.0, 64.2, 65.1 and 63.7 kg (live weight at slaughter), 42.10, 43.60, 43.20 and 42.50 kg (warm carcass weight), 40.80, 41.90, 42.30 and 41.54 kg (chilled carcass weight) and 71.18, 70.38, 71.86 and 70.80 kg (carcass length). Probably this was as a result of the termination criteria used, i.e., all pigs were

slaughtered when they attained the stipulated live weights of 65± 2.5 kg. It also suggests that the test diets had the same nutritional effects to those of the control diet.

The data obtained for the other carcass measurements i.e. weight of thigh, shoulder, belly, fillet, head, trotters, back-fat thickness and P2 were also observed to be similar (P>0.05). The values were 6.060, 6.320, 6.280 and 6.320 kg (thigh), 3.650, 3.820, 3.690 and 3.510 kg (shoulder), 3.830, 3.960, 4.000 and 3.880 kg (belly), 0.290, 0.300, 0.300 and 0.290 (fillet), 4.560, 4.720, 4.700 and 4.600 kg (head) and 1.16,1.100, 1.200 and 1.046 cm (back fat thickness). This is consistent with Okai *et al. (*2000) who reported no significant (P>0.05) differences in the relative and absolute weights of shoulder when they fed diets containing varying levels (20, 30 and 40%) of wheat bran plus an exogenous enzymes to grower - finisher pigs. However, the loin values obtained from the different treatments showed a significant (P<0.05) difference between treatments T3 (6.69 kg) and T4 (6.13 kg). The values obtained for T1 (6.230) and T2 (6.320) were also superior to the values obtained for T4. The carcass characteristics were similar to those reported by Armah *et al.* (2008) who fed varying levels (0 g, 50 g, 100 g, and 150 g/kg) of Dried Cashew Pulp to starter-grower pigs. This study has shown that the test diets are as good as the control diet. The values for the internal organs, i.e. liver, spleen, kidney, heart, respiratory tract, stomach, full GTI and Empty GIT were also not influenced significantly (P>0.05) by the dietary treatments. Tengan *et al.* (2011) observed a similar pattern when they fed varying levels of African Locust Bean Fruit pulp to growing pigs.

Table 7 ABSOLUTE (Kg) AND RELATIVE VALUES (%) OF SOME BODY COMPONENTS

Dietary Treatments						
Parameter-Absolute values (kg)	T_1	T_2	T_3	T_4	LSD	SIG
No. of Pigs	5	5	5	5		
Live weight at slaughter	63.0	64.2	65.1	63.7	2.842	NS
Warm carcass	42.10	43.60	43.20	42.50	1.912	NS
Chilled carcass	40.80	41.90	42.30	41.54	2.242	NS
Carcass length (cm)	71.18	70.38	71.66	70.80	2.323	NS
Leaf Fat	0.520	0.520	0.460	0.500	0.176	NS
head	4.560	4.720	4.700	4.600	0.311	NS
Trotters	0.920	1.040	1.020	1.020	0.192	NS
Thigh	6.060	6.320	6.280	6.320	0.414	NS
Shoulder	3.650	3.820	3.690	3.510	0.324	NS
Loin	6.230	6.320	6.690	6.130	0.518	NS
Belly	3.830	3.960	4.000	3.880	0.383	NS
Fillet	0.290	0.300	0.300	0.290	0.023	NS
Back fat thickness (cm)	1.160	1.100	1.200	1.046	0.211	NS
P2 (cm)	0.620	0.600	0.700	0.700	0.173	NS
Viscera	9.45	9.43	10.22	9.58	0.852	NS
GIT Full	6.46	6.25	6.72	6.00	0.745	NS
GIT Empty	2.950	2.800	2.980	2.864	0.358	NS
Respiratory tract	1.020	1.040	1.100	1.060	0.133	NS
Stomach	0.460	0.500	0.540	0.470	0.062	NS
Liver	1.400	1.360	1.470	1.480	0.209	NS
Spleen	0.120	0.120	0.100	0.140	0.058	NS
Heart	0.200	0.200	0.210	0.200	0.015	NS
Kidney	0.250	0.230	0.280	0.260	0.058	NS
RELATIVE VALUES (%)						
Head	4.560	4.720	4.700	4.600	0.421	NS
Viscera	9.45	9.43	10.28	9.48	1.137	NS
Full GIT	10.12	9.73	10.28	9.48	1.111	NS
Empty GIT	4.502	4.360	4.578	4.496	0.581	NS
Heart	0.312	0.312	0.322	0.310	0.025	NS
Liver	1.81	2.120	2.252	2.324	0.673	NS
Kidney	0.392	0.356	0.426	0.406	0.093	NS
Spleen	0.188	0.184	0.154	0.222	0.211	NS
Empty stomach	0.916	0.776	0.826	0.730	0.289	NS
Leaf fat	0.520	0.520	0.460	0.500	0.172	NS

LSD – Least significant difference.**Sig** – Significance level **NS** – Not significant ***** Significant at 5% **a, ab**- means in the same row with different superscripts differ significantly (p>0.05)

Relative weights of some body components.

The mean relative weights of the heart, kidney, spleen, stomach, GIT (full and empty), liver and leaf fat have also been summarized in Table4. The values did not indicate any significant differences (P>0.05) among the treatment means.

This is similar to the observations of Adesehinwa *et al*. (2009) who fed finishing pigs, diets containing rice mill by-products with or without Allzyme® SSF supplementation as a substitute for wheat bran at levels up to 30% and reported non-significant (P>0.05) differences in the relative values for some carcass traits.

However, the relative values for lungs and stomach were numerically better with the test diets as compared to the control diet. This confirms the results of the studies conducted by Fanimo *et al*. (2003) to determine the growth performance and carcass characteristics of growing rabbits fed cashew apple waste and indicated that the kidney and liver weights increased as the level of cashew apple waste in the diets increased.

4.4.0. HAEMATOLOGICAL AND SERUM BIOCHEMICAL STUDIES.

Haematological Analysis

Haematological profiles are good indicators of health and disease conditions in farm animals, consequently blood samples were analyzed to ascertain whether the dietary treatments had any effects on the blood profile of the pigs. Most of the haematological indices recorded in this present experiment and presented in Table 6 are within the normal ranges reported by Siegmund and Fraser (1982). Significant differences (P>0.05) were observed between the treatments means for Hb. The average Hb concentration of the pigs on diets T3 (13.50gd/L) and T4 (14.12gd/L were statistically (P>0.05) similar but lower (P>0.05) than the value for pigs on diet T2 (14.38gd/L). The difference observed may be due to individual differences in

haemotopoiesis (haemoglobin synthesis) and/or differences in RBC count. The results shows that the T2 with highest haemoglobin value also had the highest RBC count. Davies (1961) noted that haemoglobin is found in the RBC and make up to about 90% of the protein found those cells. It is worth noting that all the values obtained were within the normal range for pigs as stated by Friendships *et al*. (1984). These values were also similar to those reported by Tengan *et al*. (2012) who fed dried Africa locust bean pulp (ALBP) to growing pigs. The mean cell haemoglobin concentration (MCHC) for T1, T2, T3 and T4 were 28.84, 29.00, 28.82 and 28.92g/dl, respectively. There were no significant differences ($p>0.05$) among the treatment means. The MCHC values were within the normal ranges for pigs as stated by Eze *et al*. (2010), but lower than those reported by Frienship *et al*. (1984) and higher than those recorded by Rispat *et al*. (1993). The differences could be as a result of the environmental, seasonal, diet and other factors (Harapin *et al*. 2003).

Table (6): Some Haematological and Serum Biochemical Parameters of the Pigs.

	DIETARY TREATMENTS					
Item	Ti	T2	T3	T4	LSD	SIG
No. of Pigs	5	5	5	5		
Haematological Indices						
Haemoglobin (g/dL)	13.56	14.42	13.38	14.12	1.528	NS
HCT(pg)	46.82	49.08	46.76	48.88	5.24	NS
RBC($\times 10^{12}$L)	7.32	7.78	7.36	7.68	0.851	NS
WBC($\times 10^{9}$L)	17.66	16.30	14.78	16.80	4.712	NS
MCV(fL)	54.4	63.0	63.4	63.4	15.36	NS
MCH (pg)	18.60	18.46	18.26	18.34	0.859	NS
MCHC(g/dL)	28.84	29.00	28.82	28.92	0.811	NS
Platelets ($\times 10^{9}$/L)	307	251	359	306	107.6	NS
Serum Biochemical Assay						
Cholesterol (mmol/L)	2.240	2.220	2.160	2.160	0.223	NS
Triglycerides (mmol/l)	0.960	0.800	0.980	1.040	0.401	NS
HDL (mmol/l)	0.920	0.880	0.760	0.940	0.177	NS
LDL (mmol/l)	0.460	0.480	0.440	0.380	0.236	NS
Protein(g/l)	91.60	92.60	92.40	91.00	2.740	NS
Albumen (g/l)	50.00	50.80	52.20	51.00	2.468	NS
Globulin (g/l)	41.02	41.80	39.60	39.60	4.610	NS

LSD – Least significant difference. **Sig** – Significance level **NS** – Not significant ***** Significant at 5% **a, b**- means in the same row with different superscripts differ significantly (p>0.05)

The mean RBC values were 7.32, 7.78, 7.36 and 7.68 × 10^9/L for T1,T2, T3 and T4 in that order. These values did not show any significant differences (p>0.05) among treatment means but within normal range of RBC values. The mean MCV, MCH and HCT values were 54.4, 63.02, 63.36 and 63.42fL (MCV), 18.60, 18.46, 18.26 and 18.34pg (MCH) and 46.82, 49.08, 46.76 and48.88 pg (HCT) for the control, T2, T3 and T4 dietary treatment, respectively (Table 6). Again, there were no significant (p>0.05) differences between the means for the MCV, MCH and HCT values. These findings are in agreement with those reported by Angaeline and Madubuike (2004) and Alu *et al*. (2011).The values for WBC were; 17.66, 16.40, 14.78 and 18.0 ×10^{12}/L for T1,T2, T3 and T4, respectively. The WBC values were not significantly different (p>0.05) among the four dietary treatments studied. The results show that platelets levels were also not significantly (p>0.05) influenced by the four dietary treatments. In his experiment, Tengan *et al*. (2012) obtained 144.20, 155.20, 159.80,138.50 and 157.50×10^9/L as blood platelets values, but the values obtained in this current study were higher i.e. 307, 244, 359, and 279×10^9L for T1, T2, T3 and T4 respectively. However, in spite of the higher figures recorded in this current study the test material did not seem to have any negative effects on the pigs. The differences in the values could be attributed to time of day when blood samples were taken, state of the animal and other environmental factors. Swenson (1970) reported that among other things, exercise, excitement, stage of estrus cycle, time of day, environmental temperature and other factors could bring about variations in haematological indices of pigs.

Serum Biochemical Assay

The results for the serum biochemical assay for protein, albumen, cholesterol, globulin and high and low lipoproteins are shown in Table 8. The serum protein, globulin, albumen and total cholesterol levels did not indicate significant (P>0.05) differences between treatment

means. High density lipoprotein (HDL) did not also registered any significant ($P<0.05$) differences between the treatments. Even though total cholesterol levels were not significantly different ($p>0.05$), there was a decreasing trend as the level of SBMR increased and this could suggest a dietary influence. This observation is in agreement with Desmond *et al*. (1999), who reported that SBMR (Okara) has proven to reduce cholesterol levels in pork in a study on the characteristics and uses of SBMR from soymilk. The values obtained in this experiment, i.e., 2.240, 2.220, 2.160, and 2.160mmol/l were far below those reported by Tengan *et al*. (2012). Akinfala and Tewe (2001) fed growing pigs with varying level of whole cassava plant and recorded no significant ($p>0.05\%$) differences across the treatments means of the various serum biochemical parameters.

5.0. GENERAL DISCUSSION

Most often than not the introduction of an entirely new feed ingredient to livestock especially pigs will lead to decrease feed intake and associated indigestion problems. However, in this experiment the pigs on the SBMR based diets readily consumed the feed just like those on the control diet. The SBMR by itself has a very good aroma and it taste good hence its high acceptability by the pigs. On the basis of this therefore it will make a very good feed ingredient for pigs in areas where it will be available.

With an extraction rate of 0.3 kg per every 2 kg of soybean processed into soymilk estimated to be about 15%, it is possible to produce 4500tonnes of SBMR from every 30000tonnes of soybean processed into soymilk and other products. Production levels could be increased if small holder soymilk producers come together to form cooperatives societies and establish small scale processing industries to process soybean in to soymilk. With this large quantities of SBMR which will be produced and with the establishment of SBMR production centers and improved methods of drying, tonnes of dried SBMR would be produced for the animal feed industry just as with fish meal and wheat bran. With this the expectation is that, in future, production levels could reach 100000metric tonnes from medium to large scale processing.

The SBMR is produced without any form of heating hence there may be presence of anti-nutritional factors such as trypsin inhibitors which may inhibit the availability of essential nutrients such as protein. This problem may be solved by adding exogeneous enzymes to the feed. The incorporation of various enzymes into pig diets is a relatively new concept. However, if their production costs can be reduced through biotechnological synthesis or some other practical procedure, the practice might become universal. Some prospects are: proteases

to make protein more available; B-glucanase to break down complex cereal starches to glucose; cellulase to digest plant cell walls; and phytases to liberate tightly bound phosphates. Any of these enzymes could liberate specific nutrients from plant materials so that these are available to the animals in greater quantities. Adesehinwa *et al*. (2010) fed finishing pigs with rice mill by-product (RMBP) with or without allzyme R SSF supplementation as a substitute for wheat bran and reported that Allzyme SSF enhanced the digestibility and utilization of the RMBP based diets. Sheppy (2001) stated that exogeneous enzymes are feed addative together with animal drugs, growth promoting minerals, organic acids and probiotics. Sheppy (2001) further stated that the primary objective of adding enzymes to animal feeds is to improve the utilization of nutrients in feedstuffs. According to Phillipes (2010), protaese are of particular interest because protein is the second most expensive item in animal diets next to energy. Protaese enzyme supplementation is thought to be beneficial particularly to young pigs (4-6weeks of age) due to the fact that the proteolytic and amylolytic digestive system is not fully developed. Moeser and van Kempen(2002) reported that the inclusion of the fiber degrading carbohydrase improved dry matter digestibility by 2% and energy digestibility by 3% while decreasing fecal output. With the addition of exogeneous enzymes, the nutritive value of SBMR could be enhanced. There is the need for further research in to the nutrient composition of the SBMR in order to establish the amino acids present.

CHAPTER FIVE

6.0. CONCLUSION AND RECOMMENDATIONS

6.1. CONCLUSIONS

The study was undertaken to establish the nutrient composition and extraction rate of SBMR and the effects of varying levels of SBMR on growth performance, carcass characteristics and blood profile of starter- grower pigs. The study revealed that SBMR contains 20.1% crude protein and 19.34% crude fibre. The SBMR was readily acceptable to pigs and they consumed their allocation of the four diets. Diet (SBMR – 10%) gave the optimum growth performance. However, Diets T1 and T2 with SBMR inclusion levels of 0% and 5% respectively, were statistically similar in terms FWG, TG and mean daily weight gain (ADWG). Diets SBMR – 10% and SBMR – 15% registered the lowest TFC among the SBMR – containing diets and the cheapest among the four experimental diets, calculated based on the prevailing market prices of the feed ingredients used. It was also established that the levels of the SBMR in the experimental diets did not indicate any adverse effect on the health and physiology of the pigs. The SBMR inclusion levels in the diets did not have any influence on the carcass characteristics and internal organs of pigs. Finally, SBMR inclusion did not impact negatively on the haematological and blood biochemical indices of the pigs. The SBMR can serve as good protein and energy feed ingredient for monogastrics and its use as feed ingredient will help reduce the use of conventional feed ingredients such as wheat bran and soybean meal by 83% and 11.5%, respectively. This will also help to solve the problem associated with the disposal of SBMR.

5.2 RECOMMENDATIONS

1. From the study conducted, up to 15% inclusion levels i.e. 83% and 11.5% replacement for wheat bran and soybean meal respectively is profitable levels and are recommended for pig farmers in Ghana and wherever SBMR is available worldwide.

2. Higher levels of SBMR in pigs' diets could be carried out in future pig experiments.

3. Restricted feeding of wet SBMR–based diets could also be considered in future pig experiments.

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APPENDIX

Analysis of variance

Variate: BELLY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.27075	0.27075	3.35	
SEX.*Units* stratum					
TREAT	3	0.08837	0.02946	0.36	0.780
Residual	15	. 0.21225	0.08082		
Total	19	1.57137			

Analysis of variance

Variate: BACK FAT THICKNESS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00003	0.00003	0.00	
SEX.*Units* stratum					
TREAT	3	0.06853	0.02285	0.93	0.450
Residual	15	0.36829	0.02455		
Total	19	0.43685			

Analysis of variance

Variate: CARCASS_LENGTH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	8.16	8.164	2.75	
SEX.*Units* stratum					
TREAT	3	4.462	1.487	0.50	0.687
Residual	15	44.524	2.968		
Total	19	57.150			

Analysis of variance

Variate: CHILLED_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.243	0.243	0.09	
SEX.*Units* stratum					
TREAT	3	6.093	2.031	0.73	0.548
Residual	15	41.489	2.766		
Total	19	47.825			

Analysis of variance

Variate: DRESSED_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.019	0.019	0.01	
SEX.*Units* stratum					
TREAT	3	6.850	2.283	1.13	0.367
Residual	15	30.181	2.012		
Total	19	37.050			

Analysis of variance

Variate: EMPTY_GIT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00290	0.00290	0.04	
SEX.*Units* stratum					
TREAT	3	0.10094	0.03365	0.48	0.703
Residual	15	1.05802	0.07053		
Total	19	1.16185			

Analysis of variance

Variate: FILLET

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.000021	0.000021	0.02	
SEX.*Units* stratum					
TREAT	3	0.000500	0.000167	0.13	0.940
Residual	15	0.018979	0.001265		
Total	19	0.019500			

Analysis of variance

Variate: FULL_GIT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.595	0.5950	1.95	
SEX.*Units* stratum					
TREAT	3	1.4064	0.4688	1.53	0.247
Residual	15	4.5850	0.3057		
Total	19	6.5864			

Analysis of variance

Variate: HEAD

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.78408	0.78408	14.78	
SEX.*Units* stratum					
TREAT	3	0.08950	0.02983	0.56	0.648
Residual	15	0.79592	0.05306		
Total	19	1.66950			

Analysis of variance

Variate: HEART

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0001875	0.0001875	1.55	
SEX.*Units* stratum					
TREAT	3	0.0003750	0.0001250	1.030.	406
Residual	15	0.0018125	0.0001208		
Total	19	0.0023750			

Analysis of variance

Variate: KIDNEY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.005333	0.005333	2.89	
SEX.*Units* stratum					
TREAT	3	0.006500	0.002167	1.17	0.352
Residual	15	0.027667	0.001844		
Total	19	0.039500			

Analysis of variance

Variate: LEAF_FAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00833	0.00833	0.49	
SEX.*Units* stratum					
TREAT	3	0.01200	0.00400	0.24	0.870
Residual	15	0.25467	0.01698		
Total	19	0.27500			

Analysis of variance

Variate: LIVER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.05852	0.05852	2.44	
SEX.*Units* stratum					
TREAT	3	0.04938	0.01646	0.69	0.574
Residual	15	0.35948	0.02397		
Total	19	0.46737			

Analysis of variance

Variate: LOIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.2784	0.2784	1.88	
SEX.*Units* stratum					
TREAT	3	0.8911	0.2970	2.01	0.156
Residual	15	2.2161	0.1477		
Total	19	3.3856			

Analysis of variance

Variate: LUNGS

Source of variation	d.f.	s.s	.	m.s.	v.r.	F pr.
SEX stratum	1	0.027000		0.027000	2.79	
SEX.*Units* stratum						
TREAT	3	0.017500		0.005833	0.60	0.623
Residual	15	0.145000		0.009667		
Total	19	0.189500				

Analysis of variance

Variate: P2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00075	0.00075	0.05	
SEX.*Units* stratum					
TREAT	3	0.04150	0.01383	0.84	0.493
Residual	15	0.24725	0.01648		
Total	19	0.28950			

Analysis of variance

Variate: RESPIRATORY_TRACT

Source of variation	d.f.	s.s.	m.s.	v.r	. F pr.
SEX stratum	1	0.027000	0.027000	2.79	
SEX.*Units* stratum					
TREAT	3	0.017500	0.005833	0.60	0.623
Residual	15	0.145000	0.009667		
Total	19	0.189500			

Analysis of variance

Variate: SHOULDER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.03502	0.03502	0.61	
SEX.*Units* stratum					
TREAT	3	0.24438	0.08146	1.41	0.279
Residual	15	0.86698	0.05780		
Total	19	1.14638			

Analysis of variance

Variate: SPLEEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.000333	0.000333	0.18	
SEX.*Units* stratum					
TREAT	3	0.004000	0.001333	0.72	0.554
Residual	15	0.027667	0.001844		
Total	19	0.032000			

Analysis of variance

Variate: STOMACH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.000021	0.000021	0.01	
SEX.*Units* stratum					
TREAT	3	0.019375	0.006458	3.03	0.062
Residual	15	0.031979	0.002132		
Total	19	0.051375			

Analysis of variance

Variate: THIGH

Source of variation	d.f.	s.s.	m.s.	v.r	F pr.
SEX stratum	1	0.00075	0.00075	0.01	
SEX.*Units* stratum					
TREAT	3	0.23350	0.07783	0.82	0.500
Residual	15	1.41525	0.09435		
Total	19	1.64950			

Analysis of variance

Variate: TROTTERS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.03333	0.03333	1.65	
SEX.*Units* stratum					
TREAT	3	0.04400	0.01467	0.73	0.552
Residual	15	0.30267	0.02018		
Total	19	0.38000			

Analysis of variance

Variate: VISCERA

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	4 .0150	4.0150	10.06	
SEX.*Units* stratum					
TREAT	3	2.0830	0.6943	1.74	0.202
Residual	15	5.9890	0.3993		
Total	19	12.0870			

GROWTH PERFORMANCE OF PIGS

Analysis of variance

Variate: AVERAGE DAILY GAIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.027000	0.027000	12.32	
SEX.*Units* stratum					
TREAT	3	0.004095	0.001365	0.62	0.611
Residual	15	0.032880	0.002192		
Total	19	0.063975			

Analysis of variance

Variate: AVERGE DAILY INTAKE

Source of variation	d.f	.s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.03640	0.03640	1.74	
SEX.*Units* stratum					
TREAT	3	0.00476	0.00159	0.08	0.972
Residual	15	0.31412	0.02094		
Total	19	0.35528			

Analysis of variance

Variate: COST/GAIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.05461	0.05461	4.35	
SEX.*Units* stratum					
TREAT	3	0.06814	0.02271	1.81	0.189
Residual	15	0.18851	0.01257		
Total	19	0.31125			

Analysis of variance

Variate: DURATION

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	320.13	320.13	7.99	
SEX.*Units* stratum					
TREAT	3	19.60	6.53	0.16	0.920
Residual	15	601.07	40.07		
Total	19	940.80			

Analysis of variance

Variate: FEED CONVERSION RATIO

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.12160	0.12160	4.62	
SEX.*Units* stratum					
TREAT	3	0.05014	0.01671	0.63	0.604
Residual	15	0.39508	0.02634		
Total	19	0.56682			

Analysis of variance

Variate: FINAL_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	11.408	11.408	5.86	
SEX.*Units* stratum					
TREAT	3	6.100	2.033	1.04	0.401
Residual	15	29.192	1.946		
Total	19	46.700			

Analysis of variance

Variate: INITIAL_WEIGHT

Source of variation	d.f.	s.s.	m.s.	v.r	.F pr.
SEX stratum	1	7.500	7.500	3.32	
SEX.*Units* stratum					
TREAT	3	0.037	0.012	0.01	0.999
Residual	15	33.900	2.260		
Total	19	41.438			

Analysis of variance

Variate: TOTAL INTAKE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	261.43	261.43	3.20	
SEX.*Units* stratum					
TREAT	3	39.43	13.14	0.16	0.921
Residual	15	1225.58	81.71		
Total	19	1526.44			

Analysis of variance

Variate: WEIGHT_GAIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.408	0.408	0.09	
SEX.*Units* stratum					
TREAT	3	5.737	1.912	0.44	0.724
Residual	15	64.492	4.299		
Total	19	70.638			

HAEMATOLOGICAL PARAMETERS

Analysis of variance

Variate: HCT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	9.02	9.02	0.60	
SEX.*Units* stratum					
TREAT	3	24.09	8.03	0.53	0.668
Residual	15	226.861	5.12		
Total	19	259.97			

Analysis of variance

Variate: Hb

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	1.261	1.261	0.98	
SEX.*Units* stratum					
TREAT	3	3.506	1.169	0.91	0.460
Residual	15	19.275	1.285		
Total	19	24.042			

Analysis of variance

Variate: MCH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0801	0.0801	0.20	
SEX.*Units* stratum					
TREAT	3	0.3295	0.1098	0.27	0.846
Residual	15	6.0959	0.4064		
Total	19	6.5055			

Analysis of variance

Variate: MCHC

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0653	0.0653	0.18	
SEX.*Units* stratum					
TREAT	3	0.1015	0.0338	0.09	0.962
Residual	15	5.4227	0.3615		
Total	19	5.5895			

Analysis of variance

Variate: MCV

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	89.3	89.3	0.69	
SEX.*Units* stratum					
TREAT	3	295.3	98.4	0.76	0.535
Residual	15	1946.7	129.8		
Total	19	2331.2			

Analysis of variance

Variate: PLT

Source of variation	d.f.	s.s.	m.s.	v.r	F pr.
SEX stratum	1	11349.	11349.	1.78	
SEX.*Units* stratum					
TREAT	3	29283	3. 9761	1.53	0.247
Residual	15	95536.	6369.		
Total	19	136168.			

Analysis of variance

Variate: RBC

Source of variation	d.f	.s.s .	m.s.	v.r.	F pr.
SEX stratum	1	0.3413	0.3413	0.86	
SEX.*Units* stratum					
TREAT	3	0.7895	0.2632	0.66	0.589
Residual	15	5.9747	0.3983		
Total	19	7.1055			

Analysis of variance

Variate: WBC

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	5.17	5.17	0.42	
SEX.*Units* stratum					
TREAT	3	21.91	7.30	0.60	0.626
Residual	15	183.27	12.22		
Total	19	210.35			

BIOCHEMICAL ASSAY

Analysis of variance

Variate: ALBUMEN

Source of variation	d.f.	s.s.	m.s	.	v.r.	F pr.
SEX stratum	1	3.333	3.333		0.99	
SEX.*Units* stratum						
TREAT	3	12.400	4.133		1.23	0.332
Residual	15	50.267	3.351			
Total	19	66.000				

Analysis of variance

Variate: GLOBULIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00	0.00	0.00	
SEX.*Units* stratum					
TREAT	3	17.90	5.97	0.51	0.681
Residual	15	175.41	1.69		
Total	19	193.31			

Analysis of variance

Variate: HDL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.00208	0.00208	0.12	
SEX.*Units* stratum					
TREAT	3	0.09750	0.03250	1.89	0.175
Residual	15	0.25792	0.01719		
Total	19	0.35750			

Analysis of variance

Variate: LDL

Source of variation	d.f.	s.s	m.s.	v.r.	F pr.
SEX stratum	1	0.08008	0.08008	2.61	
SEX.*Units* stratum					
TREAT	3	0.02800	0.00933	0.30	0.822
Residual	15	0.45992	0.03066		
Total	19	0.56800			

Analysis of variance

Variate: TCHOL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.15408	0.15408	5.64	
SEX.*Units* stratum					
TREAT	3	0.02550	0.00850	0.31	0.817
Residual	15	0.40992	0.02733		
Total	19	0.58950			

Analysis of variance

Variate: TGS

Source of variation	d.f.	s.s.	m.s .	v.r.	F pr.
SEX stratum	1	0.06533	0.06533	0.74	
SEX.*Units* stratum					
TREAT	3	0.15750	0.05250	0.59	0.629
Residual	15	1.32667	0.08844		
Total	19	1.54950			

Analysis of variance

Variate: T_PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	1.633	1.633	0.40	
SEX.*Units* stratum					
TREAT	3	8.200	2.733	0.66	0.588
Residual	15	61.967	4.131		
Total	19	71.800			

RELATIVE VALUES OF SOME BODY COMPONENTS

Analysis of variance

Variate: EMPTY_GIT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.2394	0.2394	1.29	
SEX.*Units* stratum					
TREAT	3	0.1234	0.0411	0.22	0.880
Residual	15	2.7841	0.1856		
Total	19	3.1469			

Analysis of variance

Variate: FULL_GIT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.3111	0.3111	0.44	
SEX.*Units* stratum					
TREAT	3	2.0263	0.6754	0.95	0.442
Residual	15	10.6783	0.7119		
Total	19	13.0157			

Analysis of variance

Variate: HEART

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.0000133	0.0000133	0.04	
SEX.*Units* stratum					
TREAT	3	0.0004400	0.0001467	0.42	0.741
Residual	15	0.0052267	0.0003484		
Total	19	0.0056800			

Analysis of variance

Variate: KIDNEY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.007521	0.007521	1.64	
SEX.*Units* stratum					
TREAT	3	0.013060	0.004353	0.95	0.443
Residual	15	0.068919	0.004595		
Total	19	0.089500			

Analysis of variance

Variate: LIVER

Source of variation	d.f.	s.s	m.s.	v.r.	F pr.
SEX stratum	1	0.4189	0.4189	1.68	
SEX.*Units* stratum					
TREAT	3	0.7749	0.2583	1.04	0.405
Residual	15	3.7385	0.2492		
Total	19	4.9323			

Analysis of variance

Variate: LUNGS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.02883	0.02883	1.17	
SEX.*Units* stratum					
TREAT	3	0.02513	0.00838	0.34	0.796
Residual	15	0.36829	0.02455		
Total	19	0.42225			

Analysis of variance

Variate: SPLEEN

Source of variation	d.f.	s.s.	m.s.	v.r	.F pr.
SEX stratum	1	0.000403	0.000403	0.09	
SEX.*Units* stratum					
TREAT	3	0.011620	0.003873	0.86	0.483
Residual	15	0.067597	0.004506		
Total	19	0.079620			

Analysis of variance

Variate: STOMACH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
SEX stratum	1	0.04332	0.04332	0.94	
SEX.*Units* stratum					
TREAT	3	0.09516	0.03172	0.69	0.572
Residual	15	0.68904	0.04594		
Total	19	0.82752			