THE PROTEIN REQUIREMENT AND REPRODUCTIVE PERFORMANCE OF PREGNANT AND LACTATING SOWS FED EITHER CONVENTIONAL OR AGRO-INDUSTRIAL BY PRODUCTS (AIBPs) BASED DIETS

by

PETER ASIEDU

BSc. AGRICULTURE (HONS.)

A Thesis submitted to the Department of Animal Science, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree

of

MASTER OF PHILOSOPHY

(Animal Nutrition and Management)

Faculty of Agriculture

College of Agriculture and Natural Resources

February, 2009

DECLARATION

I, **Peter Asiedu,** hereby declare that this submission is my own work towards the award of a Master of Philosophy (MPhil) degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

Peter Asiedu (20047916)	....	11-11-09
(Student's Name & ID)	Signature	Date
Certified by:		
D.B. Okai	....	11-11-09
(Co-Project Supervisor)	Signature	Date
Certified by:		
S.W.A Rhule	....	10-11-09
(Co-Project Supervisor)	Signature	Date
Certified by:		
E.L.K. Osafo	....	11/11/09
(Head of Department)	Signature	Date

ABSTRACT

Two feeding trials were carried out; one with cereal-based diets and the other with AIBPs to determine the protein requirements and reproductive performance of pregnant and lactating sows. In experiment one, a total of eighteen Large White gilts with an average liveweight of 100.39 kg were allotted equally to three dietary treatments namely, T1, T2 and T3. Three sets of cereal-based diets containing different CP levels were fed, namely breeder, lactation and creep diets. The breeder diets were formulated to contain 13.20% (T1), 12.56% (T2) and 12.01% CP (T3). While the lactation diets were also formulated to contain 16.08% (T1), 14.54% (T2) and 13.20% CP (T3). The CP levels for the creep diets were 22.60% (T1), 21.74% (T2) and 20.01% (T3). The mean initial liveweight for the gilts on the three treatments were 99.33 kg (T1), 102.00 kg (T2) and 99.83 kg (T3). The gilts were offered the breeder diet at a rate of 2 kg/day. After parturition, sows were fed 4 kg/day of the corresponding lactation diet. All litters received creep feed from two weeks of age until weaning. The effects of the varying CP levels on piglet birth weight, number born alive and number weaned were determined. The effects of the different creep feeds on piglets ADG and weaning weight were also assessed. Milk yield of sows were also measured.The litter size (number born alive) was highest (9.17) for T1 and decreased as the CP level also decreased (ie 7.60 for T3) but the differences between the means were not significant (P > 0.05). The average birth weight of piglets from T1 was relatively higher (1.45 kg) than for those on T2 (1.35 kg) and T3 (1.42 kg) (P > 0.05). There were no significant differences in the weaning weights of piglets from the gilts on the three treatments. The ADG of piglets was relatively higher in T3 (0.20 kg) compared with the other treatments (P > 0.05). Sow weight gains during pregnancy were 30.33, 28.80 and 34.00 kg for dietary treatments

T1, T2 and T3 respectively; again the differences between the means were not significantly ($P > 0.05$) different. Increasing the CP intake of sows during lactation failed to significantly ($P > 0.05$) affect milk yield.

In experiment two, seventeen Large White primiparous sows from the first experiment were used. The initial mean liveweight of the sows on the three treatments were 126.00 (TA), 122.00 (TB) and 114 kg (TC). Treatments TA, (The control diet), was the cereal-based diet identified in experiment 1 to be ideal for the gilts and sows during pregnancy and lactation. Dietary treatments TB and TC were AIBP-based diets in which the maize in the control diet had been replaced with some selected AIBP completely. However, the three dietary treatments had similar CP levels. The mean birth weight and litter size (number born alive) were highest for piglets on dietary treatment TC than for those on TA and TB ($P > 0.05$). Sows on diets TB and TC had relatively higher liveweight gain during pregnancy (35.40 and 31.40 kg respectively) than those on dietary treatment TA (20.40 kg) although the differences were not significant ($P > 0.05$). The highest weaning weight (10.31 kg) was obtained from sow TA piglets, although the differences were not found to be significant ($P > 0.05$), again there were no significant ($P>0.05$) differences in the mean number of piglets weaned. Weight loss in the sow during lactation was highest in TC sows (28.33 kg) and lowest (20.00 kg) on TB. The milk yields of the sows were similar to each other at 14^{th} day of lactation (ie 3.48 kg (T1), 3.57 kg (T2) and 3.94 kg/day (T3) and also at 28^{th} day of lactation ($P > 0.05$). The sows fed the diet TA recorded the highest (6.79 kg) milk yield on the 42^{nd} day of lactation compared to TB (4.43 kg) and TC (4.38 kg), though the differences between the means were not significant ($P > 0.05$). The ADG for piglets on treatment TA were higher (0.21 kg/day), even though such growth rates were not statistically ($P > 0.05$) different

from piglets on treatments TB and TC. It was concluded that AIBP can be included in the diets of sows at the levels used for this study without any adverse effect on the measures of sow reproductive efficiency. The survivability of piglets could be sustained using AIBP-based diets as well as cereal-based diets.

TABLE OF CONTENTS

LIST OF TABLES

TABLE **PAGE**

LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
AIBP	Agro-Industrial By-Product
ADG	Average Daily Gain
ANF	Anti -Nutritional Factors
ARI	Animal Research Institute
Ca	Calcium
CF	Crude Fibre
CP	Crude Protein
DE	Digestible Energy
DM	Dry Matter
EE	Ether Extract
g	Grammes
G-F	Grower Finisher
HCN	Hydrogen Cyanide
Kcal	Kilocalories
Kg	Kilogrammes
Mcal	Mega calories
MJ	Mega joules
°C	Degree Celsius
P	Phosphorous
USA	United State of America
PPM	Parts Per Million
Wk	Week
WSW	Weigh-Suckle-Weigh
Wt	Weight

ACKNOWLEDGEMENTS

"It is a good thing to give thanks unto the Lord" ……… (Psalm 92:1).

My lord, I owe you much thanks, for my life, the mercies granted me and the blessings showered upon me.

I wish to express my sincere gratitude to Prof. D. B. Okai and Dr. S.W.A. Rhule my project supervisors for their guidance, constructive criticisms, invaluable support and their technical advice during the design, execution and presentation of the results of this project.

I am also indebted to the following: Dr. A. D. Adjei, Deputy Director and Dr. K. Boa-Amponsem both of the Animal Research Institute. The advice and encouragement of Mr. E. T. Sottie and Mr. K.A Darfour-Oduro are deeply appreciated. The help of the non-research and the technical staff of National Analytical Feed Quality Control Laboratory of the CSIR is sincerely appreciated. My special thanks also goes to my parents Mr. and Mrs. Asiedu and all my lovely siblings and friends for their moral support and encouragement.

Finally, this project could not have been possible without the financial support of AgSSIP (Agricultural Services Sub-Sector Investment Project) of MoFA, the Department of Animal Science, Faculty of Agriculture, KNUST, and the Animal Research Institute, the sponsors of the project. I thank them all for their support.

CHAPTER ONE

1.0 INTRODUCTION

Although many research studies have been carried out on pigs in the tropics, it would seem that a considerable number of research on the nutrient requirements for pigs have been done mostly in the temperate or developed countries and there seems to be a paucity of information on sow performance since the bulk of the research is on grower-finisher (G-F) pigs (Azian *et al.*, 1994; Coma *et al.*, 1996). Even in the developed areas, the differences with herd size, stages and durations of studies involving sows have led to difficulties in interpretation of the results. Empirical and specific recommendations for the nutrient requirements of sows during gestation and lactation have also been made (Braude, 1981). The differences in litter size and the number of piglets which can be reared and weaned have also help to establish requirements for piglets based on feeding cereal-based diets. The nutrient requirement of pigs could be influenced by physiological factors, health, stress level, age, environment, production level and type of management (Wang and Fuller, 1989; Cromwell *et al.*, 1999; Cole and Sprent, 2001).

The economic returns in pig production depend to some extent, on the frequency and the number of piglets born, birth weight and the weight of piglets at weaning all of which influence their survival. In the reproductive cycle of the sow, gestation is one of the critical phases with a high demand for nutrients for the developing foetuses. Furthermore, lactating sows have higher requirement for CP to support milk yield for the piglets (Kusina *et al.*, 1995; Pettigrew and Yang, 1997).

A reduction of feeding cost is of utmost interest to pig farmers in Ghana and elsewhere. It has been shown that, feed cost represents up to 80% of the total cost of pig production in Ghana (Okai *et al*, 2001). Usually the protein and energy sources are the most expensive components in the feeding of pigs. In Ghana and other developing countries, cereals are not only major energy sources for pigs but they also provide a substantial part of the protein in pig diets. However, in Ghana, the use of cereals in pig diets may be uneconomical due to its high cost (Cameron, 1970, Okai *et al.*, 2001).

Ghana has placed considerable emphasis on value-addition to agricultural produce leading to the availability of many agro-industrial by products (AIBPs). Some of these AIBPs are wheat bran, rice bran, maize bran, palm kernel cake, soybean meal, dried cocoa pod husk, cassava and plantain peels, groundnut skin meal and brewers spent grains (Barnes *et al.*, 1984; Okai *et al.*, 1984; Arueya, 1991 and Rhule, 1998).

Trials with cereal-based diets conducted in the temperate areas have shown that the optimum CP levels for pregnant and lactating sows are 13 and 16% CP respectively (Mahan *et al*, 1977; Jones and Stahly, 1995). Corn-soybean meal diets containing between 18 and 22 % CP have been recommended for weaner pigs (NRC, 1998). Jensen (1978) suggested that the levels of CP in the diet of starting, growing and finishing pigs should be 20, 16 and 14% CP respectively. It has also been suggested that a maize-soybean meal diet meant for pregnant sows should have 13 to 14 % CP and should contain some high fibre feedstuff to prevent gestating sows from constipating (Day and Plascencia-Gonzalez., 2000). Feeding pigs on AIBP has been found to overcome the difficulty of feeding expensive items to pigs as well as reducing the competition between human and farm animals for cereals (Pond *et al.*, 1995).

The overall objective of the study was to provide data on the reproductive performance of the sow and the growth and survival rates of piglets when fed AIBP-based diets.

The specific objectives were to:

i. Establish the requirement for crude protein by gestating and lactating sows in Ghana, when fed either cereal or AIBP-based diets.
ii. Determine the effects of the identified crude protein level on the reproductive performance of sows.
iii. Determine ideal crude protein level for creep diets for piglets in Ghana.
iv. Determine the effect of AIBP-based creep diets on growth and survival of piglets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 Protein and Amino Acid Requirements of Sows

2.1.1 Protein Requirement of Pregnant Sows

The protein requirements of pigs are usually expressed as a percentage of the total diet. Protein and amino acids are required by pigs for maintenance, growth and reproduction. In the reproductive cycle of the sow, gestation is an important phase with a high demand for nutrients. Sows in gestation have high requirement for crude protein to support foetal growth. The protein requirements of the pig vary at various phases of its life (Carpenter and Booth, 1973; Campbell *et al.*, 1985). Sows may be fed with cereal-based diets containing 12.0 to 13.0 % CP, for the entire duration of gestation (Kusina *et al.,* 1999). Pregnant sows fed 10 % CP maize-soybean diet had low piglet birth weights (Sauber *et al.,* 1994).

It has been observed that, sow weight gain during pregnancy, piglet weight gain and piglet average weight at weaning were not affected in the first reproductive cycle when sows were fed 10.0, 11.5, 13.0, 14.5 and 16.0 % CP cereal-based diet but were affected in the second reproduction cycle (Coma *et al.*, 1996). They also found out that, sow weight gain, number of piglets weaned and litter birth weight in the third reproduction cycle increased linearly. Piglet weight and number of piglets born alive were not influenced by parity (Mahan *et al.*, 1977). Preliminary studies by Grandhi, (1994) and Jones and Stahly, (1995) indicated that the optimum crude protein level in the diet of pregnant sow should be 13.0 %. The CP requirement for breeding sows through gestation has been put at 12.9% but decreases as the body weight increases (NRC, 1998).

Crude protein levels had no significant effect on piglet's birth weight, number born and carcass characteristics (Close and Mullan, 1996). The magnitude of the weight change in pregnancy influences the requirement for protein in the subsequent lactation. It has been observed that the larger the weights gain in pregnancy, the greater the weight loss in lactation (Braude, 1981). Pond *et al* (1968) fed 1.5 to 2 kg per day of maize-soybean meal diet containing 14% CP from day 100 of gestation until farrowing and reported that there were no significant effects on the number of piglets born, either alive or stillborn. In another study, Aherne and Williams (1992), fed 2.3 and 3.9 kg of a 13% CP maize-soybean meal diet per day throughout the gestation period and piglet birth weight and the number of piglet born were again not affected.

2.1.2 Protein Requirement of Lactating Sows

The requirement for protein by lactating sows is to minimize negative nutrient balance while optimizing milk production (Lewis *et al.*, 1991). Levels of nutrient intake during lactation are directly related to the amount of milk produced as well as the growth rate of nursing piglets. Lactating sows can produce about 5.3 to 11.33 kg of milk per day. For highly prolific and productive sows, nutrients from body tissue reserves could be used to support lactation leading to weight loss, extended weaning-to-oestrus interval and small litter size piglets when inadequately fed (Knabe, 1991; Baker, 1993). Weldon *et al* (1994) reported that liveweight losses of up to 30 kg during lactation have been observed for sows given low CP diet with high levels of feed during pregnancy followed by restricted intake throughout an eight week lactation period.

It has been shown that increasing CP levels above 13% did not improve the weight gains of sows (Bowland, 1970). In the growing-finishing period, feed intake, weight gains and feed efficiency were improved when pigs were fed 14% CP cereal-based diets. According to the NRC (1998), from 4th to the 6th week the requirement of CP for lactating sow is 16.3 – 17.5% and the anticipated lactational weight change is zero for the first three weeks but decreases to negative 10 kg from the 4th to the 6th week. Okai *et al*. (1977) obtained 1.3, 9.01 and 0.17 kg for birth weight, weaning weight and ADG when pigs were fed a 14.03% CP cereal-based diet. As shown in Table 1, milk yield can be influenced by the level of CP with sows fed a 12 or 14 % CP diet during lactation, producing less milk and subsequently loosing significantly ($P < 0.05$) more weight during lactation than sows fed a 16 % CP diet (Einarasson, and Rojkittikhun, 1993).

Table 1. Effect of crude protein levels during lactation on sow milk yield

Crude protein level (%)	12	14	16
Sow feed intake (kg)	4.5	4.5	4.5
Sow weight change(kg)	-25.4	-10.9	+3.7
Piglet weaning wt(kg)	5.5	6.1	6.2
Milk yield (kg)	5.5	7.4	10.5

Source: Einarasson and Rojkittikhun, (1993)

2.1.3 Amino Acid Requirement of Pregnant and Lactating Sows

Lysine is considered the first limiting amino acid in cereal-based diets for pregnant sows. The lysine requirement of sows during pregnancy has received more attention than any other essential amino acid (Belstra *et al.*, 2002). A daily intake of 8-10 g lysine has been recommended for pregnant sows (ARC, 1981). It has been suggested that, 260 g CP / day with 12 g lysine/ day would be adequate to support gestation in sows. Increasing protein intake from 260 to 340 g CP/ day and lysine from 12 to 16 g increased weight gain in gilts during gestation (Braude, 1981). Pregnant gilts can synthesize sufficient arginine to meet their entire requirement for reproduction (Baker, 1993; Yang *et al*, 2000; Nielson *et al.*, 2002). Levels between 0.40-0.52 % methionine + cystine have been found to give satisfactory performance for pregnant sows and lactating sows.

2.2 Energy Requirement of Pregnant Sows

Sows are known to eat to satisfy their energy needs and thus eat less of a high energy diet. During gestation, 60 to 80 percent of the total energy requirement is used for maintenance. The NRC (1988) indicated that the daily requirement for maintenance of pregnant sows was 106 kcal of ME or 110 kcal of DE/kg of $BW^{0.75}$/day. Noblet *et al.* (1993) also reported a daily requirement of 105 kcal of ME/kg of $BW^{0.75}$ /day for primiparous and multiparous sows.

Schrama *et al.* (1994) reached a similar conclusion from the literature ie 103 kcal of ME/kg of $BW^{0.75}$/day for primiparous sows but reported data to indicate an increase from 93 kcal in the first parity to 104 kcal in the second parity and to 113 kcal of ME/kg of $BW^{0.75}$ in the fourth parity.

The ARC (1981), Cole (1992) and Shi and Noblet (1993) reviewed the effects of energy intake during gestation on sow weight gain and reproductive performance. It may be inferred from the literature that increasing the energy density of the diet of a pregnant sow improves weight gain. It has been shown that as energy intake and weight gain during pregnancy increases, energy intake during lactation decreases with increased weight loss. It is therefore, desirable to limit energy intake during pregnancy to control weight gain (O'Grady, 1980; Brooks *et al.*, 2001).

2.3 Energy Requirement of Lactating Sows

The energy requirement of the lactating sow has been found to be very crucial as body energy reserves would be mobilized to maintain milk yield (Nielsen *et al.*, 1997; Johnston *et al.*, 1999). The energy requirement of the lactating sow would depend on its body weight, milk yield and the body composition (NRC, 1988). When lactating sows were fed 51.0 to 76.4, 54.0 to 82.0 and 55.2 to 86.0 MJ DE daily during the first, second and third lactations, it was observed that milk yield and composition as well as litter growth rate were not influenced by the different levels of energy during the first lactation. However, during the third lactation the lowest energy level seriously depressed milk yield with a corresponding depression in litter weight of about 13.5 % at the 42nd day (O'Grady *et al.*, 1985). Liveweight losses of up to 30 kg during lactation have been reported for sows given low CP diets with high levels of feed during pregnancy followed by restricted intake throughout an eight-week lactation period (Williams, 1995). Weight losses usually reflect differences in milk yield in the lactation period (Weldon *et al.*, 1994). The environmental temperature is important for lactating sows as high temperatures have been found to reduce feed intake (NRC, 1998; McNamara and Pettigrew, 2002).

Sows weighing between 145 and 185 kg live weight at farrowing and allowed daily feed intake between 4.4 and 6.1 kg of a maize-soybean diet containing 3.34 Mcal DE/ kg produced 5.0 to 7.0 kg milk per day and lost approximately 6.5 kg in a twenty-eight day lactation period (NRC, 1988). It has been shown that the modern sow could produce 10 to 12 kg milk/day and therefore, would require much higher energy intake (Evert *et al.*, 1994). An energy balance for a 150 kg sow producing 9.4 kg milk per day is shown in Table 2. As can be seen, this sow would require an average of 7 kg feed per day of a diet containing 3.34 Mcal DE/kg.

Table 2. Predicted feed and energy requirement for a 150 kg lactating sow with 10 piglets.

	Week 1	Week 2	Week 3	Week 4	Mean
Average wt of piglet , kg	2.5	4.0	6.0	8.0	5.1
Average daily gain by piglet, g/day	160	220	280	280	235
Milk yield, kg/day	6.4	8.8	11.2	11.2	9.4
Energy required Mcal DE/d	17.5	22.3	27.1	27.1	23.5
Feed/day, required, kg*	5.2	6.7	8.1	8.1	7.0
Actual feed/day, kg	4.4	5.5	6.0	5.9	5.5
Sows wt loss, kg/wk	2.6	4.1	7.5	7.8	5.5

* Diet containing 3.34 Mcal DE/kg

Source: Evert *et al.*, (1994).

The sow used in this example was suckling 10 piglets and the average piglet weight at 7, 14, 21, 28 days of age was 2.5, 4.0, 6.0, and 8.0 kg. To produce this weight gain will require 6.4, 8.8, 11.2, and 11.2 kg milk per day in weeks 1, 2, 3 and 4 of lactation respectively. The feed intake required for sow maintenance and milk production and the expected daily feed intake are also presented in Table 2. As shown in Table 2, approximately 75% of the energy required goes to milk production and 25% for maintenance. This sow therefore does not consume enough food to meet her needs. Therefore some of the energy and nutrients required by the sow must be derived from mobilization of body tissues during lactation. In this example, the sow would lose nearly 22 kg body weight during the four-week lactation.

2.4 Energy and Protein Requirement of Piglets

The requirements of piglets for protein and essential amino acid are related to the amount of energy consumed. For the first few days of life, suckling pigs receive their nutrition from the milk of the sow. It has been found that the average weight of piglets at birth appeared to be unaffected by CP levels in the sows diet when this was above 13% (Baynes and Wiseman, 2001; Brooks *et al.*, 2001). Bowland (1970) observed improved performance during the starting period with increasing starter protein content up to 20%. Increasing starter CP levels up to 17% improved weight gains while a further increase to 24% resulted in increased feed efficiency. It has also been reported that sow milk provides only 40% of the daily arginine requirement for suckling piglets. Supplementation of feed with arginine stimulates the secretion of insulin and growth hormone that regulate protein accretion (Acamovic, 2001). Arginine is the most important carrier of nitrogen in the body of piglets and participates in many metabolic pathways (Aherne, 1997).

The introduction of solid feed to piglets before weaning is termed creep feeding and it is often fed to the piglet from the second week of life. It has been found that, very little creep feed is consumed before the third week of age (Pond and Maner., 1974). Piglets below three weeks of age have intakes of less than 60 MJ DE/ day per litter of 9 piglets. Piglets older than three weeks increase their creep feed consumption because the digestive system develops with time to utilize the creep feed (Dunshea *et al.*, 2000; Partridge and Gill, 2001).

The crude protein level of creep feed has been put at 20-22 % (O'Grady, 1980; ARC, 1981; Okai *et al.*, 1994). O'Grady and Bowland (1972) fed pigs averaging 3.6 kg liveweight, diets containing energy levels of 11.8, 12.6, 13.4, 14.3 and 15.1 MJ DE/ kg and observed that up to 25 kg liveweight, feed intake decreased and daily weight gains increased with increasing energy level of the diet. It was observed that in piglets fed the low energy diets (11.8 and 12.6 MJ/ kg), compensatory growth and feed intake of piglets decreased with increasing energy content of the diet and the energy level of 13.6 and 14.6 MJ DE/ kg had no effect on weight gain.

It has been shown that small litters may have higher individual growth rates because there is more milk available for each of the pigs in the litter, whereas larger litters of 12 piglets or more will have 50 g less body weight at weaning than litters of 6 piglets (McNamara and Pettigrew, 2002; Nielsen *et al.*, 2002).

2.5.0 Mineral Requirement of Pigs

Minerals must be supplied in pig rations for optimum performance. About 5 percent of the total body weight of the pig consists of mineral elements (NRC, 1998). Minerals are essential for most of the basic metabolic reactions in the body. Minerals have a role in digestion, metabolism of protein, fats and carbohydrates; and the structure of chromosomes, enzymes, nerves, blood, skeleton, hair and milk. They are also important in reproduction, growth and resistance to diseases and parasites of pigs (NRC, 1998).It has been reported that the amount of a given mineral that a pig absorbs depends on its concentration in the diet, the mineral source, concentrations of other minerals in the diet and the mineral status of the pig (NRC, 1980; SCA, 1987; NRC, 1998). Pigs depend on the feed for their mineral requirements which must be in their proper proportions (NRC, 1998). Available reports indicate that pigs need at least 12 mineral elements in their diet ie calcium, phosphorous, sodium, chlorine, potassium, magnesium, iron, manganese, zinc, iodine, copper and selenium (Peo, 1991; NRC, 1998)

Table 3. Mineral requirements of breeding sows (%).

Mineral	Gestation	Lactation
Calcium	0.75	0.75
Phosphorus (total)	0.60	0.60
Phosphorus (available)	0.35	0.35
Sodium	0.15	0.20
Chloride	0.12	0.16
Potassium	0.20	0.20
Magnesium	0.04	0.04
Iron	0.008	0.008
Zinc	0.005	0.005
Copper	0.0005	0.0005
Manganese	0.002	0.002
Iodine	0.000014	0.000014
Selenium	0.000015	0.000015

Source: NRC (1998)

Sodium chloride (common salt) provides the principal intracellular cation and anion in the body. Common salt contains about 40% sodium and 60% chlorine (NRC, 1988). The recommended level of salt is 0.25% for a grain-soybean meal diet for growing and finishing pigs, 0.40-0.50% in starter diets, and 0.50% in sow diets. Available reports indicate that, common salt deficiency results in a reduction in rate and efficiency of growth (Pond and Maner, 1974; NRC, 1998).

Potassium, the third most abundant mineral in the body of pigs, is important in electrolyte balance and neuromuscular function. Magnesium is required for many enzyme reactions. These two minerals, along with sulfur, are generally not supplemented because diets of grain and soybean meal contain higher concentrations than necessary to meet the requirement, and no deficiencies have been shown in pigs (NRC, 1980; NRC, 1998).

Copper is necessary for the synthesis of hemoglobin and for activation of several oxidative enzymes needed for normal metabolism (NRC, 1997). Deficiency of copper leads to poor iron mobilization, abnormal formation of blood, poor keratinization, and poor synthesis of collagen, elastin, and myelin. The requirement for copper is probably no greater than 5 to 6 ppm during the growing phase (Miller *et al.*, 1979; NRC, 1998). Young growing pigs are often fed as much as 100 to 250 ppm copper to stimulate growth performance. Toxicity of copper may occur in growing pigs fed more than 250 ppm for an extended period unless 100 ppm iron and zinc or 500 ppm of sulfur are added to the diet (Gardner *et al.*, 1990). Toxicity signs include depressed hemoglobin concentrations, anemia, and bloody feces, which are the result of excessive copper accumulation in the liver and other vital organs. Reduced concentrations of zinc and iron or high calcium accentuate copper toxicity (NRC, 1998).

Iron (Fe) is an essential element of myoglobin in muscle, transferrin for Fe transport in serum; uteroferrin for iron transport in the placenta; lactoferrin in milk for Fe transfer to the nursing pig, of hemoglobin in red blood cells and hemosiderin for Fe storage in the liver (NRC, 1998). Iron deficiency rapidly develops in newly born pigs and piglets must receive supplemental iron preferably by intramuscular (IM) injection of 100-200 mg of iron in the form of iron dextran, iron dextrin, or gleptoferron during the first 3 days of life. (NRC, 1988).

Iodine is required in small quantities and is a vital component of the thyroid hormones, which affect the pig's metabolic rate. It is especially important for sows during pregnancy. Sows fed iodine-deficient diets will farrow weak or dead pigs that are hairless with enlarged and hemorrhagic thyroid. The incorporation of iodized salt (0.007% iodine), at a level of 0.2% of the diet, provides adequate iodine (0.14 ppm) to meet the needs of growing pigs fed grain-soybean meal diets (NRC, 1988).

Zinc (Zn) is required for normal epidermal tissue development and proper function of several metabolic enzymes (NRC, 1998). High calcium levels in the diet increase the Zn requirement. Excess calcium reduces zinc absorption and may speed its removal from the tissues. It has been shown that zinc requirement on a corn-soya bean meal ration is about 0.005 to 0.01 % with normal levels of calcium for growing and finishing pigs. High zinc concentrations (0.2 to 0.3 % zinc as zinc oxide) increased the growth rate of newly weaned pigs, and in some cases reduced the incidence of diarrhea. Zinc deficiency in pigs is characterized by a loss of appetite, reduced growth rate and feed efficiency and impaired sexual development, and is often accompanied by a skin condition called parakeratosis (Miller *et al.*, 1979). Zinc toxicity results in reduced growth, arthritis, hemorrhage in axillary spaces, gastritis and death. (Partridge, 1981).

2.5.1 Calcium and Phosphorus Requirements of Pregnant and Lactating Sows

For pregnant and lactating sows, calcium and phosphorus requirements are estimated at 0.75% and 0.60%, respectively. Slightly higher levels of Ca and P are fed to ensure sufficiency and to prevent posterior paralysis in heavy milking sows. These requirements are based on daily feed intakes of at least 1.8 kg of feed during gestation and 5.5 kg of feed during lactation. If less feed is consumed per day, the percentages of calcium and phosphorus may need to be adjusted upwards (Braude, 1981; NRC, 1998).

It has been shown that Ca and P play important roles in the development and maintenance of the skeletal system, blood clotting, muscle contraction and some physiological functions (NRC, 1998; NRS, 2003). The ratio of total calcium: total phosphorus should be kept between 1.25:1 for maximal utilization of both minerals. Wide calcium- to- phosphorus ratio reduces phosphorus absorption, especially if the diet is marginal in phosphorus. The ratio is less critical if the diet contains excess phosphorus. When based on available phosphorus, the ideal ratio of calcium to available phosphorus is 2-3:1 (Braude, 1981; Whittemore, 1996; NRC, 1998).

Most of the phosphorus in cereal grains and oilseed meals is in the form of phytate (organically bound phosphorus) and is poorly available to pigs, whereas the phosphorus in protein sources of animal origin, such as meat meal, meat and bone meal and fish meal, is in inorganic form and is highly available to pigs. Availability of phosphorus varies in cereal grains. For example, the phosphorus in corn is only 10-20% available, whereas the phosphorus in wheat is 50% available. It has been suggested that swine diets may be formulated on an "available phosphorus" basis to ensure that the phosphorus requirement is met (Ly, 1993).

Phosphorus supplements such as monocalcium or dicalcium phosphate, defluorinated phosphate, and steamed bonemeal are excellent sources of highly available phosphorus. These supplements are also good sources of calcium. Ground limestone is also an excellent source of calcium (Braude, 1981).

2.6 Effect of Heat on Pregnant and Lactating Sows

The adverse effects of high temperature on sows have been documented (Quiniou and Noblet, 1999).When temperature increases the voluntary feed intake decreases, which in turn reduces heat production due to the thermic effects of feed. The effects of high temperatures on the performance and feeding behavior in pregnant and lactating sows have been more accurately characterized by Quiniou *et al* (2000). Evidence from literature suggests that nitrogen losses through the urine are higher when temperatures are high rather than when temperatures are low (Holmes, 1974). Under high temperatures, diets of pregnant sows should contain high levels of protein to make up of losses through urine. Diets with low crude protein content and added fat result in low heat production. The environmental temperature of the farrowing house is one of the most critical factors affecting feed intake in lactating sows. Table 4 shows the results of an experiment in which sows were housed in a farrowing room maintained at either 27 or 21 °C. Sows maintained at the lower temperature consumed more feed, lost less weight and weaned heavier piglets in comparison to sows housed at the higher temperature (Edward *et al.*, 1995).

Table 4. Effects of Heat on Sow Reproductive Performance

Temperature (°C)	27	21
Sow feed intake (kg/day)	4.6	5.2
Sow wt loss at weaning (kg)	21.0	14.0
Piglet weight at 28 days (kg)	6.2	7.0

Source: Edward *et al* (1995).

Higher temperatures will delay or prevent estrus, reduce conception rates, and increase early death of embryos in sows (Granier *et al.*, 1998). Heat stress in the first

13 days after mating can reduce the survival of embryos by 30 to 40%. Eating, digestion, and nutrient absorption all produce heat so the reduced feed intake by pigs is a way to reduce the amount of heat their bodies produce. Reduced feed intake will result in reduced growth and reduced milk production in lactating sows kept at a room temperature above 41.70 °C (Johnston *et al.*, 1999). Heat stress that occurs during the last few weeks before farrowing could lead to a higher number of stillbirths. Smaller piglets will be weaned and the sow will lose a larger amount of weight, making it more difficult for it to return to oestrus (Quiniou and Noblet, 1999).

2.7 Effects of Dietary Fibre on Pregnant and Lactating Sows.

The term fibre has not been clearly defined in terms of chemical and physiological properties (Meunier-Salaun *et al,* 1999). Fibre is still used to mean plant polysaccharides which are resistant to ruminant and non-ruminant digestive enzymes (Noblet and Le Goff, 2001). It has also been defined as that component of plant cell wall that is resistant to the digestive enzymes of animals (Ramonet *et al,* 2000). Fibre has been recognized generally as anti-"nutritive" for animals due to the negative influences on digestion. These anti-nutritive effects appear to be more important in chickens than in pigs, also it seems to be more important in piglets than in grower and finishing pigs (Fernandez *et al.*, 1986). Effects of fibre on the digestibility of amino acid and other nutrients especially in non-ruminants such as pigs have been documented (Le Goff and Noblet, 2001).

Sows have quiet a high potential for fibre utilization (Low, 1985). Feeding pregnant sows on fibrous diets had no detrimental effects on the mean total number of piglets born, born alive and piglet weaning weight (Anderson and Lindberg, 1997). The digestive utilization of fibre depends on the type of plant and the age of the pig (Le Goff, 1999). Meunier-Salaun *et al,* (1999) reported that fibre from plants also provides metabolisable energy to the sow.

Fibre-rich diets could increase the gut size of the sows leading to a larger body weight gain during the gestation period. There is evidence that the weight of the stomach, caecum and colon could be increased when fibrous diet were fed to the pigs (Jorgensen *et al*, 1996).Previous studies (Varel *et al*, 1982) have also indicated that, fibre source and genetic differences influenced growing–finishing pigs in their response to high fibre diets. Tropical pigs have been observed to possess a disproportionately longer and larger caecum-colon as well as a relatively larger mass of the liver.

2.8.0 Role of Some Local Agro-Industrial By-Products in Pig Nutrition

The major constraint on pig production in Ghana has been the provision of adequate nutrition. Attention has been focused on agro-industrial by-products (AIBPs) as potential solution to the problem with feeding pigs. Agro-industrial by-products such as cassava peels, palm kernel cake, copra cake, soybean meal, dried cocoa pod husk, brewers spent grains, wheat bran and rice bran have been found to overcome the difficulty of feeding expensive items to pigs as well as reducing the competition between human and farm animals for cereals (Pond *et al.*, 1995).

2.8.1 Cassava Peels

Cassava peel is a by-product of cassava tuber processing. The peel represents about 20 per cent of the whole tuber and contains about 3.93% CP, 11.16% CF and 1.29% EE (Ifut, 1992). In Ghana, the peel is readily and cheaply obtained in almost all the agro-ecological zones. Cassava peels, usually discarded when the tubers are processed, can be collected and dried for use as an energy source. The peels contains two cyanogenic glycosides; linamarin and lotaustralin, which on hydrolysis yields hydrocyanic acid (HCN), glucose and a ketone or an aldehyde.. It is generally considered that the HCN content of cassava is about 1.3 to 6.3 mg HCN/100g fresh weight which limits its utilization (Ifut, 1992; Okai *et al.*, 1994). Levels as high as 30 and 37.5 % has been fed to grower-finisher pigs without any adverse effect on growth rate, and for weaner pigs the range is about 20-29% (Sonaiya and Omole, 1997) Cassava peels has been fed at levels up to 55-65% to grower-finisher pigs (Dodoo, 1981; Barnes and Oddoye, 1985). Cassava and its by-products have been shown to be good sources of vitamins and minerals for monogastrics animals (Phuc and Linberg, 2000; Phuc *et al.*, 2000). The threshold of 40% for cassava peel inclusion may cause some decline in performance. In the light of this, cassava peels should not exceed 40% due to the high cyanide content of some cassava varieties (Iyayi and Tewe, 1992).Certain treatments have been applied to detoxify cassava peels before feeding, these treatments include sun drying and ensiling (Wyllie and Lekule, 1980).

2.8.2 Palm Kernel Cake (PKC)

Palm kernel cake is produced in large quantities in a number of tropical countries and is available at competitive prices. It has been estimated that four million metric tons of PKC was produced in the world in the year 2002 with an average annual growth of 15% over the last two decades. Palm kernel cake has been widely used in pigs diets (Agunbianade *et al*, 1999; Kim *et al*, 2001; FAO, 2002).

Palm kernel cake contains about 14-21% CP and 10-20%CF. The first limiting amino acid in PKC is methionine with the content of lysine, histidine and threonine being low. Live weight gain in pigs decreased linearly with increasing levels of PKC from 21 to 62 % (Jegede *et al*, 1994; McDonald *et al*, 1995). Okeudo *et al*., (2005) however, found no significant effect of PKC inclusion on the performance of pigs fed diets with graded levels of 20, 30, 40 and 50% PKC.

Twenty per cent PKC inclusion in the diet of pigs have been found to be satisfactory (Yeong, 1983; Thorne *et al*, 1989). In Nigeria, PKC used for feeding pigs was ranked lowest in terms of protein quality compared to other local protein sources and it produced a loss in weight (Ocampo, 1994). In Columbia, good results have been reported when almost 40% of PKC was used in the diet of grower-finisher pigs (Devendra, 1992). Grower-finisher pigs have also been fed diets containing PKC at inclusion levels between 20 - 35 % respectively without any adverse effects on performance (Jegede *et al*, 1994; Rhule, 1996; Okai, 2006)

The use of PKC in the diets of pigs should be limited due to the following reasons:

- Physically, PKC is gritty and unpalatable (Ocampo, 1994).
- Nutritionally, it may contain anti-nutritional substances such as mannan or galactomannan and xylan or arabinoxylans which have been proven to decrease nutrient uptake in pigs (Balasubramaniam, 1976, Duesterhoft *et al*., 1993).
- It has been observed that the local PKC may undergo the Maillard reaction due to the heat applied during oil extraction (Babatunde *et al*. 1975; Sundu and Dingle, 2003).

2.8.3 Copra Cake (CC)

Copra cake (CC) is a by-product from the manufacture of coconut oil and it is used as protein source in non-ruminant diets (Woodroof, 1979). Copra cake is produced in large quantities in a number of tropical countries. It has been estimated that two million metric tons of CC were produced in the world in 2002 with annual growth of 1.4% of CC over the last two decades. Copra cake has been widely used in pigs diets (Kim *et al*, 2001; FAO, 2002).

Copra cake contains about 19.09% CP, 16.25% CF, 5.48% EE and 89.70% on dry matter basis (Okai *et al*, 1994). Copra cake has low levels of lysine and histidine. It has been reported that feed intake of pigs decreased linearly with increasing level of CC from 20 to 30% (Paniraghi, 1992; McDonald *et al*, 1995). Grower - finisher pigs have been fed diets containing CC at inclusion levels of 5 and 10% respectively without any adverse effect on performance (Lekule *et al*, 1986). On the contrary, Lachance and Molina, (1974) stated that various graded levels (10, 20, and 40 %) of CC improved feed conversion ratio during the finisher and grower finisher periods.

Data from Kim *et al* (2001) suggested that 10% CC in the diet of pigs had been found to be satisfactory. The incorporation of CC above 10% and possibly poor lysine availability have been found to be the main contributing factors for the decreased rate and efficiency of gain of pigs (Luis, 2002). In view of this, the maximum inclusion ~~level of CC~~ in the grower-finisher diet of pigs should not exceed 20%. The use of CC in the diet of pigs should be limited due to it susceptibility to rancidity (Mc Donald *et al*, 1988).

2.8.4 Dried Cocoa Pod Husk (DCPH)

Cocoa pod husk is what remains after the beans have been removed from the cocoa fruit. The DCPH contains about 8.1% CP, 34.8% CF, 3.3% EE, 7.6% ash and 33.6% NFE (Okai *et al*, 1994). The DCPH can present a serious disposal problem. In addition to this, it can become a serious source of disease innoculum when used as mulch in cocoa plantations (Kimura, 1979).

Grower and finisher pigs have been fed diets containing DCPH at inclusion levels of 30 to 50% without any adverse effect on performance (Arueya, 1991). In another study, the DCPH was fed without toxic effects in quantities of 2kg per day to grower-finisher pigs (Adeyanju *et al*, 1975). The incorporation of 25% of DCPH in the diet of pigs did not significantly affect performance (Barnes *et al*, 1984 and Okai *et al*, 1984). The content of theobromine as well as the low content of cystine and methionine appears to be the most important limiting factors to the use of this by-product. Theobromine inactivates digestive enzyme by the formation of enzymes complexes in the digestive tract (Owusu-Domfeh, 1972). Due to the presence of theobromine in cocoa cake, cocoa-cake-with-shell should not exceed 0.21% in the diets of pigs (Rhule, 2001).

2.8.5 Brewers' Spent Grains (BSG)

Brewers spent grains (BSG) is a by product from beer production. The material can be fed in the wet or dried form. It is bulky, especially when wet, low in energy but quiet high in crude protein (21 %) and crude fibre (20 %) on DM basis (Chenost and Mayer, 1977). Wet brewers spent grains (WBSG) has been used in feeding both ruminants and non - ruminants. The palatability of WBSG declines, with increasing storage time. However, brewer's dried grains usage is limited in monogastrics because of its high fiber (24 % ADF) content, so it is not normally used in intensive feeding systems. Brewers spent grains is a potential source of protein, especially where soybean and fishmeal are not available (Yaakugh and Tegbe, 1990).

High BSG levels in diets depressed feed intake and growth rate. It has also been shown that the bulky nature of BSG diets may adversely affect the digestibility as well as the availability of amino acids and other nutrients for pigs (Tebge 1985; Yaakugh and Tebge, 1990). The inclusion of brewers spent grains at up to 15% in the diets of pigs from weaning until slaughter at 92 kg had no significant effect on performance. In sows, inclusion rates up to 20% of BSG did not depress average daily gain or feed conversion efficiency. The BSG has been found to be satisfactory source of protein in most finishing pig rations (Amaefule *et al.*, 2006).

2.8.6 Soybean Meal (SBM)

Soybean meal (SBM) contains about 44.0% CP, 7.30% CF, 7.84% EE, 3.3% cellulose and 3.48% hemicellulose on DM basis (Pond *et al.*, 1995). Soybean meal has very high protein and energy digestibility and is considered good source of supplemental protein in diets for swine. It is often referred to as the "gold standard" in that all other protein sources are generally compared to SBM. It has an excellent profile of highly digestible amino acids being a rich source of lysine, tryptophan, threonine, isoleucine and valine but low in methionine (Dunsford *et al.*, 1989; Li *et al*, 1991~~; Makinde *et al.*, 1996~~).

Soybean meal can be used at levels of 10% in grower (30 to 65 kg) pig diets without affecting pig performance while they can be used at levels of 20% in finisher pig (65 kg) diets without affecting pig performance. A typical starter diet for nursery pigs may contain SBM at levels ranging from15 to 25% (O' Doherty and Keady, 2000; McKeon and O' Doherty, 2001). Soybean meal may contain anti-nutritional factors, which have been implicated with decreased growth performance of newly weaned pigs when fed directly (Li *et al*, 1991). The inhibitors such as tannins, saponins and trypsin inhibitors are however, destroyed by heat, during the normal processing steps in preparing SBM. Due to the anti-nutritional factors and crude fibre content of soyabean meal, SBM should not exceed 40% in the diet of pigs (O' Doherty and Keady, 2000).

2.8.7 Rice bran (RB)

Rice bran, a by-product in the processing of paddy rice, contains about 14.00% CP, 2-3% EE and 12.90% CF (Sikka 1990). Rice bran actually is a mixture of the pericarp, seed coat and some of the aleurone layer. Rice bran is a good source of B-vitamins and is fairly palatable to pigs (Sikka and Chawla, 1984). Steyaert *et al* (1989) suggested that rice bran could be used up to 300 g/kg for broilers. Tiemoko (1992) reported that 300 g/kg rice bran in broiler diets, replacing maize, significantly ($P<0.01$) improved liveweight gain while feed conversion efficiency was unaffected. The use of rice bran has also been shown to reduce feed cost per kg weight gain. Rice bran has been found to contain a high level of dietary fibres (beta-glucan, pectin and gum), in addition, it also contains 4-hydroxy-3-methoxycinnamic acid (ferulic acid) which affects growth rate and digestibility in growing pigs and sows. Rice bran can be used as a replacement for WB and as a partial replacement for maize or the cereal component of the diet (Okai, 1998). The substitution of 20 or 30% RB for maize in a maize-soybean meal diet reduced weight gain and significantly reduced feed efficiency and carcass firmness (Tuah and Boateng, 1982).

Rice bran can be used at levels up to 40% in grower-finisher diets without reducing performance. Good results have been reported when 30-40% RB was included in the diets of grower-finisher pigs (Campadadal *et al,* 1976). It has also been observed that levels as high as 50% could be satisfactory for pigs (Tuah and Boateng, 1982). However, Tuah *et al* (1974) had earlier indicated that RB levels between 40 and 60%, when fed to finishing pigs reduced growth rate.

2.8.8 Wheat Bran (WB)

Wheat bran (WB) is a commonly used by-product. It serves as an energy source in the diets of non-ruminants. Wheat bran contains about 16% CP and 1322 Kcal ME/kg (NRC, 1998). Wheat bran is produced in large quantities as a by-product of the flour milling industry in Ghana. Wheat bran is not very digestible, however, its water holding capacity and the consequent slight laxative effect makes it particularly well adapted for use in pig rations. Its amino acid balance is superior to that of whole wheat but inferior to that of most protein supplements. Wheat bran is quiet high in phosphorus, but low in calcium, so that a nutritional imbalance of calcium and phosphorus occurs, if WB is a major component of the diet (Pond and Maner, 1974; Okai *et al*, 1995). It has been shown that WB is palatable and a good source of iron, manganese and Vitamin B complex (Ranjhan, 2001).

Wheat bran is regarded as a good feed ingredient and it is quite common to have diets containing at least 25%. Finishing pigs can be fed diets containing as much as 40% WB and even though there could be a significant decline in growth rate, carcass traits would be better and such diets are found to be cheaper and lead to reduction in feed cost per kg gain (Okai *et al.*, 2000). Wheat bran can be safely used for all classes of pigs and levels up to 30% can be included satisfactorily in diets for finishing pigs. Studies with finishing pigs indicated that growth performance and some carcass characteristics could be depressed significantly when WB level exceeded 40 per cent of the diet (McDonald *et al*, 1995).

Okai *et al* (2000) fed wheat bran (WB) at WB_{20} (control), WB_{30} + Optizyme and WB_{40} + Optizyme inclusion level to grower-finisher pigs without any adverse effect on performance. The inclusion rate for the Optizyme was 50g/100 kg diet. The ADG were 0.60, 0.68, 0.63 kg/day respectively. The feed/gain recorded when growing-finisher pigs were fed WB_{20} (control), WB_{30} + Optizyme and WB_{40} + Optizyme were 3.19, 3.07, and 3.12 respectively. There were no significant differences ($P > 0.05$) between the observed means.

2.9.0 Effect of Anti-Nutritional Factors (ANF) on Pig Performance

Certain inherent chemical constituents in different kinds of feedstuffs interfere with the optimum utilization of nutrients (Chubb, 1987). Anti-nutritional factors may therefore be defined as the chemical constituent of feedstuff, which interferes with the normal digestion, absorption and metabolism of feed. Some common ANF include: tannins, trypsin inhibitors, phytic acid, theobromine and gossypol (Nityanand, 1997).The presence of ANF in the diets of pigs can have very profound influence on their growth performance. Studies have shown that the presence of these compounds depressed the digestion and utilization of proteins and adversely affected the utilization of mineral elements and could also lead to increases in the requirement for some vitamins (Okai *et al*, 1995).

2.9.1 Tannins and Theobromine

Tannins are complex polymeric phenols found in the seeds of many broad-leaved plants and can be lethal (Nityanand, 1997). Levels exceeding 6% on a dry matter basis will kill pigs. The ingestion of tannins has been implicated in the decreased digestiblility of protein by monogastrics (Butler *et al*, 1985). Nityanand (1997) indicated that hydrolysable tannins such as tannic acid can also be absorbed through intact or injured gastro-intestinal tract and ultimately cause kidney and liver necrosis. Tannins combine with proteins including enzymes in the digestive tract and interfere with the digestive action of trypsin and ά-amylase by binding the protein into a non-digestive form (Gohl, 1982). It negatively affects the digestibility of proteins (Jansman *et al*, 1995) and carbohydrates, thus reducing the growth rate of pigs, the efficiency of feed utilization and the availability of metabolisable energy in the diet (Rostango, 1972, Bressani, 1993).

The presence of theobromine in cocoa husk has been found to be responsible for the declining growth rate of grower-finisher pigs when cocoa pod husk is fed at high inclusion levels (Bressani, 1993). The negative effect of cocoa pod husk on pig growth has also been attributed to the high fibre content when high inclusion levels are used in diets (Teguian and Begaen, 2004). Increasing the proportion of cocoa pod husk in the diets of pigs affects performance due to the presence of theobromine.

2.10 Determination of Milk Yield in Sows

Sow milk yield is one of the important factors limiting neonate piglet growth (Boyd and Kensinger, 1998). It has been shown that sow milk yield is affected by the level of suckling intensity, which encompasses several sow litter interaction including suckling frequency, litter size, age and size of piglets (King, 2000).

Different methods have been used to measure the milk yield of sows (Salmon-Legagneur, 1956). Milk yield in the sow has been assessed with the weigh-suckle-weigh (WSW) method (Speer and Cox, 1984; Noblet and Etienne, 1989) or machine-milking the sow after the administration of oxytocin (Hartmann *et al.*, 1984) or by weekly weight gains of piglets (Boyd and Kensinger, 1998) or with the isotopes dilution technique (Pettigrew *et al.*, 1987). All the methods however, require a considerable amount of experienced labor, and this renders them unsatisfactory for routine measurement; as a result it is not practical to use milk yield determinations as a selection criterion for improving the sow herd (Mahan *et al.*, 1971). The method mostly used by researchers for the determination of milk yield is the WSW method. It is a laborious method though and involves the weighing of piglets immediately before and soon after suckling with the difference in weight being taken as the amount of milk ingested by the piglets. Litters are usually separated from their sows between weighing and are only returned at predetermined interval for suckling. The procedure is repeated several times throughout the day and the weights obtained are used to estimate the daily milk yield (Speer and Cox, 1984). It has been observed that, the separation of piglets from their sows disrupts the normal suckling patterns of the piglets and may either adversely affect the milk yield of the sow or leads to unsuccessful milk let down (Pettigrew *et al.*, 1987).

There is a problem of under estimation of milk yield due to piglet factors such as litter size, teat order, litter health and metabolic processes (Noblet and Etienne,1989; Pettigrew *et al.*, 1987).Milk yield alters according to the stage of lactation reaching a peak in most sows between the third and fourth week of lactation eg 5.1, 6.5,7.1, 7.2, 7.0, 6.6, 5.7, and 4.9 kg/24h at 1, 2, 3, 4, 5, 6, 7 and 8 weeks of lactation respectively (Atwood and Hartmann, 1995; Hurley, 2001). Milk yield is higher in second and third parity sows than in first parity sows (Noble *et al.*, 2002).

2.11 Summary of the Literature Reviewed

The literature reviewed suggests that nutrient requirement for pigs used in Ghana are based on values determined mostly in the temperate regions usually Europe and U. S. Environmental factors pertaining in Ghana could greatly modify the requirements. With the escalating cost of feeding pigs, in addition to the scarcity of feedstuffs during some period in the year it is important that feeds available are used efficiently. Excess supply of nutrients to the pigs, especially crude protein and minerals, beyond the requirements of the category, are excreted and could constitute a major pollution of the soil and subsequently water sources.

It may be inferred from the literature that the optimum CP levels for pregnant, lactating and starting pigs have been put at 14, 16 and 22% (Mahan *et al*, 1977; Jones and Stahly, 1995; Day and Plascencia-Gonzalez., 2000). The literature review also suggests that agro–industrial by-products from the agro–processing industry appear promising as protein and energy source for pigs. These are quite cheap, readily available and preferably unsuitable for human consumption.

Quite a number of experiments have been conducted with these products (Okai *et al.,* 2006; Rhule 1996, 1998) where they were used as a source of dietary protein and energy for pigs. In the light of these, the project will focus on feeding breeding sows in Ghana, with either conventional feeds or AIBP to determine the CP level for pregnant and lactating sows in Ghana. The objectives of this study were to:

i. Establish the requirement for crude protein by gestating and lactating sows in Ghana, when fed either cereal or AIBP-based diets.

ii. Determine the effects of the identified crude protein level on the reproductive performance of sows.

iii. Determine ideal crude protein level for creep diets for piglets in Ghana.

iv. Determine the effect of AIBP-based creep diets on growth and survival of piglets.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Location of Study

The study was conducted at the Animal Research Institute, Frafraha, Accra. The location is in the Coastal Savannah Zone of Ghana and situated in the Adenta Municipal Assembly area of the Greater Accra Region. The monthly temperature of the Zone varies between 26 and 29 °C. The highest mean monthly temperature of 29 °C occurs during March and April while the lowest of 26 °C is in August. The Zone has a bimodal rainfall pattern with the major rainy season occurring between April and July and the minor between September and October. A short dry season separates the two periods in August. The major dry season (Harmattan) lasts from November to February. The average relative humidity is usually about 65%.

3.2.0 Experiment One

3.2.1 Animals and Experimental Design

Eighteen Large White gilts with an average live weight of 100 kg were used. The gilts were distributed equally into six groups by the completely randomized block design. The groups were then randomly assigned to one of the three dietary treatments (ie T_1, T_2 and T_3) with two replicates to a treatment. The mean initial weights of the gilts in the three treatments were 99 kg (T1), 102 kg (T2) and 99 kg (T3). Gilts were ear tagged for easy identification. The gilts in each group were housed in concrete-floored, well-ventilated pens measuring $2m^2$. Each pen had a wallow and water and feeding troughs.

3.2.2 Dietary Treatments

Three cereal-based diets containing different crude protein levels were formulated for breeders, lactating sows and for creep feeding. The feeds were compounded using facilities available at the feed mill of the Animal Research Institute at the Achimota Station. The breeder diets were formulated to contain 14.16 % CP (T1), 13.36%CP (T2) and 12.02% CP (T3). The lactation diets were formulated to contain 16.54% (T1), 15.15% (T2) and 13.40% (T3) CP and the creep diets were also formulated to contain 22.60% CP (T1), 21.74% CP (T2) and 20.01% CP (T3). The percentage compositions of the diets fed are shown in Table 5.

3.2.3 Feeding, Breeding and Management

Gilts were initially group-fed the breeder diets; the feed allowance was 2 kg / gilt / day. After parturition, each sow was fed 4 kg / day of the corresponding lactation diet. Piglets were injected intramuscularly with 2ml Fe-dextran before 3 days of age. All litters received corresponding creep feed from 2 weeks of age until weaning at 6weeks of age. Gilts that came on heat were sent to the boar for mating and were checked from day 19 postmating for possible return to oestrus; gilts which did not return to oestrus were assumed to be pregnant. The gilts were mated between February and June and farrowing occurred between June and September, 2007.

Routine health and management practices such as the control of endoparasite and ectoparasite were initially carried out at the beginning of the study using **Levamisole powde*r and **Ivomec*, ®.

**Levamisole*·*; treatment of anthelmintic infections caused by adult and larve stages of gastro-insiestinal nematodes and longworms by Anglian Nutrition Products Company. Crockatt Road, UK.*

**Ivomec*, ®; *Control of both endoparasite and ectoparasite (longworms, and lice).Tiiet Int.Madras.*

Table 5. Percentage composition of the cereal-based diets used in Experiment 1

	TYPE OF DIET								
	Breeder			Lactation			Creep		
Ingredients	T1	T2	T3	T1	T2	T3	T1	T2	T3
Maize	49.46	50.44	59.10	48.60	48.10	48.51	46.96	47.90	49.60
Wheat bran	45.27	45.86	37.20	38.30	41.80	45.56	20.13	22.95	24.80
Fishmeal	1.00	1.00	1.00	3.80	2.20	1.03	11.74	10.15	8.50
Soybean meal	2.57	1.00	1.00	7.60	5.30	2.50	19.46	16.97	14.80
Oyster shell	1.00	1.00	1.00	1.00	2.00	1.91	1.01	1.33	1.40
Common salt	0.50	0.50	0.50	0.60	0.50	0.44	0.50	0.50	0.60
Vitamin and TMP•	0.20	0.20	0.20	0.10	0.10	0.05	0.20	0.20	0.30
Total	100	100	100	100	100	100	100	100	100
Calculated Composition (%)									
Crude protein	13.16	12.56	12.01	16.08	14.54	13.20	22.01	21.46	20.00
Crude fibre	5.85	5.89	5.24	5.31	5.56	5.85	3.89	4.11	4.04
Ether extract	3.92	3.97	3.93	3.96	3.88	3.90	4.16	4.11	4.25
Lysine	0.40	0.37	0.35	0.62	0.51	0.40	1.35	1.35	1.39
Methionine	0.20	0.19	0.19	0.26	0.23	0.20	0.43	0.39	0.36
Calcium	0.50	0.50	0.49	0.60	0.90	0.83	0.88	0.94	0.90
Phosphorus	0.23	0.23	0.20	0.27	0.24	0.22	0.37	0.35	0.32
Analysed Composition %(DM)									
Dry matter	86.14	87.20	87.61	88.24	86.95	88.10	88.33	89.14	88.42
Moisture	13.86	12.80	12.39	11.76	13.05	11.90	11.67	10.86	11.58
Ash	7.47	7.47	6.81	6.02	5.14	5.14	6.02	6.45	9.45
Crude protein	14.16	13.36	12.02	16.54	15.15	13.40	22.60	21.74	20.01

•Vitamin and TMP (Trace Mineral Premix): Inclusion rate is 25 kg/tonne to supply the following per tonne of feed: Vit.A, 12,000,000 IU; Vit.E, 15000 mg; Vit.B1, 1500 mg; Niacin 30,000 mg; Vit.B6, 1500 mg; Vit.D3, 4500,000 mg; Vit. K3, 3,000 mg; Pantothenic acid,12000 mg; Vit.B12, 10,000 mg; Vit. B2,6000 mg; Folic acid, 800 mg, Iron, 60,000 mg; Copper 75,00 mg; Iodine, 750 mg; Manganese, 130,000 mg; zinc, 70,000 mg; Selenium, 300mg calcium,17.50%, Lysine,1,330 mg; Methionine, 1,075 mg; B-Corotenic acid, 350 mg.

3.2.4 Weigh-Suckle-Weigh Method of Milk Yield Determination

The milk yield of each sow was measured on day 14, 28 and 42 of lactation by the weigh- suckle- weigh (WSW) method ie piglets were weighed before and after suckling as described by Speer and Cox (1984). This method has been recognized as the most precise method of measuring the quantity of milk produced by a sow (Salmon-Legagneur, 1956). Piglets were separated from their dam at 6am each morning, weighed to obtain a pre-suckling weight and then placed in a clean empty pen for two hours. They were returned to the sow and allowed to suckle until the end of vigorous synchronized suckling. After suckling, piglets were collected and weighed, to obtain a post-suckling weight. This procedure was repeated every two hours until a minimum of five consistent measurements of milk yield was obtained. The milk yield was estimated to be the difference between pre-suckling and post-suckling litter weights

3.3.0 Experiment Two

3.3.1 Animals and Experimental Design

Seventeen Large White primiparous sows from the first experiment were used. The sows were redistributed using the randomized block design for the three treatments namely TA, TB, and TC. The mean initial liveweight for the three dietary treatments were 126.00 kg (TA) 122.00kg (TB) and 114.00 kg (TC). These weights were the weights of the sows at the time the piglets were weaned. After weaning, the sows were mated at the first oestrus (August and December, 2007) and farrowing occurred between December 2007 and April 2008. Sows were checked for possible return to oestrus on the 19th, 20th and 21st day post mating. Sows which did not return to oestrus were deemed to be pregnant. A sow was considered as a replicate, thus there were five replicates for treatment TA and six replicates per treatment for TB and TC. Each sow was housed individually in a well ventilated concrete-floored pen, measuring 2 meters square and each pen was equipped with water and feed troughs.

3.3.2 Dietary Treatments

There were three dietary treatments as stated earlier. Treatments TA, the Control was the cereal-based diet which was identified in Experiment 1 (T1) to be ideal for the gilts and sows during pregnancy and lactation while dietary treatments TB and TC were AIBP-based and no maize diets (Table 6). The three dietary treatments had similar CP contents for each phase ie breeder, lactation and creep and were formulated to contain 14, 16 and 22% CP respectively. The diets fed are shown in Table 6.

3.4.0 Chemical Analysis

Ground samples of both the cereal and AIBP-based diets were analysed for CP, CF, EE, Ash and DM using the standard methods of AOAC (1990) at the National Animal Feed Control Laboratory, ARI based at Achimota.

3.5.0 Data Collection and Statistical Analysis

Parameters considered were liveweight gains of the gilts during pregnancy, liveweight changes of the sows during lactation, litter size, number born alive, average birth weight of piglets, average daily liveweight gain of piglets, weaning liveweight of piglets, number of piglets weaned and milk yield of the sow. The liveweight of each sow was taken before the first mating then at farrowing to determine the sow weight gain. Birth weight of piglets and the sow liveweights immediately after parturition were recorded within 24 hours post partum. Litter size, number born alive, stillbirths and sexes of piglets were also recorded. Live weights of the piglets were also recorded at the 2nd, 4th and 6th week post partum. The number of piglets weaned per sow and piglet weaning weight were recorded. The sows were weighed at weaning to determine changes in the liveweight during lactation.

All data collected were analysed statistically using the Analysis of Variance (ANOVA) technique and the Tukey HSD multiple comparison method was used to determine the extent of the differences between means (Steel *et al.*, 1997). The details of the statistical analysis are presented in the Appendices.

Table 6. Percentage composition of the control and AIBP-based diets used in Experiment 2

	TYPE OF DIETS								
	Breeder			Lactation			Creep		
Ingredients	TA	TB	TC	TA	TB	TC	TA	TB	TC
Maize	48.40			48.60			46.96		
Wheat bran	45.40			38.30			20.13		
Maize bran			26.50			19.70		11.10	7.90
Rice bran		29.00			22.10	8.20		17.70	19.80
Cocoa cake					10.60				
Cassava peel		29.00	27.4		22.0	18.00		19.10	18.20
Brewers spent grains			18.1						
Cocoa expeller cake		10.05	4.0			3.30		6.20	3.20
Copra cake			18.80			15.70			15.80
Palm kernel cake		20.00			30.10	8.20		17.70	7.90
Soyabean meal	2.60	5.90	1.50	7.60	8.20	15.40	19.46	16.40	15.80
Fishmeal	1.00	3.00	1.00	3.80	4.50	9.80	11.74	10.20	10.00
Oyster shell	1.90	1.90	2.00	1.00	1.80	1.00	1.01	1.00	0.80
Common salt	0.50	0.50	0.50	0.60	0.50	0.50	0.50	0.40	0.40
Vitamin and TMP•	0.20	0.20	0.20	0.10	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100	100	100	100	100
Calculated Composition (%)									
Ether extract	3.80	5.40	5.40	3.90	6.50	5.70	4.10	5.90	8.50
Crude fibre	5.70	12.90	10.7	5.30	13.60	8.60	4.10	9.80	8.50
Crude protein	12.60	13.80	13.1	16.00	16.90	16.30	22.50	22.40	22.60
Analysed Composition % (DM)									
Dry matter	87.80	89.66	89.44	90.86	90.99	90.05	86.68	88.66	88.20
Moisture	12.20	10.34	10.59	9.14	9.01	9.95	13.32	11.34	11.80
Ash	5.23	7.20	7.66	8.96	9.34	9.78	5.95	9.35	8.31
Crude fibre	5.90	10.55	10.55	5.72	11.63	10.91	4.35	9.07	9.37
Crude protein	13.40	13.25	13.56	16.48	16.45	16.39	22.63	22.47	23.63
Ether extract	4.93	6.28	7.44	7.35	6.61	7.02	4.02	6.21	9.37

•Vitamin and TMP (Trace Mineral Premix): Inclusion rate is 25 kg/tonne to supply the following per tonne of feed: Vit.A, 12,000,000 IU; Vit.E, 15000 mg; Vit.B1, 1500 mg; Niacin 30,000 mg; Vit.B6, 1500 mg; Vit.D3, 4500,000 mg; Vit. K3, 3,000 mg; Pantothenic acid,12000 mg; Vit.B12, 10,000 mg; Vit. B2,6000 mg; Folic acid, 800 mg, Iron, 60,000 mg; Copper 7500 mg; Iodine, 750 mg; Manganese, 130,000 mg; zinc, 70,000 mg, Selenium, 300mg, calcium,17.50%, Lysine,1,330 mg, Methionine, 1,075 mg; B-Corotenic acid, 350 mg.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1.0 Experiment One

4.1.1 Health of Animals

The eighteen gilts remained healthy throughout the trial and no abnormality that could be attributed to the diets fed was observed. There were no outbreaks of diseases during the experimental period. However, one gilt from treatment T2 was taken off the study after several unsuccessful attempts to make it pregnant.

4.1.2 Chemical Composition of the Cereal-Based Diets

The chemical compositions of the three cereal-based diets fed are shown in Table 5. With regard to the CP content of the analysed diets, the values were 14.16% (T1), 13.36% (T2) and 12.02% (T3) for the breeder, 16.54% (T1), 15.15% (T2) and (13.40%) for the lactation and 22.60% (T1), 21.74% (T2) and 20.01% (T3) for the creep diets. For the calculated compositions the values were 13.16% (T1), 12.56% (T2) and 12.01% CP (T3) for the breeder, 16.08% (T1), 14.54% (T2) and 13.20% CP (T3) for the lactation and 23.01% (T1), 21.46% (T2) and 20.00% CP (T3) for the creep diets. It was observed that the analysed composition of the diets did not differ considerably from the calculated values. The CF levels in the lactation diets also increased as the CP level decreased. The CF level in the creep diets were rather low compared to the lactation diets considering their composition (Table 5). The analysed CF showed a trend of high values in both T1 (5.85) and T2 (5.89) than in T3 (5.24) for the breeder diets.

4.1.3 Reproductive Performance of Sows fed the Varying Levels of CP.

Seventeen (17) out of the total of eighteen (18) gilts used for the study farrowed successfully. In all, eight (8) incidence of stillbirths were recorded, two on T1, one from T2 and five on T3. Table 7 shows the effects for the dietary treatment on sow reproductive performance measured as mean number of piglet born alive, mean birth weight, sow weight gain and mean sow weight loss. The mean birth weight of piglets from sows fed diets T1, T2 and T3 were similar (P > 0.05). The values for T1, T2 and T3 were 1.45, 1.35 and 1.42 kg respectively. Mean birth weight of piglets from T1 were slightly higher than those on T2 and T3, this observation is similar to reports on preliminary studies by Grandhi, (1994), Jones and Stahly (1995) who indicated that the optimum crude protein level in the diets of pregnant sows was 13.0 % CP. Coma *et al* (1996) also reported that varying levels of CP (10.0, 11.5 and 13.0 %) fed to sows had significantly no effect on piglets birth weight.

The mean number born alive for diets T1, T2 and T3 were 9.17, 8.40 and 7.60 respectively. The mean number born alive was relatively highest on T1 (9.17) and decreased as the CP in the diet decreased T3 (7.60) although this was not found to be significant statistically (P > 0.05).

The mean sow weight gains during pregnancy were 30.33, 28.80 and 34.00kg for dietary treatments T1, T2 and T3 respectively. Gilts fed the T3 diet recorded the highest weight gain as compared to treatments T1 and T2. However, there were no significant differences between the treatments means, thus, confirming the observation of Coma *et al* (1996) that sow weight gains during pregnancy were not affected in the first reproduction cycle when sows were fed 10.0, 11.5,13.0 and 14.5 % CP diets.

Table 7. Reproductive Performance of Sows and Pre-Weaning Weight of Piglets and the Economics of Production on Cereal Based-Diets with Varying CP Levels (Experiment 1).

DIETARY TREATMENTS					
Parameter	T1	T2	T3	SIG	SED
Crude protein levels (%)					
Breeder diet	14.16	13.36	12.02	-	-
Lactation diet	16.54	15.15	13.04	-	-
Creep diet	21.60	21.74	20.01	-	-
Number of sows	6	5	6	-	-
Total number of piglets born	51	40	38	-	-
Total stillbirth	2	1	5	-	-
Mean number born alive	9.17	8.40	7.60	NS	0.95
Mean birth wt (kg)	1.45	1.35	1.42	NS	0.06
Number weaned	6.83	8.80	7.00	NS	0.51
Mean Sow wt gain during pregnancy (kg)	30.33	28.80	34.00	NS	4.71
Mean sow wt loss during lactation (kg)	12.30	19.00	21.60	NS	2.97
Mean 14-day piglets live wt (kg)	4.51	4.01	4.57	NS	0.19
Mean 28-day piglets live wt (kg)	7.23	7.02	6.73	NS	0.28
Mean weaning wt (kg)	9.31	9.29	9.01	NS	0.51
Mean ADG of piglets (kg/day)	0.19	0.17	0.20	NS	0.01
Feed cost(GH¢/kg)					
Breeder diet	0.40	0.40	0.44	-	-
Lactation diet	0.42	0.40	0.40	-	-
Creep diet	0.48	0.47	0.47	-	-

SIG: level of significance.

NS: not significant. (P>0.05). SED: standard error of differences of means

The average weight losses for sows at weaning (Table 7) were 12.33, 19.00 and 21.60 kg for T1, T2 and T3 respectively. The average weight loss in the sows increased with decreasing CP level of the lactation diets, being lowest in T1; again, there were no significant (P > 0.05) differences between the observed means. Weldon *et al* (1994) reported that liveweight losses of up to 30 kg during lactation have been observed for sows given low CP diets but with high levels of feed during pregnancy followed by restricted intake throughout an eight week lactation period.

4.1.4 Piglet Growth Performance

The effects of the varying levels of CP in the three lactation diets on 14th, 28th and 42nd day piglet weights is shown in Table 7. The 14th day weights of the piglets were 4.51, 4.01 and 4.57 kg for sow fed the T1, T2 and T3 lactation diets. No significant (P > 0.05) differences were observed between the treatments. The average 14th day weights obtained in the studies were similar to values from other temperate areas reported by Evert *et al* (1994). Sows fed the T3 diet had their piglets recording a slight higher weight than piglets suckling from sows fed the T1 diet; the slight differences in weight could be due to the number of piglet suckling (Nielsen *et al* 2002) however, differences were not significant (P > 0.05).

The effects of the CP levels of the creep diets on mean 28th day weights, ADG, number weaned and weaning weight of piglets involved in this experiment are also shown in Table 7. The mean 28th day values were similar (P>0.05) ie 7.23, 7.02 and 6.73 kg for dietary treatment T1, T2 and T3 respectively. There was however, a trend of decreasing liveweight at the 28th day with decreasing level of CP in the creep diet.

The mean weaning weights of piglets were 9.31, 9.29 and 9.01 kg for treatments T1, T2 and T3 and these values were similar even though numerical differences were observed. The high birth weight of piglets on treatment T1 (Table 7) were translated into higher weaning weight (Table 8), although the differences were not found to be significantly different (P > 0.05).

The ADG of piglets fed creep diets T1, T2 and T3 were 0.19, 0.17 and 0.20 kg/day respectively. The ADG was slightly higher on treatment T3 compared with the other treatments (Table 7), even though the differences were again not found to be significantly different (P > 0.05). Though the growth rate in treatment T2 was lower, it compared favorably with the growth rate of 0.17 kg/day reported by Okai *et al* (1977).

The unit costs of the breeder diets are shown in Table 7. The cost of T3 was higher than diets T1 and T2 respectively. The increased feed cost of diet T3 was due to the higher inclusion rate of maize as reported earlier by Cameron, (1970) and Okai *et al* (2001). The unit cost of T1 for lactation and creep was in each case slightly higher than the corresponding T2 and T3 due to the reduced inclusion rate of fish meal. Breeder diet T1 would elicit a more profitable production for the number born alive with lactation diet T2 being more economical for the number weaned. Considering the influence of the weaning weight or the survival of the weaned pigs, the cumulative effects of lactation diet T2 and creep diet T2 would lead to greater economy of production and profit.

4.1.5 Milk Yield of Lactating Sows Fed Cereal-Based Diets with Varying CP Levels.

Increasing the CP intake of primiparous sows during lactation failed to significantly (P > 0.05) affect milk yield as shown in Table 8. The 14[th] day milk yield varied between 3.04 to 7.00 kg / day being highest in sows fed diet T1 (high CP level). However, the differences between the means were not significant ($P > 0.05$).

The 28[th] day milk yield of sow on treatment T1, T2 and T3 were 3.20, 6.79 and 5.44 kg/day respectively. Again these values were not significantly different ($P>0.05$). The milk yields in T2 are comparable to the 7.40 kg/d for sows fed 4.5 kg of cereal based diets containing 14% CP reported by Einarasson and Rojkittikhun, (1993), but considerably lower than the 11.2 kg/d at the 28[th] day obtained by Evert *et al* (1994). The 28[th] day milk yield of 3.20 kg/d for treatment T1 was a drastic reduction from that obtained on the 14[th] day ($P>0.05$). The results may suggest that the feed allowance of 4 kg/sow/day may have been inadequate for maximum milk production (Evert *et al*., 1994). The milk yields recorded on the 42[nd] day were 4.96, 8.29 and 3.59 kg/d for dietary treatments T1, T2 and T3 respectively. The amount of milk obtained from treatment T2 (8.26 kg/d) compared favorably with the 6.6 kg/d obtained from a WSW experiment reported by Atwood and Hartmann (1995).

Table 8. Milk yield of lactating sows fed cereal-based diets with varying CP Levels (Experiment 1)

Dietary Treatments					
Parameter	T1	T2	T3	SIG	SED
Crude Protein levels (%)	16.54	15.15	13.04	-	-
Mean 14-day milk yield (kg/day)	7.03	3.04	3.76	NS	0.77
Mean 28-day milk yield (kg/day)	3.20	6.79	5.44	NS	0.91
Mean 42-day milk yield (kg/day)	4.96	8.29	3.59	NS	1.04

SED: standard error of differences of means
SIG: level of significance.
NS: not significant ($P > 0.05$).

5.1.0 Experiment Two

5.1.1 Reproductive Performance of Sows Fed AIBP-Based Diets (Experiment 2)

The chemical composition of the three AIBP-based diets fed has been shown in Table 6. The analysed CP content for breeder, lactation and creep diets were similar for all the treatments. The CF content of the diets was markedly increased in all the AIBP based-diets as compared to the control (TA) for the breeder, lactation and creep diets respectively.

The reproductive performance of the 17 sows involved in this experiment is shown in Table 9. The values for the mean birth weight were 1.43, 1.54 and 1.54 kg for dietary treatment TA, TB and TC respectively. The sows fed the AIBP-based diets during pregnancy recorded higher birth weight than those fed the control diet (TA). The mean birth weight values for dietary treatment TB and TC were similar ($P > 0.05$). The inclusion of cassava peels in diets TB and TC up to the levels of 29.0 and 27.4% respectively did not have any significant ($P>0.05$) adverse effect on the birth weight of piglets. Levels as high as 30 and 37.50% of cassava peels have been fed without any adverse on grower-finisher pigs (Sonaiya and Omole, 1997; Rhule, 1998). The mean numbers of piglets born alive were 9.40, 8.80 and 10.00 kg for treatments TA, TB and TC respectively. The mean number of piglets born alive were higher in TC compared to the control, TA and TB, again the results obtained did not follow any consistent pattern and there were no significant differences between the treatment means ($P>0.05$). The lowest mean number of piglets born (8.80 kg) was in sows fed the diet TB which contained 30.10% PKC. Treatment TB also contained cocoa expeller cake which is known to contain about 2.1% theobromine (Rhule, Unpubl.). Theobromine could be toxic to pigs when fed above a level of 0.2% in the diet (Rhule, 2001), this could also account for the low number of piglets born alive on

Table 9. Reproductive and Economics Performance of Sows and their Litters Fed AIBP-Based Diets. (Experiment 2)

	Dietary Treatments				
Parameter	TA	TB	TC	SIG	SED
Crude protein levels (%)					
Breeder diet	13.00	13.00	13.00	-	-
Lactation diet	16.00	16.00	16.00	-	-
Creep diet	22.00	22.00	22.00	-	-
Total number of piglets	42.00	46.00	50.00	-	-
Number of sows	5.00	6.00	6.00	-	-
Total stillbirth	2.00	6.00	1.00	-	-
Mean number born alive	9.40	8.80	10.00	NS	0.65
Mean birth wt (kg)	1.43	1.54	1.54	NS	0.06
Mean Sow wt gain during pregnancy (kg)	20.40	35.40	31.40	NS	3.69
Mean sow wt loss during lactation (kg)	21.50	20.00	28.33	NS	3.63
Mean 14-day piglets live wt(kg)	3.81	4.39	4.59	NS	0.16
Mean 28-day piglets live wt(kg)	6.89	7.33	7.08	NS	0.41
Mean weaning wt (kg)	10.31	9.00	8.96	NS	0.52
Mean ADG (kg/day)	0.21	0.18	0.18	NS	0.12
Number weaned	7.60	7.40	9.00	NS	0.67
Feed cost (GH¢/kg)					
Breeder diet	0.40	0.17	0.17	-	-
Lactation diet	0.42	0.17	0.25	-	-
Creep diet	0.48	0.23	0.24	-	-

SIG: level of significance.
NS: not significant. (P>0.05).
SED: standard error of differences of means

dietary treatment TB, which contained 10.5% (TB) compared to 4.0% cocoa expeller cake in treatment TC.

The mean sow weight gains during pregnancy were 20.4, 35.4 and 31.4 kg for sows on treatments TA, TB and TC respectively. The sows on TB and TC had relatively higher liveweight gain during pregnancy than those on diet TA (Control). It has been shown by this study that sows on the AIBP-based diets had higher liveweight gains than those on the control diet during pregnancy. With regards to calculated CP content, diet TB had a higher CP than both TA and TC and could have accounted for the increased liveweight gain in pregnancy (Table 6) despite its considerably higher CF values of 13.60% compared to value of 5.3% in TA. Weight loss in the sows during lactation was highest on diet TC with the lowest for those fed diet TB. These values (Table 9) were however not found to be significantly different ($P>0.05$). Sows fed the TB diet had the highest liveweight gain and the lowest liveweight loss ($P > 0.05$).

5.1.2 Growth Performance of Piglets fed AIBP-Based Creep Diets (Experiment 2)

Table 9 shows the mean 14th and 28th-day weight, weaning weight, ADG and the number weaned. The mean 14-day weight of piglets fed creep diets TA, TB and TC were 3.81, 4.39 and 4.59 kg respectively. However, the differences between the means were not found to be significant ($P > 0.05$). The mean 28th day weight of piglets recorded were 6.89, 7.33 and 7.08 kg for treatments TA, TB and TC respectively; again the piglets fed diet TB recorded the highest liveweight compared to treatment TA and TC ($P > 0.05$). The corresponding mean weaning weights of piglets were 10.31, 9.00 and 8.96 kg ($P > 0.05$). Piglets fed dietary treatment TA had the highest average growth rate (0.21 kg/day), even though the growth rates were similar ($P>0.05$) to those obtained by piglets on diets TB and TC.

Both breeder diet TB and TC were 57.5% cheaper than TA. In terms of the number of pigs born alive both breeder diets TB and TC would be more economical to use than TA. The weaning weight of the piglets would be from the combined influence of the lactation and creep diets. However, lactation and creep TB and TC would auger for more pigs weaned, lower feed cost and more profitable production of pigs. It is therefore economically feasible and very profitable to use AIBPs for feeding pigs. Sow milk production was similar, the number of piglets born, number weaned and the weaning weight were not significantly different but on the average 57.5, 51.0 and 51.1 percent cheaper on the AIBP-based breeder, lactation and creep diets than on the respective control (cereal) diets.

5.1.3 Milk Yield of Lactating Sows Fed AIBP-Based Diets with varying CP Levels (Experiment 2)

The mean 14th day milk yields recorded were 3.48, 3.57 and 3.94 kg/day for dietary treatments TA, TB and TC respectively (Table 10). Even though there were numerical differences in the values for 14th day milk yield, these differences were not significant ($P>0.05$). Sows fed diet TC (Table, 10) had a higher milk yield (3.94kg/day) than sows fed the control diet, TA and diet TB. There was the indication that the milk yield increased progressively for treatments TA and TB with time whilst there was a decline after the 28th day on TC. The mean 42nd day milk yield values obtained in experiment 1 was 4.96 kg/day for sow fed T1 diets while the corresponding values for experiment 2 was 6.79 kg/day. Peaker and Wilde (1990) have suggested that milk yield is higher in second and third parity sows than first parity sows.

Table 10. Milk yield of lactating sows fed AIBP-based diets

Dietary Treatments					
Parameter	TA	TB	TC	SIG	SED
Crude Protein levels (%)	16	16	16	-	-
Mean 14-day milk yield (kg/day)	3.48	3.57	3.94	NS	0.40
Mean 28-day milk yield (kg/day)	4.02	4.27	6.11	NS	0.49
Mean 42-day milk yield (kg/day)	6.79	4.43	4.38	NS	0.57

SIG: level of significance.
NS: not significant. (P > 0.05).
SED: standard error of differences of means

CHAPTER FIVE

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the foregoing results, the following conclusions can be drawn:
The present study indicates that gilts fed the high CP breeder diets (ie 14.16% CP) performed better than the gilts fed the low CP breeder diets, ie 13.36 and 12.02% respectively. It was, however noted that during the lactation stage, the 14-day weight of piglets from sows fed the 16.08%, 14.54% and 13.20% CP respectively, were similar (P>0.05). It was also observed during the course of the experiment that piglets fed the high 22.60% CP cereal-based diets performed better than piglets fed the 21.74 and 20.01% CP respectively, even though such differences were not significant (P>0.05).

Increasing the CP levels of the diets of primiparous sows during lactation failed to significantly (P > 0.05) affect milk yield. Agro-industrial by-product can be included in the diets of sows at the levels used for this study without any adverse effect on the measures of sow reproductive efficiency. It is possible to exclude cereals, eg maize, from the diets of all categories of pigs. Agro-industrial by-product could be packaged into economically feasible diets for pigs. It has been shown that the survivability of piglets could be sustained on AIBP-based diets as well as cereal-based diets.

6.2 Recommendations

- Agro-industrial by-products based diets should be used to replace the expensive cereal-based diets for all categories of pig studied.

- Agro-industrial by-products used in this study have shown to be potential sources of nutrients for high pig performance such that the constraints of feeding pigs in Ghana could be removed using locally AIBPs.
- It would be worthwhile to use large number of sows for such a study in order to have results that would be easily appreciated.
- The optimum levels of some of the AIBP in the various diets may have to be studied further in view of the rather high stillbirth rate obtained on one of the AIBP-based diets.

7.0 REFERENCES

Acamovic, T. (2001). Nutrient requirements and standards for poultry. Review Nutritional standards for livestock. Avian Science Research Centre.SAC. 65: 76-85.

Adeyanju, S.A., Ogutuga, D.B.A., Ilori, J.O., and Adegbola, A. A. (1975). Potentialities of cocoa husk in livestock feeds. Proceedings of the Fifth International Cocoa Research Conference. Ibadan, Nigeria. Cocoa Producers Alliances, Lagos. Pp 505-510.

Agricultural Research Council (1981). The Nutrient Requirements of Pigs: Technical Review Edition Slough, England. Commonwealth Agricultural Bureau 22: 307.

Agunbianade, J. A., Wiseman, J., and Cole, D. J. A. (1999). Energy and nutrient use of palm kernels meals and palm kernel oil in diets for growing pigs. Animal Feed Science and Technology, 80:165-181.

Aherne, F. X and Williams, I. H. (1992). Nutrition for optimizing breeding herd performance. Can. J. Anim. Sci. 30: 910.

Aherne, F.X. (1997). Nutrition of the early weaned sow. Proc. 18th Western Nutr. Conf., Winnipeg, Man. Pp 43-61.

Amaefule, K U, Okechukwu, S O, Ukachukwu, S .N., Okoye, F .C and Onwudike O.C (2006). Digestibility and nutrient utilization of pigs fed graded levels of brewers' dried grain based diets. Livestock Research for Rural Development. Volume 18, Article #5. *http://www.cipav.org.co/lrrd/lrrd18/1/amae18005*.htm

Anderson, C. and Lindberg, J. E. (1997). Forages in diets for growing pigs.1. Apparent nutrient digestibilities and partition of nutrient digestion in barley-based diets including luceana and white-clover meal. Anim. Sci. 65: 483–491.

AOAC (1990). Association of Official Analytical Chemist. (15th edition). Official Methods of Analysis, Washington, DC, USA.

Arueya, G. (1991). Utilisation of cocoa pod husk in the production of washing powders. In: Abst. Int. Cocoa Conf.: Challenges in the 90s, Kuala Lumpur, Malaysia, pp. 25-28.

Atwood, C.S., and Hartmann. P.E (1995). Assessment of mammary gland metabolism in the sow (iii). Cellular metabolites in the mammary secretion and following weaning. J. Dairy Res. (62): 221-236.

Azian, M.J, Tomkin, T., and Sowinski J.S. (1994). Effect of protein and energy enriched lactation diet on sow and litter performance: Interaction with supplemental milk replacer. J. Anim. Sci. 72 (Suppl. 2): 65 (Abstract).

Babatunde, G. M., Fetuga, B. L. and Oyenuga, V. A. (1975). Unique problems in formulating swine diets in the hot humid tropical environment. Proceeding of the first International Symposium on feed composition animal nutrition requirements and computerization of diets. UTAH State University, Logan U.S.A.

Baker, D.H. (1993). Amino acid nutrition of pigs and poultry. In "Recent developments in pigs nutrition II" Nottingham University Press Louborough. Pp 123-129.

Balasubramaniam, K. (1976). Polysaccharides of the kernel of maturing and mature coconut. Journal of Food Science, 41:1370-1373.

Barnes, A.R and Oddoye, E.O.K (1985). Preliminary studies on the effect of a combination of dried cocoa husk and dried cassava meal on performance of finishing pigs, Proc. 16[th] GASA Symp. 1985, Univ. of Ghana, Legon. 84- 86.

Barnes, A .R., Amega, W. K., Manu, M and Rhule, S. W. A. (1984) Utilization of cocoa husk meal by growing-finishing pigs. In: Proceedings of the 9th International Cocoa Research Conference, 12-18 February, Lomé,Togo, pp 449-454.

Baynes, P. and Wiseman, J. (2001). The weaner pig nutrition and management. British Society of Animal Production, Edinburg, Pp.199-232.

Belstra, B. A., Diekman, M. A., Richert, B. T. and Singleton, W. L. (2002). Effects of lactation length and an exogenous progesterone and estradiol-17ß regimen during embryo attachment on endogenous steroid concentrations and embryo survival in sows. Theriogenology 57: 2063–2081.

Bowland, J.P. (1970). Protein and amino acid requirements of market pigs. Univ. of Alberta, 49[th] Ann. Feeders Day Report, Pp.15-18.

Boyd, R.D and Kensinger, R.S. (1998). Metabolic precursors for milk synthesis. In: "The Lactating Sow". Wageningen University Press. The Netherlands. Pp. 60-93.

Braude, R. (1981). The nutrient requirement of pigs. Commonwealth Agricultural Bureaux. Farnham Royal, UK. Pp. 92- 120.

Bressani, R (1993) Grain quality of common beans. Food Review International 9:217-297.

Brooks, P.H., Moran, C.A., Beal, J. D., Demeckova, V. and Campbell, R. G. (2001). The weaner pig nutrition and management.CABI Publishing 85: 119-532.

Butler L.G., Rogler, J. C., Mehansho, H. and Carlson, D. M. (1985). Dietary effect of tannins. Plant flavonoids in biology and medicine: Biochemical pharmacological and structure activity relationship. Pp 141-157, New York,

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

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

Campbell, R. G., Taverner, M. R,. and Curic, M. M. (1985). The influence of feeding level on the protein requirement of pigs between 20 and 45kg live weight. Animal Production, 40: 489-496.

Carpenter, K. J. and Booth, V. H. (1973). Damage to lysine in food processing: Its measurement and its significance. Nutrition Abstracts and Review, 43:423-451.

Chenost, M. and Mayer, L. (1977). Potential contribution and use of agro-industrial by-products in animal feeding. In: New feed resources. Proceedings of technical consultation held in Rome (22-24 November, 1977). Pp 1-27. http://www.fao.org/docrep/004/x6503e/x6503e00.htm

Chubb, L. G. (1987). The significance of anti-nutritional factors in feedstuffs. J. Sci. Food Agric. 40: 30-32.

Close, W. H., and Mullan, B. P. (1996). Nutrition and feeding of breeding stock. In: Pig Production. (ed, M. R. Taverner and A. C. Dinkin). Elsevier, NY. Pp. 169-202.

Cole, M. (1992). Influence of yeast culture on feeder calves and lambs. J. Anim. Sci. 70: Pp. 1682–1690.

Cole, M. and Sprent M. (2001). Protein and amino acid requirements of weaner pigs. In: Forbes, J.M., Varley, M.A and Lawrence, T.L, (eds).Weaner pig nutrition and management. Occasional Publication No 13, Brit. Soc. Anim. Prod. NY Pp. 79-95.

Coma, J., Zimerman, D.R and Carrion, D. (1996). Lysine requirement of the lactating sow determined by using plasma urea nitrogen as a rapid response criterion. J. Anim. Sci. 74:1056-1062.

Cromwell, G. L., Torner, L. W., Gates, R. S., Taraba, J. L., Lindemann, M. D., Taylor, S. L, and Dozier, W. A. (1999). Manipulation of swine diets to reduce gaseous emissions from manure that contributes to odor. J. Anim. Sci 77: 69-74. (Suppl. 1).

Day, O.J. and Plascencia-Gonzalez, H.G. (2000). Soybean protein concentrate as a protein source for Turbot (*Scophthalmus maximus*, L). Aquaculture Nutrition, 6: 221-228.

Devendra, C. (1992). Non-conventional feed resources in Asia and the Pacific. Strategies for expanding at the small farm level (4th edition) FAO: Regional

Animal Production and Health Commission for Asia and the Pacific. FAO Bangkok, Thailand.

Dodoo, E.N.A. (1981). Use of cassava as a major source of energy for swine. BSc. Dissertation. Faculty of Agriculture, University of Ghana, Legon.

Dunsford, B.R., Knabe, D.A., and Haensly, W.E. (1989). Effect of dietary soybean meal on the microscopic anatomy of the small intestine in the early weaned pig. J. Anim. Sci. 67: 1855–1863.

Dunshea, F.R., Ketron D.K., Cranwell P.D., Campbell, R.G., Mullan B.P., King, R.H and Pluske, J.R. (2000). Dietary lysine requirements of heavy and light pigs weaned at 14 days of age. Australian Journal of Agricultural Research, 51:531-539. www.pubish.csiro.au/jpurnals/ajar.

Dusterhoft, E. M., Bonte, A. W. and Vorgen, A. G. J. (1993). Solubilisation of non-starch polysaccharides for degrading enzymes. Journal of Science, Food and Agriculture 63:211-220.

Edwards, S. A., Riddoch, I and Fordyce, C. (1995). Effect of outdoor farrowing hut insulation on piglet mortality and growth. Farm Building Progress. 117: 33-35.

Einarsson, S. and Rojkittikhum, T. (1993). Effects of nutrition on pregnant and lactating sows. J. Reprod. Fert. Suppl. 48:229-239.

Evert H., Blok, M. C., Kemp, B. van der Peet-Schwering, C. M. C, and. Smiths, C. H. M. (1994). Nutrient requirements of gestating sows. (in Dutch) CVB-Documentaticrapport No. 9. Centraal Veevoederbureau, Lelystad. The Netherlands.

FAO (2002). FAOSTAT Agriculture Date: http://apps.fao.org.

Fernandez, J.A., Jorgensen, H. and Just, A. (1986). Comparative digestibility experiments with growing pigs and adult sows. Anim. Prod. 43: 127–132.

Fuller, M. F., McWilliam, R., Wang, T. C., and Giles, L. R. (1989). The optimum dietary amino acid pattern for growing pigs. II. Requirements for maintenance and for tissue protein accretion. Br. J. Nutr. 62: 255-267.

Gardner, J. A. A., Dunkin A. C. and Lloyd L.C. (1990). Pig production in Australia. Pig Research Council, Butterworths, Sydney. Pp 34-41.

Gohl, B. (1981). Tropical feeds. Feed information summaries and nutritive values. FAO Animal production and health series, No 12. FAO Rome http://www.fao.org./ag/AGA/AGAP/FRG/fris/default.htm

Grandhi, R. R. (1994). Apparent absorption and retention of nutrients during the pool weaning period in sows fed supplemental fat or lysine. J. Anim. Sci. 74:123-128.

Granier, R., Massabie, P. and Bouby, A. (1998). Effect of the humidity level of ambient air (temperature 28°C) on the growth performance of growing-finishing pigs. J. Rech. Porc Fr. 30: 331–336.

Hartmann, P.E., Mc Cavley, I., Gooneratne, A.D and Whitely, J.L. (1984). Inadequacies of sow lactation: Survival of the fittest. In: Physiological strategies in lactation. Symp. Zool. Soc. London, UK, 51: 301-321.

Holmes, C.W. (1974). Further studies on the energy and protein metabolism of pigs growing at a high ambient temperature. Anim. Prod. 19:211-220.

Hurley, W. L. (2001). Factors affecting mammary development and milk production in lactating sows. Livest. Prod. Sci. 70:149–157.

Ifut, O. J. (1992). The potential of cassava peels for feeding goats in Nigeria. In: Cassava as livestock feed in Africa. Proc. of the IITA/ILCA/ University of Ibadan workshop on the potential utilization of cassava as animal feed in Africa. Hahn, S. K., Reynold, I.and Egbunike, G. N. (Eds). Ibadan , Nigeria, pp. 72-84.

Iyayi, E. A. and Tewe, A. A. (1992). Effect of protein deficiency on utilization of cassava peel by growing pigs. In: Cassava as livestock feed in Africa. Proc. of the IITA/ILCA/University of Ibadan workshop on the potential utilization of cassava as animal feed in Africa. Hahn, S. K., Reynold, I.and Egbunike, G. N. (Eds). Ibadan , Nigeria, pp. 68-69.

Jansman, A.J, Verstegen M.W.A, Huisman, J and Van den Berg J. W (1995). Effects of hulls of faba beans (Vicia faba L.) with low or high content of condensed tannins on the apparent ileal and fecal digestibility of nutrients and the excretion of endogenous protein in ileal digesta and feces of pigs. J. Anim. Sci. 73: 118-127.

Jegede, J. O., Tegbe, T. S. B., Aduku, A. O and Olorunju, S. A. S. (1994). The effect of feeding palm kernel meal on performance and carcass characteristics of pigs. Nig. J. Anim. Prod., 21: 88-94.

Jensen, A.H (1978). Effect of protein intake during gestation and lactation on the lactational performance of primiparous sows. J. Anim. Sci. 50: 41-44

Johnston, L. J., Ellis, M., Libal, G. W., Mayrose, V. B. and Weldon, W. C. (1999). Effect of room temperature and dietary amino acid concentration on performance of lactating sows. J. Anim. Sci. 77: 1638–1644.

Jones, D.B and Stahly, T.S (1995). Impact of amino acid nutrition in lactation on subsequent reproductive function of sows. J. Anim. Sci. 73(suppl.1): 85(Abstr.).

Jørgensen, H., Zhao, X. Q and Eggum, B. O. (1996). The influence of dietary fibre and environmental temperature on the development of the gastrointestinal tract, digestibility, degree of fermentation in the hindgut and energy metabolism in pigs. Br. J. Nutr. 75:365–378.

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

Kimura, K. (1979). Amino acid and energy interrelationships in pigs weighing 20 to 50 kg. Rate and efficiency of protein and fat deposition. J. Anim. Sci. 69: 70 - 718.

King, R. H. (2000). Factors that influence milk production in well-fed sows. J. Anim. Sci. 78(suppl. 3): 19-25.

Knabe, D.A. (1991). Bioavailability of amino acids in feedstuffs for swine. In "Swine Nutrition" edited by E.R Miller, Buherwirth -Heinemann, London. Pp 79-80.

Kusina, J., Pettigrew, J. E., Sower, A. F., White, M. E., Crooker, B. A. and Hathaway, M. R. (1999). Effect of protein intake during gestation and lactation on the lactational performance of primiparous sows. J. Anim. Sci. 77:931–941.

Kusina. J., Pettigrew, J. E., Sower, A.F., Hathaway, M. R., White M. E, and Crooker B. A. (1995). The effect of protein (lysine) during gestation on mammary development of the gilt. J. Anim. Sci. 73 (Suppl. 1): 189 (Abstr.).

Lachance, P. A. and Molina, M. R (1974). Nutritive value of a fibre-free coconut protein extract obtained by an enzymatic chemical method. J. of Food Sci. 39: 123-130.

Le Goff, (1999). Effect of dietary fibre on the energy value of feeds for pigs. Fiftieth Annual Meeting of the European Association for Animal Production, Wageningen, Pp 269.

Le Goff, G., and Noblet. J. (2001). Comparative total tract digestibility of dietary energy and nutrients in growing pigs and adult sows. J. Anim. Sci. 79:2418-2427.

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

Lewis, A. J., Cromwell, G. L., and Pettigrew, J. E. (1991). Effects of supplemental biotin during gestation and lactation on reproductive performance of sows: a cooperative study. J. Anim. Sci. 69: 207-214.

Li, D. F., Nelssen, J. L., Reddy, P. G., Blecha, F., Klemm, R. D., Giesting, D.W., Hancock, J.D., Allee, G.L. and Goodband, R. D. (1991). Measuring suitability of soybean products for early weaned pigs with immunological criteria. J. Anim. Sci. 69: 3299–3307.

Low, A.G (1985). Role of dietary fibre in pig diets. In: Recent Advances in Animal Nutrition. London, Nottingham University Press Pp. 87–112.

Luis, E. (2002). Use of hemicellulose in copra meal rations to improve broiler performance. Http://www.chemgen.com/coprameal.html.

Ly, J. (1993). The role of monogastric animal species in the sustainable use of tropical feed resources. Proc. VII World Conf. Anim. Prod. Edmonton 1:95-117.

Mahan, D.C., Moxon, A. L. and Hubbard, M. (1977). Protein requirement for lactating sow. J. Anim. Sci. 45:783-788.

Mahan, D. C., Beker, D. E., Norton, K. and Jensen, A. H. (1971). Milk production in lactating sows and time lengths used in evaluating milk protein estimates. J. Anim. Sci.33:35-45.

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

McDonald, P. R. A. Edwards, R.A., and Greenhalgh, J. F. D. (1988). Animal Nutrition (4th edition). Longman, London and New York. Pp 230-239.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D. and Morgan, C. A. (1995). Animal Nutrition (5th edition) Addison Wesley, Longman Ltd. Edinburgh,UK, Pp 514-516.

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

McNamara, J. P. and Pettigrew, J. E. (2002). Protein and fat utilization in lactating Sows. J. Anim Sci. 80: 2452-2460.

Meunier-Salaun, M.C., Garnsworthy, P.C. and Kliseman, J. (1999). Fibre in diets of sows. Recent advances in animal nutrition. Nottingham University. Nottingham, UK. Press. Pp 57-273.

Miller, E. R., Stowe, H. D., Ku, P. K and Hill. G. M. (1979). Copper and zinc in swine nutrition. In: National Feed Ingredients Association Literature Review on Copper and Zinc in Animal Nutrition. West Des Moines, Iowa: National Feed Ingredients Association. Nutrition, 19: 547-564.

National Institute of Animal Husbandry (1980). Standard nutrient requirement of swine. Animal Husbandry Institute. Unpublished mimeograph. Pp 69.

National Institute of Animal Husbandry (1995). Composition and nutritive value of animal feeds in Vietnam. Hanoi, Vietnam.

National Research Council. (1980). Mineral Tolerance of Domestic Animals. National Academy Press, Washington, DC. Pp. 577.

National Research Council. (1987). Predicting Feed Intake of Food Producing Animals. National Academy Press, Washington DC.

National Research Council. (1988). Quality protein maize. National Academy Press. Washington DC

National Research Council. (1997). The role of chromium in animal nutrition. National Academy Press, Washington, DC. Pp.80

National Research Council. (1998). Nutrient requirement of swine National Academy Press, Washington DC.

Nielsen, T. T., Trottier, N. L. Stein., H. H., Bellaver, C. and Easter, R. A. (2002). The effect of litter size and day of lactation on amino acid uptake by the porcine mammary gland. J. Anim. Sci. 80: 2402–2411.

Nielsen, T. T., Trottier, N. L., Bellaver, C., Hans, H. H. and Easter, R. A. (1997). Effect of litter size on mammary gland amino acid uptake in lactating sows. Livest. Prod. Sci. 50: 167 (Abstr.).

Nityanand, P. (1997). Feed Processing Technology. (Textbook) Vikas Publishing House PVT, LTD. Pp. 51-56.

Noble, M. S., Rodriguez-Zas, S., Cook, J. B., Bleck, G. T., Hurley, W. L. and Wheeler, M. B (2002). Lactational performance of first parity transgenic gilts expressing bovine alphalactalbumin in their milk. J. Anim. Sci. 80: 1090-1096.

Noblet, J. and Le Goff G. (2001). Effect of dietary fibre on the energy value of feed for pigs. Anim. Feed Sci. Tech. 90:35-52.

Noblet, J. and Etienne, M. (1987). Metabolic utilization of energy and maintenance requirements in pregnant sows. Livest. Prod. Sci. 16: 243-257

Noblet, J., and Etienne. M. (1989). Estimation of sow milk nutrient output. J. Anim. Sci. 67:3352–3359.

Noblet, J., Shi, X.S. and Dubois, S. (1993). Metabolic utilization of dietary energy and nutrients for maintenance energy requirements in sows: basis for a net energy system. Br. J. Nutr. 70: 407–419.

Nutrient Requirement Standard (2003). Nutrient requirement standard for pigs. British Society of Animal Science. Page 101-110.

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

O' Grady, J.F. (1980) Energy and protein nutrition of the sow. In: Recent advances in animal nutrition, Butterworth, London, Pp. 121- 131

O` Grady, J.F. and Bowland, J.P. (1972). Response of early weaned pigs to diets of different DE concentration and the effect of cereal source and added molasses on performance. Can. J. Anim. Sci. 52: 87-96.

O' Grady, J. F., Lynch, P. B and Kearney, P. A. (1985). Voluntary feed intake by lactating sows. Livest. Prod. Sci. 12: 355-365.

Ocampo, A. (1994). Raw palm oil as the energy source in pig fattening diets and *Azolla filicoloides* as a substitute for soybean meal. Livest. Res. Rur. Dev. 6(1): 8-17.

Okai, D. B. (1971). Cassava versus maize in fattener pig rations. Annual research report. Faculty of Agriculture, University of Science and Technology, Kumasi. Vol. 21: 3-8.

Okai, D.B., Aherne. F.X and Hardin, R.T (1977). Effects of sow nutrition in late gestation on the body composition and survival of the neonatal pig .Can. J. Animal Science. 57; 439- 449.

Okai, D. B., Osafo, E. L. K., and Adomako. D. (1984). Utilization of cocoa husk meal by growing-finishing pigs. Proceedings of the 9th International Cocoa Research Conference, 12-18 February, Lomé, Togo. Cocoa Producers Alliances, Pp 455-459.

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

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

Okai, D.B. (1998). Alternative Feed Resources for Pigs in Ghana. De-graft Graphics, Kumasi, Ghana.

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

Okai, D. B., Osei, S. A and Tuah, A. K. (2001). Growth performance and economic traits of pigs fed diets containing either normal maize or obatanpa, a quality protein maize. J. Univ. Sci. and Tech. Vol. 21:1-5.

Okai, D. B., Rhule, S. W. A., Nyannor, E. K. D and Tandoh, I. K. (2006). Feed packages based on local agro-industrial by-product for small scale pig farmers in the Ashanti Region. Paper presented at the project Leaders meeting. Proc. of the 15th Bien. Conf. GSAP, Knust. Pp 131-134

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

Owusu-Domfeh. K. (1972). The future of cocoa and its by-products in the feeding of livestock. Ghana J. agric. Sci. 5, 57-64.

Paniraghi, S. (1992). Effects of different copra meals and amino acid supplementation on broiler chick growth. British Poultry Science, 79: 77-79.

Parsons, M. J. (1979). The iron requirement of the neonatal pig from parental iron dextran. Mich. Agric. Exp. Stn. Res. Rep. 386:14-21.

Partridge, I. G. (1981). A comparison of defluorinated rock phosphate and dicalcium phosphate, in diets containing either skim milk powder or soybean meal as the main protein supplement, for early-weaned pigs. Anim. Prod. 32:67–73.

Partridges G.G., and Gill, B.P (2001). Recent development in pig nutrition ,Nottingham University Press. 89:76-96.

Peaker, M and Wilde, C. J. (1990). Autocrine control in milk secretion. J. Agric. Sci. 114:235–238.

Peo, E. R., Jr. (1991). Calcium, phosphorus, and vitamin D in swine nutrition. Asian Australasian Journal of Animal Science, 14: 821-830.

Pettigrew, J. E., and Yang. H. (1997). Protein nutrition of gestating sows. J. Anim. Sci. 75: 2723-2730.

Pettigrew, J. E., S. G. Cornelius, R. L. Moser, and A. F. Sower. (1987). A refinement and evaluation of the isotope dilution method for estimating milk intake by piglets. Livest. Prod. Sci. 16:163–174.

Phue , B. H. P., Ogle, B. and Linberg, J.E. (2000). Effect of replacing soyabean protein with cassava leaf protein in cassava meal based diets for growing pigs on digestibility and nitrogen retention. Anim. Feed Sci. and Tech. 83: (4) 223-235.

Phuc, B. H. N. and Linberg, J. E. (2000). Ileal and total tract digestibility in growing pigs given cassava root meal diets with inclusion of cassava leaves, leucaena leaves and groundnut foliage. Animal Science 71 :(2) 301- 308.

Pluske, J. R. (2003). Effects of different sources and levels of dietary fibre in diets on performance, digester characteristics and antibiotic treatments of pigs after weaning. Anim. Feed Sci. Technol, 107: 129-142.

Pluske, J. R., Williams, I. H. Zak, L. J., Clowes, E. J., Cegielski, A. C. and Aherne. F. X. (1998). Feeding lactating primiparous sows to establish three divergent metabolic states: III. Milk production and pig growth. J. Anim. Sci. 76: 1165–117.

Pond, W. G. and Maner, J. H. (1974). Swine Production in Temperate and Tropical Environments. W. H. Freeman Co. San Francisco. Pp. 646-650.

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

Pond, W. G., Walker, E. F Jr. and Kirkland, D. (1978). Effect of dietary Ca and P levels from 40 to 100 kg body weight on weight gain and bone and soft tissue mineral concentrations. J. Anim. Sci. 46: 686–691.

Pond, W. G., Wagner, W. C., Dunn, J. A. and Walker, E. F. Jr. (1968). Reproduction and early postnatal growth of progeny in swine fed a protein-free diet during gestation. J. Nutr. 94:309-311.

Quiniou, N. and Noblet, J. (1999). Influence of high ambient temperatures on performance of multiparous lactating sows. J. Anim. Sci. 77: 2124–2134.

Quiniou, N., Renaudeau, D., Dubois, S., and Noblet, J. (2000). Effect of diurnally flluctuating high ambient temperatures on performance and feeding behaviour of multiparous lactating sows. Anim. Sci. 71:571–575.

Ramonet, Y., van Milgen, J., Dourmad, J. Y., Meunier-Salaun, M. C and Noblet. J. (2000). The effect of dietary fibre on energy utilization and partitioning of heat production over pregnancy in sows. Br. J. Nutr. 84:85–94.

Ranjhan, S. K. (2001). Animal Nutrition in the Tropics. Vikas Publishing House. PVT LTD. 5th ed. Pp. 281.

Rhule, S. W. A. (1996). Growth rate and carcass characteristics of pigs fed on diets containing palm kernel cake. Animal Feed Science and Technology 61:167-172.

Rhule, S. W. A. (1998). The influence of type of palm kernel cake on the growth rate and carcass characteristics of pigs. Ghana Journal of Agricultural Science 31 (2): 128-129.

Rhule, S. W. A. (2001). The reproductive performance of breeding sows fed diets containing cocoa-cake-with-shell and dried cocoa husk. Ghana J. Agric. Sci. Pp. 27-30.

Rhule, S. W. A., Nelson, F. S., and Otchere E. O. (2005). The influence of graded levels of palm kernel cake (PKC) on the performance of the layer fowl. Ghana Jnl agric. Sci. (NARS edn No.I): 165-168.

Rostango, H.S. (1972). Nutritive evaluation of sorghum grains in chicks. PhD Thesis. Purdue University, West Lafayette, Indiana, USA.

Salmon-Legagneur, E. (1956). La mesure de la production laitiere chez la trvie. Ann. Zootech. (Paris) 5: 95-98.

Sauber, T.E., Sahly T.S, Ewan R.C and Williams N.H (1994). Interactive effects of sow genotype and dietary amino acid intake on lactational performance of sows nursing large liters. Journal Animal Science 72(suppl 2); 66 (Abstr.).

SCA (1987). Feeding Standards of Australian Livestock – Pigs. Standard Committee on Agriculture CSIRO Editorial and Publishing Unit, East Melborne, Vic.

Schrama, J.W., Bosch, M.W., Verstegen, M.W.A., Vorselaars, A.H.P.M., Haaksma, J. and Heetkamp, M.J.W. (1998). The energetic value of non-starch polysaccharides in relation to physical activity in group-housed, growing pigs. J. Anim. Sci. 76: 3016–3023.

Shi, X.S. and Noblet, J. (1993). Digestible and metabolizable energy values of 10 ingredients in growing pigs fed ad libitum and sows fed at maintenance level comparative contribution of the hindgut. Anim. Feed Sci. Technol. 42: 223-236.

Sikka, S. S (1990). Comparative utilisation of nutrient in poultry and swine. Ph.D. Dissertation submitted to Punjab Agricultural University, Ludhiana, India

Sikka, S. S., and Chawla J. S. (1984). Effect of quality of rice bran on the performance of growing pigs. Journal of Research of Punjab Agriculture University 21(3): 457-459.

Sonaiya, E.B. and Omole T.A. (1997). Cassava peels in rabbit diets. Nutrition Reports International. Pp 11-15.

Speer, V. C., and Cox. D. F. (1984). Estimating milk yield of sows. J. Anim. Sci. 59:1281-1285.

Steel, A., Nussberger, S., Romero, M.F., Boyd, C.A.R. and Hediger, M.A. (1997). Stoichiometry and PH dependence of the rabbit proton, oligopeptide transporter pepti. Journal of Physiology. 498: 563-569.

Steyaert, P., Buldgen,N, A. and Compere, R. (1989) Influence of the rice bran content on growth performance of broiler chickens in Senegal. Bulletin des Recherches Agronomiques de Gembloux, 24: 385—388.

Sundu, B and Dingle, J. (2003). Use of enzymes to improve the nutritional value of palm kernel meal and copra meal. Proceedings of Queensland Poultry Science Symposium. Australia 1(14):1-15.

Tegbe, T.S.B (1985). The effect of feeding iso-nitrogenous brewers dried grain diets on performance of different classes of pig. Nigerian Journal of Animal Production 12:49-51.

Teguian, A. and Begaen, A.C. (2004). Nutritional aspect of broiler production in small-holder farms in Cameroon. Livestock Research for Rural Development, 16:(1) 20-24.

Thorne, P. J., Wiseman, J., Cole, D. J. A., and Machin, D. H. (1989). The digestible and metabolisation energy value of copra meals and their prediction from chemical composition. Anim. Prod. 49: 459-466.

Tiemoko, Y. (1992) Effects of using rice polishings in broiler diets. Bulletin of Anim. Health Prod. in Africa, 40: 161—165.

Tuah, A.K and Boateng, S.A. (1982). The effects of rice mill feed (Rice brin) in the finishing diets on the growth performance, feeding economy and carcass quality of pigs fed basal maize diets, Kumasi-Tech. J. of Agric Sci.1:1-14.

Tuah, A. K., Buadu, M. K. and Boa-Amponsem, K. (1974). Effects of three different levels of rice mill feed (rice bran) in the finishing diets on performance and carcass characteristics of pigs fed on basal maize diets. Proceedings of the 7th Ghana Animal Science Association Symposium, University of Ghana, Legon, Ghana. Pp 61-78.

Varel, V.H., Pond J.C., Perkas, S. and Yen, J.T. (1982). Influence of high fibre on bacterial proliferations in gastrointestinal tracts of obese and lean genotypes pigs. Appl. Environ. Microbiol. 44: Pp 123-134.

Wang, T. E. and Fuller, M. F. (1989). The optimum dietary amino acid pattern for growing pigs. Experiments by amino acid deletion. Brit. J. Nutr. 62:77-89.

Weldon, W., CLewis,. A. J. Louis, G. F., Kovar, J. L., Giesemann, M. A. and Miller. P. S. (1994). Postpartum hypophygia in primiparous sows. Effect of gestation feeding level on feed intake, feeding behaviour and plasma metabolic concentrations during lactation. J. Anim. Sci. 72:387.

Whittemore, C. T. (1996). Nutrition reproduction interactions in primiparous sows: A Review. Livest. Prod. Sci. 46:65-83.

Williams, I. H. (1995). Sow's milk as major nutrient source before weaning. In: Manipulating Pig Production. Australasian Pig Sci. Assoc., Anim. Res. Inst., Werribee, Australia. Pp. 7–261.

Williams, I.H., Close, W.H. and Cole, D J.A (1985). Strategies for sow nutrition: Predicting the response of pregnant animals to protein and energy intake. In: Recent Advances in Animal Nutrition. London, UK. Page 133-147.

Woodroof, J. G. (1979). Coconut: Production, Processing, Products, 2nd Edition. AVI Publishing Company, Westport. Pp. 34-40.

Wyllie, D. and Lekule, F.P (1980). Cassava and molasses for fattening pigs under village condition in Tanzania. Trop. Agric (Trinidad) . 57 (3): 267- 276.

Yaakugh, I.D.J. and Tegbe, T.S.B. (1990). Performance and carcass characteristics of grower and finisher pigs fed diets containing brewer's dried grains. Nigerian Agricultural Journal 24:31-40.

Yang, H., Pettigrew, J. E., Johnston, L. J., Shurson, G. C and Walker, R. D. (2000). Lactational and subsequent reproductive responses of lactating sows to dietary lysine (protein) concentration. J. Anim. Sci. 78:348–357.

Yeong, S.W.(1983). Amino acid availability of palm kernel cake, palm oil sludge and sludge fermented product (Prolima). Mardi Res. Bul., 11: 84-88.

Zarkadas, L.N and Wiseman, J. (2000). Inclusion of differently processed full fat soybean in diets for piglets: II. Digestibility and intestinal morphology of weaner pig. British Society of Animal Science, Penicuik, Midlothian, UK, Pp. 46.

8.0 APPENDICES

EXPERIMENT 1

I. Reproductive Performance of Sows Fed Varying Levels of CP

Appendix 1: Anova for mean number of piglets born

Sources	df	ss	ms	F	p
Treatments	2	6.70	0.02	3.35	0.58
Error	15	77.23	5.94		
Total	17	83.94			

Appendix 2: Anova for mean birth weight (kg)

Sources	df	ss	ms	F	p
Treatments	2	0.03	0.02	0.25	0.78
Error	15	0.81	0.06		
Total	17	0.84			

Appendix 3: Anova for mean sow weight gain (kg)

Sources	df	ss	ms	F	p
Treatments	2	71.87	35.93	0.09	0.92
Error	15	5262.13	404.77		
Total	17	5334.00			

Appendix 4: Anova for mean weight loss in sows (kg)

Sources	df	ss	ms	F	p
Treatments	2	146.90	73.45	0.49	0.63
Error	15	1966.53	151.27		
Total	17	2113.44			

II. Piglets Growth Performance

Appendix 5: Anova for mean 14-day weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	1.06	0.53	0.91	0.43
Error	15	7.62	0.59		
Total	17	8.68			

Appendix 6: Anova for mean 28-day weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	0.68	0.34	0.24	0.79
Error	15	18.69	1.44		
Total	17	19.37			

Appendix 7: Anova for mean weaning weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	0.29	0.15	0.03	0.97
Error	15	62.42	4.80		
Total	17	62.71			

Appendix 8: Anova for ADG of piglets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	0.001	0.001	0.23	0.80
Error	15	0.033	0.003		
Total	17	0.034			

Appendix 9: Anova for number of piglets weaned

Sources	df	ss	ms	F	p
Treatments	2	12.36	6.18	1.62	0.24
Error	15	49.63	3.82		
Total	17	62.00			

III Milk **Yield of Lactating Sows fed Cereal-Based Diets with varying CP levels.**

Appendix 10: Anova for 14-day milk yield of lactation sows fed cereal-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	41.65	20.83	2.66	0.11
Error	15	101.96	7.84		
Total	17	143.61			

Appendix 11: Anova for 28-day milk yield of lactation sows fed cereal-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	35.52	17.76	1.40	0.28
Error	15	164.98	12.69		
Total	17	200.50			

Appendix 12: Anova for 42-day milk yield of lactation sows fed cereal-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	58.95	29.47	1.92	0.19
Error	15	199.45	15.34		
Total	17	258.41			

EXPERIMENT 2

IV. Reproductive performance in sows fed AIBP-based diets

Appendix 16: Anova for mean number of piglets born

Sources	df	ss	ms	F	p
Treatments	2	3.60	1.80	0.26	0.78
Error	15	84.00	7.00		
Total	17	87.00			

Appendix 17: Anova for mean birth weight (kg)

Sources	df	ss	ms	F	p
Treatments	2	0.04	0.02	0.28	0.76
Error	15	0.87	0.07		
Total	17	0.91			

Appendix 18: Anova for mean sow weight gain (kg)

Sources	df	ss	ms	F	p
Treatments	2	603.33	301.67	1.60	0.24
Error	15	2257.60	188.13		
Total	17	2860.93			

Appendix 19: Anova for mean weight loss in sows (kg)

Sources	df	ss	ms	F	p
Treatments	2	137.90	74.45	0.51	0.73
Error	15	1856.53	150.37		
Total	17	194.43			

V. Growth Performance of Piglets fed AIBP-Based Creep Diets.

Appendix 20: Anova for mean 14-day weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	1.63	0.82	2.45	0.13
Error	15	3.99	0.33		
Total	17	5.62			

Appendix 21: Anova for mean 28-day weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	0.48	0.24	0.09	0.92
Error	15	34.02	2.84		
Total	17	34.50			

Appendix 22: Anova for mean 42-day weights of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	1.06	0.53	0.91	0.43
Error	15	7.62	0.59		
Total	17	8.68			

Appendix 23: Anova for mean weaning weight of piglets (kg)

Sources	df	ss	ms	F	p
Treatments	2	5.90	2.95	0.70	0.52
Error	15	50.51	4.21		
Total	17	56.41			

Appendix 24: Anova for mean number of piglets weaned

Sources	df	ss	ms	F	p
Treatments	2	7.60	3.80	0.53	0.60
Error	15	86.40	7.20		
Total	17	94.00			

VI .Milk Yield of Lactating Sows Fed AIBP-Based Diets.

Appendix 13: Anova for 14-day milk yield of lactation sows fed AIBP-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	0.59	0.30	0.11	0.90
Error	15	33.12	2.76		
Total	17	33.71			

Appendix 14: Anova for 28-day milk yield of lactation sows fed AIBP-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	13.03	6.51	2.12	0.16
Error	15	36.82	3.07		
Total	17	49.85			

Appendix 15: Anova for 42-day milk yield of lactation sows fed AIBP-based diets (kg/day)

Sources	df	ss	ms	F	p
Treatments	2	18.97	9.48	2.36	0.14
Error	15	48.25	4.02		
Total	17	67.22			