UNIVERSITY OF EDUCATION, WINNEBA
COLLEGE OF AGRICULTURE EDUCATION
DEPARTMENT OF ANIMAL SCIENCE EDUCATION
MAMPONG - ASHANTI

GROWTH, REPRODUCTION, MILK QUALITY, BLOOD PROFILE AND CARCASS CHARACTERISTICS OF PIGS FED DIETS CONTAINING GRADED LEVELS OF *Moringa oleifera* LEAF MEAL

BY

AFFRAM DAVID YENTUMI
(B.Sc. AGRICULTURE TECHNOLOGY)

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION ,WINNEBA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF PHILOSOPHY IN ANIMAL SCIENCE (ANIMAL PRODUCTION AND MANAGEMENT)

JULY, 2015

DECLARATION

STUDENT'S DECLARATION

I, Affram David Yentumi, hereby declare that with the exception of references to other people's work which have been duly acknowledged, this thesis is the result of my own work and it has neither in whole nor partially been presented elsewhere.

…… ……

AFFRAM DAVID YENTUMI **DATE**

SUPERVISORS' DECLAREATION

I hereby declare that the preparation of this thesis was supervised in accordance with guidelines and supervision of thesis laid down by the University of Education, Winneba.

…… . …….....

PROF. J.K. KAGYA-AGYEMANG **DATE**

(PRINCIPAL SUPERVISOR)

…… ……

PROF A. K. TUAH **DATE**

(CO-SUPERVISOR)

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DEDICATION

I dedicate this thesis to the Almighty God, Mrs. Victoria Nkenya Affram and Madam Ama Odumgya.

ABSTRACT

The study which lasted for thirteen months was undertaken to evaluate *Moringa oleifera* leaf meal (MOLM) as feed ingredient on the growth, reproduction, milk quality, blood indices and carcass characteristics of pigs. The specific objectives were to determine the impact of *Moringa oleifera* leaf meal fed at varying levels (0%, 5%, 7.5%, 10%, and 12%) on the growth rate, reproductive performance, milk quality, haematological and biochemical indices and carcass characteristics of pigs. The study was carried out at the Piggery Section of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti Campus, Ghana from 5th April, 2014 to 17th April, 2015. A total of twenty four (24) large white weaner pigs comprising twenty females and four males which were 10-11 weeks of age and an average body weight of 11 kg were used for the experiment. The females were randomly grouped into five treatments with each animal constituting a replicate in a randomized complete design and each treatment had four replicates (animals). The four young boars were used to cross the gilts when they were on heat. The control diet contained no moringa leaf meal (0%), while Diets 2, 3, 4 and 5 contained moringa leaf meal at the rate of 5, 7.5, 10 and 12%, respectively. Data collected were subjected to the analysis of variance procedure of Statistical Analysis Systems (SAS 2010). The results showed that there were no significant differences ($P>0.05$) in initial body weight, final body weight, total weight gain and daily growth rate among treatment means. However, daily feed intake, total feed intake and feed conversion efficiency showed significant ($P<0.05$) difference among treatments with feed conversion efficiency means being 0.25, 0.25, 0.26, 0.24 and 0.23, for 0, 5, 7.5, 10 and 12% MOLM respectively. The biochemistry blood parameters, cholesterol and albumen were significantly ($P<0.05$) different among dietary treatments but total protein and globulin were not significantly ($P>0.05$) different among dietary treatments with cholesterol means being 175.05, 124.95, 132.65, 111.50 and 144.20 (ml/L) for 0, 5, 7.5, 10 and 12% MOLM respectively. Red

blood cells, packed cell volume, mean cell volume and neutrophil values for haematological parameters were not significantly different (P>0.05) among dietary treatments. However, white blood cells, haemoglobin and lymphocytes values were significantly (P<0.05) different, hemoglobin means were 12.48, 11.75, 11.75, 11.95 and 10.97 (g/dl) for 0, 5, 7.5, 10 and 12% MOLM respectively. Reproductive parameters showed no significant (P>0.05) differences in age at puberty, piglet birth weight, litter size at birth, litter size at weaning, weaning weight and mortality rate. However, piglet growth rate showed significant (P<0.05) difference among dietary treatments with its means being 0.12, 0.12, 0.10, 0.08 and 0.10 (kg) for 0, 5, 7.5, 10 and 12% MOLM respectively. All the parameters measured for pork quality; moisture, protein, fat, ash, carbohydrate, pH and energy were significantly (P<0.05) different among dietary treatments with fat means being 8.54, 8.38, 8.55, 8.38 and 8.19 for 0, 5, 7.5, 10 and 12% MOLM respectively. Similarly, the following parameters protein, fat, cholesterol and total solids measured for milk quality were significantly (p<0.05) different with cholesterol means being 0.64, 0.55, 0.42, 0.36 and 0.24 for 0, 5, 7.5, 10 and 12% MOLM respectively. However, water and milk sugar values did not (P>0.05) differ. In the same vein the following parameters; dam live weight, carcass with fur, dressing weight, dressing percentage, visceral fat weight, heart weight, lung weight, liver weight, spleen weight, kidney weight, visceral with content, visceral without content, stomach with content and back fat thickness measured for carcass characteristics were significantly (P<0.05) different with back fat thickness means being 3.05, 2.78, 1.55, 1.25 and 1.00 for 0, 5, 7.5, 10 and 12% MOLM respectively. However, values for stomach without content did not (P>0.05) differ. It could be concluded that Moringa leaf meal has no deleterious effect on the growth, reproduction and the blood indices of pigs. MOLM also has the potential to reduce fat in pork, cholesterol in milk and blood of pigs.

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LIST OF ABBREVIATIONS

C P	Crude Protein
CF	Crude Fibre
DE	Digestible Energy
ECM	Energy Corrected Milk
EE	Ether Extract
FCE	Feed Convention Efficiency
Hb	Haemoglobin
IALM	*Ipomoea Asarifolia* Leaf Meal
MCH	Mean Cell Haemoglobin
MCV	Mean Cell Volume
MSD	Meteorological Services Department
MOLM	Moringa Oleifera Leaf Meal
NFE	Nitrogen Free Extract
NRC	National Research Council
PCV	Packed Cell Volume
PML	Pellets of *Moringa Oleifera* Leaves
PPM	Parts Per Million
RBC	Red Blood Cells
SBM	Soya Bean Meal
SNF	Solid- Not- Fat
WBC	White Blood Cells
WSLM	Wild Sunflower Leaf Meal

CHAPTER ONE

1.0 INTRODUCTION

The production of pigs is a major component of livestock production in most West African countries like Ghana and Nigeria, especially in parts of the countries where there are no cultural or religious inhibitions to pork production and consumption (Ewuziem, *et al*., 2009). Pig production in recent times is gaining attention in many parts of the country and pork is now consumed in many communities in Ghana (Koney, 2004).

The relative advantages of the pig are its high rate of survival and the ability to utilize a variety of agro-industrial by-products and crop residue (Okai *et al.*, 2005). Significantly, pigs are also known to be prolific producers, realizing 20-30 piglets from 2 to 3 liters per year and of high feed convention efficiency (Adesehinwa *et al*., 2003). Pig farming therefore is a viable venture and could generate more profits than other livestock production enterprises if properly managed (Olomide *et al*., 2003).

Despite the advantages of pig production, the increasing costs and unpredictable availability of conventional feed stuffs notably fish meal (FM) and soya bean meal (SBM) as a source of protein for monogastric livestock, has been a limiting factor to pig production. Feed cost alone in pig and poultry production is estimated to represent 65 to 75% of the total cost of production (Ameral *et al*., 2007). Consequently, many commercial farmers and institutional farms are not able to produce to full capacity. This has necessitated the search for non-conventional feed stuffs which are relatively cheap in cost and readily available (Robinson and Menghe, 2007).

The use of non-conventional sources of feed stuff to feed livestock has effectively moderated and reduced the cost of non-ruminant animal production (Ekenyem and Madueke, 2007).

Recent research trends indicate that there is an increase interest towards the search for alternative protein sources to meet the increasing demand for protein sources for the expanding livestock industry, especially, in the developing countries (Janardhanan *et al*., 2003).

Moringa oleifera leaf meal with significant crude protein levels between 19.3% and 26.4% (Aregheore, 2002) can be a suitable alternative non-conventional feed stuff to conventional feed staff to be used as an ingredient in pig diet to reduce the cost of production and to expand pig production. *Moringa oleifera* from the *Moringaceae* family is a fast growing plant widely available in the tropics and sub-tropics with several economic uses for both industrial and medicinal purposes (Richter *et al.,* 2003).

The edible parts of the Moringa tree are exceptionally nutritious (Teketay, 2001). The leaves are a promising source of food in the tropics because the tree is usually full of leaves during the dry season when other foods are typically scarce (Fahey, 2005).

It has been reported that the success of every pig enterprise is largely dependent on litter size at birth and their survival up to weaning (Deka *et al*., 2002). Although reproductive traits like litter size are known to be of poor heritability (Ehlers *et al*., 2005; Holm *et al*., 2005). However, Koketsu *et al.* (1996) maintained that minerals and vitamins affect the ovario-uterine system, influencing follicular development, rate of ovulation, conception and the ability of females to maintain

pregnancy. *Moringa oleifera* has a significant source of vitamins A, B, C, E and K which enhance reproduction (Peter, 2008).

Despite the characteristic good nutritional value of Moringa, there is little information regarding its utilization in pig diet. Oduro-Owusu *et al.* (2015) used MOLM to investigate the growth performance of pigs but did not investigate into the reproduction. However, the present study investigated on the effect of MOLM on both growth and reproduction.

The present study was therefore conducted to determine the optimum level of *Moringa oleifera* leaf meal (MOLM) that will maximize growth, reproduction, milk quality, blood profile and carcass quality of pigs.

The specific objectives of the study were to:

- determine the growth performance of pigs fed diets containing graded levels of MOLM.
- determine the litter size and litter weight of sows fed diets containing graded levels of MOLM.
- determine the effect of including graded levels of MOLM in fed diets on milk quality of sows.
- assess the effect of including graded levels of MOLM in fed diets on the blood indices of pigs.
- evaluate the effect of including graded levels of MOLM in fed diets on carcass characteristics of pigs.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 World pork production and consumption

Records have shown that since 2005, China has been the leading producer of pork, producing about 50% of the world's pig population, followed by E.U-25 countries of Europe, United States of America (USA), Brazil and Canada. For the first five pork production countries, world pork production has increased by 15.1% from 2000 to 2005, the top five countries in percent increase in pork production over this five year period are Brazil (39.3%), Vietnam (27.8%), China (23.2%), Russia (17.0%), and Canada (16.8%) (FAS/USDA, 2006).

World pork consumption has increased by 27% from 1997 to 2005, with total global pork consumption for 2005 at over 93 million metric tons (mmt). In recent decades pork has become the meat of choice worldwide and offers opportunities for both U.S.A and foreign pork producers to expand international sales (Plain, 2006). According to The Food and Agriculture Organization (FAO, 2013) of the United Nations (UN), pork is the most eaten meat in the world. Table 2.1 shows the top four meat consumption in the world.

Table 2.1: Meat quantity and % consumed in the world

Meat	Meat consumed (mmt)	Percentage of Meat (%)
Pork/porcine	110.8	37.4%
Poultry	104.5	35.3%
Bovine	66.8	22.6
Ovine	13.9	22.6
Total common meat	296.0	100%

Source: Food and Agriculture Organization (FAO, 2013) of the United Nations (UN).

2.2 The state of pig production in Ghana

In the recent past, religious taboos and sanitation problems had put many Ghanaians off pork consumption but the current high level of meat hygiene and good husbandry practices in the pig industry have increased the consumption pattern of pork among the populace (Koney, 2004). As a result, pig rearing is gaining great popularity in many communities making the pig industry to see development in the country (Koney, 2004). Awuku *et al*. (1991) reported that pig production and pork consumption increased in Ghana as a result of the organization of the pork show in 1986.

Animals produced in Ghana including pigs are mostly used for local consumption (Adzitey, 2013). Between 2001 and 2010, live goat production was the highest in Ghana, followed by sheep, cattle and pig. Subsequently, pig production increased by 72% (Adzitey, 2013). With regards to live pig production, there was a decrease in production between 2001 and 2005 owing to the outbreak of the swine fever; later in the years, production increased (FAOSTAT 2012). In 2010 beef recorded 25,775 t, pork 17,506 t, mutton 16,914 t and chevon 14,273 t (Adzitey, 2013). Table 2.2 shows the live production of pigs from 2001 to 2010 in Ghana.

Table 2.2 Live production of pigs in Ghana from 2001 to 2010 (1000)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Pigs	312	310	303	300	290	477	491	506	521	536

Source: FAOSTAT (2012). The figures for the pigs are all in thousands.

2.3 Constraints to pig production in Ghana

Trends in the pig industry have revealed that the greatest challenge in the sector is the cost of feeding. Okai (1998) confirmed this fact by reporting that feed cost alone represent between 70-80% of the cost of pig production, aside medication. He added that farmers are being educated on

the use of alternative feed resources, more especially, agro-industrial by-products and crop residues. The general lack of understanding among livestock farmers about the feeding value of agriculture by-products limits their incoporation into monogastric feed. This calls for intensified extension activities to communicate research findings to the livestock farmer (Okai, 1998). According to Fleischer and Barnes (1998) feed unavailability and cost were the major challenges to the pig industry followed by finance and water. They also indicated that farmers have challenges with their breeding stock, routine management practices and cost of medication.

2.4 Future prospects for the pig industry in Ghana

Many researches have been conducted on the use of agro-industrial by-products and crop residues as an alternative cheap and nutritious source of feed for monogastric livestock like pigs. This has made it possible to overcome the feeding constraint of pigs which is a major challenge in pig production in Ghana. Examples of agro industrial by-products includes: cassava peels, rice bran, maize bran, oil palm slurry, pito mash, groundnut skin, brewer's spent grains, molasses, citrus pulp and wheat bran. Examples of crop residues include: cocoa pod husk and coffee pulp. Most of these agro industrial by-products and crop residues abound in Ghana (Rhule *et al*., 2007). Leaves of shrubs such as *Leaucaena spp*, moringa, aquatic plants, fruits (palm fruits, pawpaw, and guava) and small animals such as earth worms can be used in pig feed production (Sonaiya, 1990).

Pigs are highly prolific realizing about 20 piglets in a year, meaning they provide animal protein faster compared to goat, sheep and cattle. On the average, a sow produces 9-10 piglets per farrowing with little intervals (Awuku *et al*., 1991; Koney, 2004). Comparatively, pig production

has been found to have a quicker turnover rate on investment than cattle and other ruminants (Koney, 2004).

2.5 Nutrition and nutrient requirements of pigs

The primary principles of feeding are to help the animal to maintain good physical and reproductive conditions for the profitability of the farmer (Lukefahr, 1992). Naturally, pigs have the ability to obtain required nutrients from a wide variety of feed stuff. Feed items including their by-products are sometimes used in feeding pigs (Okai *et al.,* 2005).

The diet of the animal must contain the right quantities of nutrients for the efficient functioning of the animal's body processes (Okai and Bonsi, 1994). The major nutrients required by pigs are water, fat (essential fatty acids), proteins (amino acids), carbohydrate, mineral elements and vitamins which the pig farmer should have knowledge about. Practically, the amount of nutrients required by pigs is influenced by their age or stage of production, sex, environment and disease states. Table 2.3 indicates the level of major nutrients required by pigs during various phases of their life cycle.

Table 2.3: Levels of major nutrients required by pigs during various phases of their life cycle

NUTRIENT	STARTER	GROWER	FINISHER
	7.20 kg	**20-45kg**	**45-90 kg**
Crude protein %	18-22	16	13-14
Energy %	3500	3300	3300
Calcium %	0.8	0.7	0.5

Phosphorus %	0.6	0.5	0.4
Lysine %	1.2	0.7	0.6
Methionine %	0.7	0.5	0.6

Source: Okai and Bonsi (1994)

Table 2.4: Nutrient Requirement at Different Stages of Growth and Production in Pigs

NUTRIENT	3-5kg L W	5-10kg L W	10-20kg L	20-50kg L	50-80kg L	80-120kg L	Gestation	Lactation
Estimated feed intake (g/day	250	500	1,000	1,855	2,575	3,075	1850	5250
Estimated DE feed intake (kcal/day)	855	1690	3400	6305	8760	10450	6290	17850
Estimated ME feed intake (kcal/day)	820	1620	3265	6050	8410	10030	6040	17135
Crude Protein (%)	260	23.7	20.9	18.0	15.3	13.2	14.0	19.2
Amino acid	Requireme	True	ileal	digestible	Basis (g/da			
Lysine	3.4	5.9	10.1	15.3	17.1	15.8	8.5	0.9
Threonine	2.1	3.7	6.3	9.7	11.0	10.5	7.0	0.56
Tryptophan	0.6	1.1	1.9	2.8	3.1	2.9	1.7	0.17
Methionine+Cystene	1.9	3.4	5.8	8.8	10.0	9.5	6.1	0.43
Phenylalanine+tyrosine	3.2	5.5	9.5	14.4	16.1	15.1	8.5	1.02
Arginnine	1.4	2.4	4.2	6.1	6.2	4.8	0.0	0.50
Histidine	1.1	1.9	3.2	4.9	5.5	5.1	2.7	0.36
Isoleucine	1.8	3.2	5.5	8.4	9.4	8.8	5.0	0.50
Leucine	3.4	6.0	10.3	15.5	17.2	15.8	8.1	1.03
Valine	2.3	4.0	6.9	10.4	11.6	10.8	5.8	0.77
Mineral element					Requireme			
Calcium	0.90	0.80	0.75	0.60	0.50	0.45	0.75	0.75
Phosphorus, available (%)	0.55	0.40	0.32	0.23	0.19	0.15	0.35	0.35
Sodium (%)	0.25	0.20	0.15	0.10	0.10	0.10	0.15	0.20
Chlorine (%)	0.25	0.20	0.15	0.08	0.08	0.08	0.12	0.16
Magnasium (%)	0.40	0.40	0.40	0.40	0.40	0.40	0.04	0.04
Potasium (%)	0.30	0.28	0.26	0.23	0.19	0.17	0.20	0.20
Iron (mg/kg)	100.00	100.00	80.00	60.00	50.00	40.00	80	80
Copper (mg/kg)	6.00	6.00	5.00	4.00	3.50	3.00	5.00	5.00
Manganese (mg/kg)	4.00	4.00	3.00	2.00	2.00	2.00	20	20
Iodine (mg/kg)	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15
Selenium (mg/kg)	0.30	0.30	0.25	0.15	0.15	0.15	0.15	
vitamin					Requireme			
Vitamin A (I U)	2,200	2,200	1,750	1,300	1,300	1,300	4000	2000
Vitamin D (I U)	220	220	200	150	150	150	200	200
Vitamin E (I U)	16	16	11	11	11	11	44	44
Vitamin K (mg/kg)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Biotin (mg/kg)	0.08	0.05	0.50	0.05	0.05	0.05	0.20	0.20
Choline (g/kg)	0.60	0.50	0.40	0.30	0.30	0.30	1.25	1.00
Folacine (mg/kg)	0.30	0.30	0.30	0.30	0.30	0.30	1.30	1.30
Thiamine (mg/kg)	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Niacin available (mg/kg)	20.00	15.00	12.50	10.00	7.00	7.00	10	10
Pantothenic acid (mg/kg)	12.00	10.00	9.00	8.00	7.00	7.00	12	12
Reboflavin (mg/kg)	4.00	3.50	3.00	2.50	2.00	2.00	3.75	3.75
Vitamin B6 (mg/kg)	2.00	1.50	1.50	1.00	1.00	1.00	1.00	1.00
Vitamin B12	20.00	17.50	15.00	10.00	5.00	5.00	15	15

Source NRC (1998) L W = Live Weight

Table 2.4 shows the various nutrient requirements for pigs from growth to reproduction.

2.5.1 Energy requirement of pigs in the tropics

Tewe and Adesehinewa (1995) used the National Research Council's (NRC) recommendation for energy to compound diets for pigs in the tropics and observed a depression in both feed and nutrient intake. Usually in the tropics, environmental temperature is above critical temperature which reduces feed intake (Ewan, 1976). At any given time when the effective ambient temperature of a pig exceeds the upper critical temperature by 1^0C, DE intake is reduced by 1.7% (NRC, 1998). Rao *et al*. (1976) explained that animals in the tropics will therefore perform better when they are fed on energy levels less 10% the NRC recommendations (Table 2.4).

2.5.2 Amino acid requirements of pigs

According to Gillespie (1992) proteins are generally referred to as organic compounds made up of amino acids, hydrogen, carbon, oxygen and nitrogen. In addition, others contain sulphur, phosphorus and iron. The body protein is made up of 22 amino acids, 10 cannot be synthesized in sufficient amounts by the body and must be provided in the feed. These amino acids are termed essential amino acid e.g. lysine, arginine, histidine, isoleucine, leucine and methionine. The non-essential amino acids can be synthesized sufficiently in the pig's body. In the nutrition of pigs, the most quality protein is the one that will provide these10 essential amino acids for the body functioning of the animal (Adesehenwa and Ogunmdede, 1995). According to Kellems and Church (2002) amino acid requirement of pig is high for young animals and reduces with age (Table 2.4).

2.5.3 Minerals requirements of pigs

According to Kellems and Church (2002), the inorganic components of the diet are termed minerals. They are solid and crystalline elements that cannot be decomposed or synthesized by

chemical reaction. Dietary minerals are classified into two, macro or major minerals and micro or trace minerals. This classification is basically based on the concentration found in the animal's body. The concentration of macro minerals in the animal's body exceed 100 parts per million(ppm) and include Ca, P, Cl, Mg, K, Na and S but micro minerals are found in concentration less than 100 ppm and include Cr, Co, Cu, Fe, I, Mn, Mo, Ni, Se, Si, and Zn (Kellems and Church, 2002). The skeletal structure of animals has minerals as constituents e.g. Ca, P, etc. and organic compounds (i.e. present in protein and lipids), involved in physio-chemical action (such as maintenance of the body pH, ion antagonism, osmotic pressure, cell membrane permeability of colloidal substances) and play biochemical roles (such as iron in haemoglobin, phosphorus in adenosine di phosphate and mineral-containing enzymes and hormones) (Ranjhan, 2003). Their deficiency symptoms are: Deficiency in P, Mg, Cl, Fe and Zn causes rickets in young animals and osteomalacia in adults. Deficiency in K and Fe causes poor appetite. Deficiency in Na and Zn causes ataxia. Deficiency in K, Cu and Mn causes unthriftness. Deficiency in Na causes Para keratosis. Deficiencies in Zn, Ca and P cause rough hair coat and goiter (Siegmund and Fraser, 1982). Table 2.4 provides the quantitative mineral requirements for pigs.

2.5.4 Vitamin requirements for pigs

Vitamins are organic compounds in feed required in small (trace) amounts for maintenance and growth of animals (Ranjhan, 2003). Pigs require fourteen vitamins which are grouped into fat-soluble and water-soluble vitamins. Fat-soluble vitamins are those that can dissolve in fat which includes, vitamins A, D, E and K. Water-soluble vitamins are those that can dissolve in water which includes vitamin C (ascorbic acid) and B-complex vitamins, i.e. thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, cyanocobalamin, biotin, choline, inositol and para-amino

benzoic acid (Gillespie, 1992). Gillespie (1992) summarized the functions of the vitamins as follows:

- Vitamin A is needed for healthy eyes, good conception rate and disease resistance.
- Vitamin D is required for good bone development and mineral balance of the blood.
- Vitamin E is associated with normal reproduction and muscle development.
- Vitamin K helps in blood clot and prevents excessive bleeding from injuries.
- Vitamin C helps in teeth and bone formation and the prevention of infection.
- The B-complex vitamins are necessary for the chemical action in the animal's body and also help improve appetite, growth, and reproduction. Table 2.4 provides the vitamin requirements for pigs.

2.5.5 Fibre requirements for pigs

Crude fibre is the non-digested fraction of dietary carbohydrate. Generally, it is not a nutrient for pigs but a limited amount is required in pig diets for gastrointestinal motility. However, fibre can be fermented by the pig's intestinal micro flora in the caecum to produce volatile fatty acids which pigs can absorb and use as energy source (Kidder and Manner, 1978). Fibre dilute dietary energy, increases bulkiness and reduces overall nutrient digestibility (NRC, 1998). Mavromichalis (2006) therefore advised that crude fibre in the diet should not exceed 2-3% for pigs below 10-12kg and 5% for heavier pigs.

2.5.6 Water requirement for pigs

Most often water is overlooked as a nutrient, notwithstanding, its needfulness in the life of animals cannot be overemphasised. The water content of the animal's body differs with age. It is usually

from 80% in a neonatal pig to 55% in finishing pigs. Water is required in pigs for digestion, nutrient transport, waste excretion and temperature regulation. Water should therefore be given *ad libitum* (MacDonald *et al*., 1998). The main source of water to the animal's body is by drinking (MacDonald *et al.,* 1998; Kellems and Church, 2002). In effect, water restriction results in reduced feed intake, reduction in growth rate, poor efficiency of feed utilization and reduced milk production in lactating sows. A severe limitation of water therefore can result in the death of animals (Kellems and Church, 2002).

When water is served *ad libitum*, a grower pig will drink about 4.5 liters per a day, a gestation sow will drink about 9-15 liters per a day and a lactating sow will drink about 9-20 liters per a day (Patience, 1990).

2.6. Origin and distribution of moringa

Moringa oleifera belongs to the monogeneric family, with other 12 species (Olson, 2002). According to Fahey (2005) the exact origin of *Moringa oleifera* species is not well known due to its wide spread cultivation. He added that it was cultivated and used by the ancient Romans, Greeks and Egyptians. It is now cultivated throughout the tropical and sub-tropical regions of the world Fahey (2005). However, *Moringa oleifera* is believed to have been cultivated first in the sub-Himalayan of northern India (Duke, 2001). Some researchers also believe it originated from western Asia (i.e. Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen) and even northern Africa (ICRAF, 2001).

Moringa has also been reported to be widely cultivated in other tropical regions of the world, for example, southern and eastern Asia including Afghanistan, Israel and Iran (Papillo, 2007). Moringa is also cultivated in many Pacific islands, including Kiribati, Guam, the Marshall Islands, the Northern Mariana Islands, the Solomon Islands and the Federated States of Micronesia (Hancock and Henderson, 1988).

2.6.1. The use of conventional and non-conventional feed in pigs' diet

Convention feedstuffs are the feedstuffs that are traditionally used to feed farm animals and are usually used to prepare commercial feed. E.g. maize, soya beans and fish (Ameral *et al*., 2007). Conventional feedstuffs are characterized by their high cost. As a result of conventional feed, feed cost alone in pig enterprise is estimated to represent 65 to 75% of the overall cost of production (Ameral *et al*., 2007).

Non-conventional feed resources (NCFR) are those feeds that have been adapted as alternative feed to feed farm animals and are not normally used in commercially prepared rations for livestock (Sontakke, 2014). These include various feeds of crops and animal which are usually industrial by-products (Sontakke, 2014). This term, "NCFR", has also been used to depict the new feed sources such as blood meal and leaf meals which are used to feed farm animals (Sontakke, 2014).

Hew and Devendra (1977) carried out a research in Malaysia where blood meal was used to feed pigs at an inclusion level of 0, 3, 6, 9, 12 and 15. It was noted that there were no significant differences among treatments. Hew and Devendra (1977) then suggested, based on growth rate and feed efficiency data that 3% level of blood meal was best in diets for pigs.

Adesehinwa (2007) also reported on the use of palm kernel in pig diet. In that research palm kernel cake was included in the diets of pigs at level of 50% and 100% to replace maize while the control diet contained 30kg of maize. The results on growth performance obtained on the grower pigs during the experimental period showed no significant difference among treatments. The daily feed intake, daily weight gain, FCE and protein utilization were similar among the treatments.

2.6.2 Uses of moringa

Various research reports have highlighted the importance and the use of moringa trees and shrubs leaves as livestock fodder or in supplementing the low-value fodders or rations in the dry season (Atta-Krah, 1989). *Moringa oleifera* for its variety of uses for both human beings and animals has been described as a 'miracle tree' by many authors. It is purposely grown in many parts of the world as a 'vegetable tree'. All the parts: leaves, fruits, roots and flowers have all been used as food and feed (Lu and Olson, 2001). The leaves can be compared to spinach in nutritional quality and are the most widely used part (Papillo, 2007). Because *Moringa oleifera* produces leaves during the dry season it has been used as a green vegetable in many developing countries during the dry season (Folkard and Sutherland, 1996). The leaves are eaten either cooked fresh or dried (Papillo, 2007). The fruits, or 'drumsticks,' are cooked and eaten like green beans especially in India (Papillo, 2007). The leaves, roots and back are also used in local medicines for the treatment of ear, eye and bronchial ailment, skin infections, fevers, stomach ulcers, diarrhea, syphilis and nervous disorders (Qaiser, 1973; Price, 2000; EcoPort, 2007). It is believed also that the juice from the leaves is used to stabilise blood pressure, the flowers are used to treat inflammations, the pods are used to cure joint pains, the roots are used to treat rheumatism, and the bark is used as a digestive material (Papillo, 2007). It has also been widely described as having antibiotic properties

and as a cancer preventative (Fahey, 2005). Scientific reports have confirmed that the flowers and roots contain pterygospermin compound which has been found to have powerful antibiotic and fungicidal properties (Price, 2000). *Moringa oleifera* is used as a green manure in some countries, where it significantly enriches agricultural land (Price, 2000). The dry wood is a good source of fuel for cooking and the bark can be used as an agent for tanning hides (Duke, 1983).

2.6.3 Nutrient composition of moringa

It has been reported by researchers at the Asian Vegetable Research and Development Center (AVRDC) (2006) that leaves from four different *Moringa* species (*Moringa oleifera, Moringa peregrina, Moringa stenopetala* and *Moringa drouhardii*) all contained high levels of nutrients and antioxidants. It was found out that Vitamin A was at its peak during the hot-wet season, while iron and vitamin C were highest during the cool-dry season (Price, 2007).

Moringa leaves provide significant quantities of the key nutrients required for a healthy diet (Kamal 2008). Kamal (2008) again reported that moringa has an outstanding source of nutrients. Its nutrients in the leaves compared to other sources of nutrients in grams have the calcium equivalent of four times that of milk, the vitamin C content is seven times that of oranges, while its potassium is three times that of bananas, three times the iron of spinach, four times the amount of vitamin A in carrots and two times the protein in milk. In addition, the leaves can serve as a rich source of beta-carotene (Nambiar and Seshadri, 2001). The leaves are also a good source of vitamin C, E and polyphenolics (Ross, 1999). The leaves of Moringa also contains high amount of Ca, Mg, K, Mn, P, Zn, Na, Cu and Fe (Aslam *et al*., 2005).

Moringa Oleifera leaf extracts contain pterygospermin and other related compounds such as isothiocyanates which are used in the treatment of some skin infections because it has antibiotic and fungicidal properties (Price, 2007). Apart from it serving as a vegetable and as medicinal plant in most developing countries, it is also a good source of oil (Bennet *et al*., 2003).

Fuglie (2005) reported that 8 g serving of dried moringa leaf powder will satisfy a child within ages 1-3 with 14% of the protein, 40% of the calcium, 23% of the iron, and nearly all the vitamin A requirement that a child needs in a day. Also, 100 g portion of dry moringa leaves could provide a woman with a third of her daily need of calcium and give her important quantities of iron, protein, copper, sulphur, and B-vitamins. Table 2.5 shows the amino acid profile of moringa leaves and Table 2.6 also shows energy, moisture and nutrients in moringa leaves.

Table 2.5: Amino acid composition (16 g N) of leaves of *Moringa oleifera* and FAO reference protein point.

Amino acids	Leaves (%)	FAO (%)
Protein reference		
Lysine	5.60	5.80
Leucine	8.70	6.60
Isoleucine	4.50	32.80
Methionine	1.98	2.50
Cystine	1.35	2.50
Phenylalanine	6.18	6.30
Tyrosine	3.87	6.30
Valine	5.68	3.50
Histidine	2.99	1.90
Threonine	4.66	3.40
Serine	4.12	-
Glutamic acid	10.22	-
Aspartic acid	8.83	-
Proline	5.43	-
Glycine	5.47	-
Alanine	7.32	-
Arginine	6.23	-
Tryptophan	2.10	1.10

Source: Zarkadas *et al*. (1995)

Table 2.6 Energy, moisture and nutrient composition of moringa leaves

Nutrient reference	Nutrient amount in 100 g
Energy (Kcal, MJ)	304 +/- 87 kcal, 1.3 +/- 0.36
Moisture (mg)	7.4 +/- 2.89
Protein (g)	24 +/- 5.8
Carbohydrates (g)	36 +/- 9.2
Fat (g)	6 +/- 2.5
Fiber, crude (g)	9 +/- 7.45
Fiber, total dietary (g)	20.6 – 28.6
Ca (mg)	1897 +/- 748.4
P (mg)	297 +/- 149.0
Na (mg)	220 +/- 180.0
K (mg)	1467 +/- 636.7
Mg (mg)	473 +/- 429.4
Fe (mg)	32.5 +/- 10.78
Zn (mg)	2.4 +/- 1.12
Cu (mg)	0.9 +/- 0.48
Vitamin B-6 (mg)	2.4
Vitamin A (µg RAE)	3639 +/- 1979.8
Vitamin C (mg)	172 +/- 37.7
Vitamin E (mg)	56 – 113

Source Aslam *et al*. (2005)

2.6.4 Anti-nutritional factors present in the leaves of moringa

According to Barnes and Amega (1984), anti-nutritional factors are compounds mainly organic in origin which when present in a diet, may affect the health of the animal or interfere with normal

feed utilization. They may occur as natural constituents of plants or artificially when processing feed.

A research conducted by Makkar and Becker (1997) has revealed that Moringa leaves are free from most of the anti-nutritional factors except for saponins and phenol. However, the concentration of phenol is far below the toxic threshold levels for animals and saponins are inactive as far as haemolytic properties are concerned. Upon a phytochemical screening, Bamishaiye *et al.* (2011) indicated that leaves of moringa contain phenolics, tannins, alkaloids, saponins, flavonoids, and steroid and do not contain phylobatanin, and tripertenes. Table 2.7 shows the anti-nutrients present in moringa leaves.

Table 2.7 Anti-nutrient present in leaves of the moringa plant

Substance	**Leaves**
Total phenols (% tannic acid equivalent)	4.4
Tannins (% tannic acid equivalent)	1.2
Saponins (% diosgenin equivalent)	8.1
Phytate (% dry matter)	2.1
Lectins (1/mg of meal that produced haemagglutination per ml of assay medium)	ND
Cyanogenic glycosides (%)	ND
Glucosinolates (mmol/g)	ND

Source: Makkar and Becker (1997)

ND - not detected

2.7 Effect of dietary fibre on digestibility in pigs

Dietary fibre is defined as a heterogeneous mixture of structural and non-structural polysaccharides and lignin and is not digested by endogenous secretions by the pig (Souffrant,

2001). According to Bach and Jorgensen, (2001) a major fraction of dietary carbohydrates constitutes the diet for pigs and consists of mono, di, and oligosaccharides and two broad classes of polysaccharides, starch and non-starch polysaccharides. Good enough, starch and disaccharides are broken down by a combination of salivary, pancreatic and mucosal enzymes in the small intestine with the end products (glucose, galactose and fructose) which are then absorbed into the portal vein. On the contrary no enzymes in the small intestine of pigs can cleave the bonding in some oligosaccharides and non-starch polysaccharides. These carbohydrates can only be broken down by microbial fermentation in the large intestine with the end products to be short-chain fatty acids and lactic acid.

Dietary fibre is generally considered as a fraction of diet with low energy content, and in the pig causes regular peristaltic action that avoids the possibility of constipation (Wenk, 2001).
In general, the digestibility of dietary fibre is lower in young animals than in adult animals and the negative effects of dietary fibre on the digestibility of energy and nutrients are highest in young animals (Bach and Jorgensen, 2001).

Chabeauti *et al*. (1991) found that in diets with similar amounts of non-starch polysaccharides, plant cell walls from soya bean hull and sugar beet pulp diets were highly digestible (0.74 and 0.69 for total non-starch polysaccharides, respectively) while those from wheat bran and wheat straw diets were low (0.51 and 0.30 for total non-starch polysaccharides, respectively). Therefore, it is not only the level of dietary fibre that is important, but also the type or source of fibre plays a significant role in digestion and absorption.

2.8 Effect of leaf meal on growth performance of pigs

Many researchers have reported on the effects of leaf meal on animal performance. Some findings have shown that, inclusion of leaf meals does not improve animal performance but other researchers have discovered improvement. According to some of these findings feed conversion efficiency tends to be low in diets containing high levels of leaf meals (D'Mello and Devendra, 1995; Laswai *et al.,* 1997). Oduro-Owusu *et al*. (2015) in a feed trial used moringa leaf meal to feed pigs at an inclusion level of 0, 1, 2.5, 3.5 and 5% and discovered that the growth rate of pigs fed 5% MOLM was better than those on the control and 2.5% MOLM diets. It was further indicated that the feed conversion efficiency (FCE) of 0% MOLM, 1% MOLM, 2.5% MOLM and 3.5% MOLM were not significantly different from each other. Mukumbo *et al*. (2014) in a feed trial used moringa leaf meal to feed pigs and discovered that there was no significant difference in the average daily gain and slaughter weight but there was significant difference in feed conversion efficiency of the pigs.

Nuhu (2010) used moringa leaf meal to feed weaner rabbits and observed that the final body weight and the total weight gain increased with increasing levels of MOLM. However, the treatment means were not significantly different. The daily weight gain also increased with increasing level of MOLM, and the animals that were fed the control diet (0% MOLM) performed poorer than those fed the MOLM inclusion diets. The daily feed intake and feed conversion ratio (FCR) values were similarly improved with increasing level of MOLM, but the treatment means were not significantly different.

Adegun and Aye (2013) researched into the effect of moringa leaf meal on the performance of West African dwarf rams and realized there were no significant differences in body weight gain in all the treatment groups. Nevertheless, the diet had significant effect on feed conversion ratio (FCR) with diet 5 containing 5% of moringa leaf meal having the best FCR (6.90). Diets 2 and 4 containing 2% and 4% moringa leaf meal respectively were similar (7.39 and 7.38 respectively) while diets 1 and 3 containing 1% and 3% moringa leaf meal respectively were not different (7.93 and 7.84 respectively). In a growth performance study of grower rabbits, groundnut cake was replaced with moringa leaf meal. It was observed in that experiment that final body weight showed significant difference among the treatments. The rabbits fed 60% groundnut cake replaced with *moringa oleifera* had the highest final body weight value of 2.2kg which was different from all the other treatments. The control (0% MOLM), 80 and 100% groundnut cake replaced with *Moringa oleifera* showed lower final body weight which were comparable (Adeniji and Lawal, 2012).

2.8.1. Feed intake of pigs

According to Forbes (1995) a rise in feed intake in pigs may be due to insufficient essential amino acids in the leaf meal as a result of their interaction with fibre or phenolic constituents. This leads to the pigs eating more to compensate for the insufficient amino acids.

Mukumbo *et al*. (2014) in a feed trial used moringa to feed pigs and discovered significant differences in the average daily feed intake of the pigs among treatments, with T4 pigs (fed 7.5% MOLM) consuming a higher amount of feed on a daily basis.

2.8.2 Birth weight of pigs

Birth weight of pigs is the weight of an individual piglet or litter(s) recorded within a period of 24 hours after farrowing. There is a close relationship between birth weight and piglet survival. Generally, increase in litter size at birth reduces the chance of survival due to the negative relationship between litter size and individual piglet weight (McGlone and Pond, 2002). Pond and Maner (1974) observed that first born piglets mostly have higher birth weights than last-born piglets within the same litter and therefore the first born piglets have higher chances of survival. Rohe and Kalm (1997) reported that an increase in litter size from 9 to 14 piglets was associated with a decrease in their average birth weight from 1.6 to 1.4 kg. Quiniou *et al*. (2002) analysed differences in the correlations existing between the litter size and body weight of piglets, in all 965 litters were studied and it was found out that with the increasing number of piglets from 11 to 16, decreased their birth weight from 1.59 to 1.26 kg.

Duyet *et al.* (2003) in an experiment observed no significant difference in the birth weight of piglets when sweet potato leaves were used to investigate the reproductive performance of sow. Duyet *et al.* (2004) carried out a reproductive experiment on pigs using sweet potato leaves, water spinach and fresh cassava foliage and observed significant difference in the birth weight of the piglets even though there was no clear pattern observed in the piglets birth weight.

2.8.3. Pre-weaning growth rate of pigs

Several researchers have reported on an improved growth rate of heavier birth weight piglets (Bérard *et al.,* 2008). Bérard *et al.* (2008) in an experiment observe no differences in the pre-weaning growth rate of low birth weight, average birth weight, and heavy birth weight piglets.

Wolter *et al.* (2002) also in an experiment did not observe any differences in pre-weaning growth rate of light and heavy birth weight piglets but pre-weaning mortality was lower for heavy birth weight piglets than for light birth weight piglets.

Duyet *et al.* (2003) in an experiment investigate the reproductive performance of sow using sweet potato leaves as a test ingredient at 20% and 50% inclusion level and observed no significant difference in pre-weaning growth rate of the piglets.

2.8.4 Weaning weight of pigs

Weaning in pig production is a gradual process that cannot be defined as a specific time period but rather a shift from the reliance on the sow's milk by piglets to a reliance on feed (Lean, 1994). Weaning weight is a main factor in early-weaned pigs as it has been shown to have an effect on subsequent growth performance (Wolter *et al.*, 2002). A heavier piglet at weaning usually has a higher rate of gain post-weaning compared with lighter piglet. Heavier piglets have the ability to better cope with the stresses of weaning and having a more developed digestive and immune systems, the better their post-weaning growth rate (Aherne *et al.*, 1992). Sloat *et al*. (1985) reported that heavy piglets at weaning comparatively have more body fat hence a better ability to withstand the period of under feeding during weaning. Heavy piglets also have a more developed digestive tract and therefore have a better ability to cope with transition to the post-weaning diet.

In a feed trial, Duyet *et al.* (2003) used sweet potato leaves as a test material on the reproductive performance of sow at an inclusion level of 20 and 50% and observed no significant difference in the weaning weight of the piglets. Further, Duyet *et al.* (2004) in an experiment investigated the

effect of sweet potato leaves, water spinach and fresh cassava foliage on the reproductive performance of pigs at an inclusion level of 0, 50 and 100% to replace soya beans. Significant differences in the weaning weight of the piglets were observed. The 100% inclusion level had the least weaning weight compared with the 0 and the 50% inclusion levels.

2.9 The effect of leaf meal on biochemical and haematological components of pigs

According to Bone (1988) blood is the red liquid that circulates in the arteries and veins composed of fluid (plasma) and cells [erythrocytes or red blood cells (RBC), leukocytes or white blood cells (WBC) and platelets]. Veulterinora (1991) reported that diets have significant influence on haematological and biochemical parameters. According to Duke (1985) the main purpose of investigating blood composition is to have a means of distinguishing between the normal states of an animal from the state of stress. These stress factors can be as a result of poor management, inadequate nutrition and physical or environmental stress. Akinmutimi (2004) stated and explained that biochemical components are sensitive to elements present in the feed, including elements of toxicity. He emphasized also on the fact that haematological components can also be used to monitor the quality of protein in the feeds. Diets that are rich in protein such as liver, dried beans, poultry and cabbage have been reported to increase both hematocrit levels and haemoglobin concentration in humans and animals (Bolarinwa *et al.,* 1991). Poor quality protein therefore can be detected in the low levels of haemoglobin concentration (Hb) in the blood of the animal (Abu *et al.,* 1998).

Oyawoye and Ogunkunle (1998) reported that the reduction in the concentration of packed cell volume (PCV) in the blood normally suggests the presence of a toxic factor (e.g. haemagglutinin)

which has adverse effect on blood formation. Eggum (1970) in another perspective said, high white blood cell (WBC) count are associated to microbial infection or the presence of a foreign body or antigen in the circulating system. High blood urea levels are also associated with poor protein quality. According to Lindsay (1977) the reduction in packed cell volume and red blood cell values could be associated with low protein intake or mild anaemia. Akinola and Abiola (1991) reported that total serum protein is an indication of the protein retained in the animal's body.

Oduro-Owusu *et al.* (2015) in a feed trial used moringa leaf meal (MOLM) to feed pigs at 0, 1, 2.5, 3.5 and 5% inclusion levels and realized that all the haematological characteristics, haemoglobin, packed cell volume, red blood cells, white blood cells, neutrophils, lymphocytes and eosinophils did not vary among dietary treatments. The MOLM did not vary the biochemical components of the pigs in terms of cholesterol and albumin. However, the total protein and globulin levels in the blood showed significant differences with no particular pattern. The cholesterol levels in the blood of the pigs were reduced as the level of MOLM increased in the diets.

Olayeni *et al*. (2006) in an experimental trial used wild sunflower (*Tithonia diversifolia*) leaf meal (WSLM) to feed pigs at 0, 10, 15 and 20 inclusion levels. The results indicated that haemoglobin Hb, PCV, RBC, MCH, MCHC and MCV were not significantly affected, while significant effects were noted in the values for WBC, platelets, neutrophils and lymphocytes.

Ekenyem and Madubuike (2007) observed changes in the haematological indices of pigs fed diets containing 0, 5, 10 and 15% levels of *Ipomoea asarifolia* Leaf Meal (IALM) which represented treatments 1, 2, 3 and 4 respectively. The results showed that the haemoglobin (Hb) and MCH

values did not vary among treatments. Also cholesterol, creatinine and total protein were similar in values among treatments.

In a feed trial using 24 Large White growing pigs, wild sunflower leaf meal was given in 3 varying inclusion levels (10, 20 and 30%) as protein supplements in the diet. Results revealed that PCV and neutrophils were not significantly affected as the levels of the test diet increased in dietary treatments. The WBC count values of pigs were significantly affected by the varying levels of the test ingredient inclusion at 0, 10, 20 and 30% in diets 1, 2, 3 and 4 respectively. Pigs on diet 4 had the highest value of 18093mm^3, followed by those on diets 3 and 1 at 16105mm^{3}and 6298mm^3 respectively. WBC value for pigs on diet 2 had the lowest value of 3932mm^3. Apart from diet 1 whose pigs had the significantly lowest average value of neutrophils (N) at 30.25%, diets 2, 3 and 4 had similar values of 36.10, 35.20 and 35.15% respectively. A significantly higher lymphocytes (L) value was recorded for pigs on the control diet 1 at 58.10%. Pigs on diets 2 and 3 had similar lymphocytes values of 50.15 and 50.10% respectively. The lymphocytes value of 51.15% obtained for pigs on diet 4 was also significantly different from the other lymphocytes values. The pigs on diet 3 had a significantly the highest eosinophils value of 5.05%, while all other values were similar 4.05, 4.10 and 4.05% for pigs on diets 1, 2 and 4, respectively. PCV for all the diets having the test ingredient were superior to the control diet (Fasuyi *et al.,* 2013).

Nuhu (2010) investigated the haematological and biochemical traits of weaner rabbit using moringa as the test ingredient and discovered that the test ingredient (MOLM) did not change most of the blood characteristics studied. Haemoglobin, Packed Cell Volume, White Blood Cell, Neutrophils, Lymphocytes, Eosinophils, Cholesterol, Total protein, Albumin and Globulin were

not different among treatment means. However, the MOLM reduced the cholesterol level in the blood.

2.10. Leaf meal and animal reproduction

According to Smith and Somade (1994), productivity in livestock production mostly depends on reproductive performance of the animals. As a result, Trenkle and Wilham (1977) have concluded that reproductive performance in commercial beef cow business is approximately five times economically more important compared to growth and ten times economically more important compared to beef quality. Many factors like biological, genetic type, physical environment and nutrition have been identified to have effects on the reproductive performance of farm animals (Smith and Somade, 1994)

2.10.1. Effects of feed, energy and protein intake on puberty

Diet can be manipulated to either hasten or delay puberty in livestock animals (Smith and Somade, 1994). Den and Kempen (1980) in a research observed that increasing energy intake of gilts by 34 % resulted in the reduction of their puberty age by nine days. It was also reported that the restriction of dietary energy and protein has been used to delay puberty (Smith and Somade, 1994). Research on pigs has revealed that about 50% *ad-libitum* feed or energy restriction will significantly delay age at puberty (Den and Kempen, 1980). According to Robinson (1990), the age of an animal has an influence on the severity of the effects caused by energy restriction on puberty and that the effect of energy restriction is severer in young animals than in older animals.

2.10.2. Effects of feed, energy and protein intake on ovulation rate

It is a common practice in pig rearing to increase energy intake before mating in order to increase ovulation rate (Den and Kempen, 1980). Report has shown that when daily ME intake was increased from 21 to 34 MJ during the period of growth average ovulation rate of the pigs was increased by 1.5. However, during the oestral cycle when ME intake was further increased to 41 MJ daily, average ovulation rate increased to 1.8 (Smith and Somade, 1994). Aherne and Kirkwood (1985) in a research report proposed that flushing an animal not more than 11 days before mating is most favourable. Robinson (1990) reported also that flushing effect may either be positive or negative if it is done on the day before mating or on the day of mating. However, he was quick to add that no effect was observed when flushing was done on the day after mating. Robinson (1990) noticed that positive effects are more likely to be observed at the early puberty ages of the animal compared to the adult age. According to Smith and Somade (1994), it is still not very certain the influence of varying levels of protein intake on ovulation rate in both ruminants and pigs. Ahene and Kirkwood (1985) reported that little effect has been observed on ovulation rate of pigs when protein levels were between 12.5 and 16% irrespective of the source of the protein. In the same view, Robinson (1990) pointed out that all the studies carried out on the effect of changing amino acid concentration and protein levels did not change ovulation rates above usual.

2.10.3. Effects of feed, energy and protein intake on pregnancy

Mckelvey and Robinson (1988) reported that, even under different nutritional levels, the influence of nutrition on conception rate, embryo and foetal growth and survival rates are usually normal.

Mckelvey and Robinson (1988) therefore concluded that, the effect of nutrition on fertilization rate in the pig is generally small.

Den and Kempen (1980) made use of high and low feed intakes up to puberty and in the oestral cycle period in 26 experiments and observed that nutrition has a significant effect on embryo survival during pregnancy. However, they concluded generally that, the nutrient requirements for foetal growth places little demands on the dam and can easily be met under normal feeding. Nevertheless, Vincent *et al*. (1985) also concluded that high feed restrictions on the dam can negatively affect foetal growth and survival in pigs.

2.10.4. Effects of feed, energy and protein intake on lactating dams

According to Seerley (1989) when maternal dams are under fed, it indirectly reduces energy in the offspring which negatively affects neonatal survival. In the same context, restricted feeding in the sow results in the reduction of glycogen reserves in the piglet which negatively affects their survival (Seerley, 1989).

Odeyinka *et al*. (2008) carried out a feed trial using five experimental diets to evaluate the reproductive performance of rabbits fed *Moringa oleifera* as a replacement for *Centrosema pubescens*. Freshly harvested *Centrosema pubescens* and *Moringa oleifera* leaves were offered to the animals at 2% of their live weights at the ratios of 100:0 (M0), 75:25 (M25), 50:50 (M50), 25:75 (M75) and 0:100 (M100), respectively in addition to the concentrate feed offered to the animals. The results showed that M0 and M100 had the highest litter size at birth of 5.12 and 5.81 respectively (though not significantly different). M50 thus, had the lowest litter size at birth (4.06) and this was significantly different from that of M100 (5.81). There was no significant difference

in gestation length of the does on the different treatments as well as in the litter weight at birth. Both litter size and litter weight at weaning were highest in M0 and M100 groups recording a litter size of 5.00 for both treatments and a significant difference in litter size at weaning across all treatments. The average daily weight gains per kit were 6.99, 8.06, 8.64, 8.13 and 6.78 g/day for M0, M25, M50, M75 and M100 treatments, respectively. There was a significant difference in average daily weight gain per kit.

2.11. Effects of vitamin intake on pig reproduction

Mahan (1991) reported in an experiment conducted on pigs how an increased in dietary vitamin E levels increased the number of total piglets born, despite the fact that there was also a higher number of stillborn piglets when the dietary vitamin E level increased. He observed that sows in the complete confinement facility had an increased litter size as dietary vitamin E levels increased (10.88, 11.48, and 12.03 respectively), whereas sows that were housed in the outside lots during gestation had a similar number of piglets born (12.83, 12.45, and 12.51, respectively) as dietary vitamin E levels increased (Mahan 1991). The number of piglets born per sow increased to parity 3 and then reached a peak at parity 5. Both litter size and litter birth weights increased as dietary vitamin E levels increased. There was however, no effect on individual pig birth weights when the three dietary vitamin E levels were provided (Mahan 1991). Mavromatis *et al.* (1999) reported an increase in litter size, number of piglets and piglet weight at birth and at weaning after supplementation with vitamin E (50 mg/kg of feed). Carmona-Garcia (1983) reported that when sows are supplemented with vitamin C for 1 week before farrowing, it had no effect on reproductive performance, whereas supplementation of vitamin C throughout gestation increased litter size. Migdal and Kaczmarczyk (1993) reported on how piglet weight at birth and weaning

and number of piglets that were alive on day 21 were higher in groups of sows supplemented with vitamin E compared with the control group.

2.12. Leaf meal and milk production

Pig production is usually not towards milking the animals for sale. As a result, most farmers pay no attention to lactation and its importance in pig production (Hartmann and Holmes, 1989). Nevertheless, to subsequently ensure a profitable meat production of the sow's offspring's, milk is very important for the supply of important nutrients to piglets. Milk and colostrum composition and production is crucial for growth and survival of the piglet during the lactation period and after weaning (Devillers *et al.*, 2007). The survival of piglets during the first few days of the nursing period is dependent on the high intake of colostrum (Rooke and Bland, 2002).

In an experimental trial conducted by Devillers *et al.* (2007), it was observed that 82% of the piglets that did not ingest enough colostrum did not survive after three days. Naturally, neonatal piglets are deficient in their immune system because they have never been exposed to any antigens (Rooke and Bland, 2002). Research has revealed that the structure of the placenta of the pig does not allow immunoglobulins or glycoproteins to be transferred through it to foetus (Rooke and Bland, 2002). As a result, the newborn piglet uses ingested immunoglobulins from the colostrum to develop passive immunity. In view of this piglets that do not obtain sufficient colostrum will subsequently be more prone to diseases (Rooke and Bland, 2002).

Piglet mortality is usually as a result of short nursing period observed by some farmers which account for a very high economic loss in pig production (Rooke and Bland, 2002). According to Cabrera *et al.* (2010) in North America the nursing period was shortened in the 90's from about 21 days to 12-14 days. However, in most European countries the nursing period is now four weeks.

2.12.1. Formation of colostrum and milk

Milk production (mammogenesis) which continue throughout the period of lactation once the teats are suckled, all starts during pre-puberty and puberty (Farmer *et al.*, 2004). When the teats of a sow are not sucked within the first seven to ten days during lactation it results in involution (Kim *et al*., 2001). Research has shown that during gestation the last one third of mammogenesis is rather faster as compared to the first two thirds and this trend is important for the formation of milk and colostrum (Ji *et al.*, 2005). According to Ji *et al.* (2005), insufficient milk production is observed in gilts and primiparous sows as a result of low feed intake and underdeveloped mammary tissues. As a result additional nutrition is always needed to support mammogenesis especially for those that were not well matured at first matting (Ji *et al.* 2005). Colostrum production in the porcine mammary gland starts before parturition and it continues until up to 48 hours after the onset of lactation (Klobasa *et al.*, 1987). Mammary gland continues to produce colostrum which is gradually replaced by mature milk within 24 to 36 hours after parturition (Rooke and Bland, 2002).

2.12.2. Yield of colostrum and milk of sows

According to Hartmann and Holmes (1989), regular milking which is done in dairy cattle is practically not possible in sow since the porcine mammary gland does not contain cisterns which store milk when the epithelial cells of the alveoli secrete the milk. They explained why the removal of milk from the alveoli and milk ducts can only be done by inducing the milk ejection reflex which is achieved by using piglets to stimulate the teats for a minute to release oxytocin for milk ejection. According to Hartmann and Holmes (1989), sows nurse their piglets for about 20 times

per day. However, the duration for nursing and milk flow is only about ten to twenty seconds. As a result, Hartmann and Holmes (1989) concluded that the yield of sow colostrum and milk is quite difficult to measure.

2.12.3. Factors affecting milk production of sows

Genotype is the main factor that influences Colostrogenesis, colostrum yield, colostrum composition as well as milk yield and composition (Farmer and Quesnel, 2009). Bergsma *et al.* (2008) explained how comparism can be made between the heritability for milk yield of sows and that of the dairy cattle. According to Veerkamp (1998) the heritability for milk yield of sows and dairy cattle is estimated to be only about 0.32. The composition of colostrum and milk yield can easily be affected by feed manipulations (Farmer and Quesnel (2009). Research also shows how management, parity and health can also affect milk yield and composition (Farmer and Quesnel, 2009).

2.12.4. Effects of milk yield and composition on piglet growth and health

Suckling of Piglets' after parturition usually starts 20 to 30 minute (Le Dividich *et al.,* 2005). Colostrum intake by the piglet is influenced by birth weight, birth order and litter size (Le Dividich *et al.*, 2005). Normally, higher birth weight piglets are more motile and therefore compete for selected udder which usually have higher milk production and can consequently ingest a higher amount of colostrum compared to piglets with light birth weight and less active. Consequently, the more the amount of colostrum the piglet ingest the better its growth and its immediate or subsequent health condition (Le Dividich *et al.*, 2005). Apparently, individuals from larger litter size have little access to both colostrum and milk as a result of a greater competition between

piglets (Devillers *et al.*, 2007). According to Devillers *et al.* (2007), average piglet birth weight is negatively correlated to litter size. Thus, individual piglet birth weight reduces as litter size increases. Devillers *et al.* (2007) observed that for every extra piglet in the litter the average individual birth weight of the piglets will decrease by 25 g. According to Le Dividich *et al.* (2005), the available colostrum/milk per piglet decreases with an average of 22-42 g/day if the litter increases with one piglet. Reduction in milk and colostrum affect piglet growth and health since piglets obtain passive immunity through the immunoglobulins in colostrum by ingestion through the gastrointestinal tract until they have their own active immune system (Rooke and Bland, 2002). At the time piglets can produce their own antibodies, their immune system is considered to be active (Rooke and Bland, 2002). After birth immunoglobulins are passed from the gastrointestinal tract into the blood within 24 to 26 hours and it closes. Once immunoglobulins are contained in the colostrum it suggests that piglets that had access to more colostrum stand advantage to fight diseases hence good health (Rooke and Bland, 2002).

Immunoglobulins that are transferred to the piglet are specific to the antigens that the sow has been exposed to. It therefore means that the sow cannot protect the piglet from new antigens which it has not previously been exposed to (Rooke and Bland 2002; Stalder *et al.*, 2004). The immune ability of the piglets is also dependent on the age of the sow (Cabrera *et al.*, 2010).

Reyes *et al*. (2005) conducted an experiment to evaluate the effect of feeding different levels of *Moringa oleifera* leaf meal on intake, digestibility, milk production and milk composition on dairy cows. The animals were given *Brachiaria brizantha* hay *ad libitum*; the control diet was not supplemented with moringa leaf meal. Diet 2 was supplemented with 2 kg of moringa leaf meal and diet 3 was supplemented with 3 kg of moringa on a dry matter (DM) basis.

The results revealed that mean daily milk production was significantly higher for cows offered Moringa supplement than for those offered *brizanthahay* only. Increasing the amount of moringa offered from 2 to 3kg DM did not increase daily milk production but supplemented cows produced significantly more milk (1.80 and 1.97 kg, respectively) than cows offered *brizantha hay* alone. Milk composition was not significantly different among the treatments, although protein concentration increased and total solids and fat concentrations decreased slightly with increased levels of moringa in the diets. The higher milk yield of cows supplemented with Moringa resulted in significantly higher yields of milk fat, milk protein and fat corrected milk yield.

Mendieta-Araica *et al.* (2010) in a research evaluated the effect of using moringa leaf meal as a protein source in concentrate given to six lactating dairy cows fed a basal elephant grass diet on milk yield, milk composition and ration digestibility. The basal elephant grass diet and a concentrate containing 20% soybean meal was compared with a concentrate where the soybean meal was replaced with the same amount of moringa leaf meal. In the third diet commercially available components were used to compose an "Iso" concentrate with the same energy and protein content as the concentrate containing Moringa leaf meal. The results at the end revealed that the average daily milk yield during the experiment was 11.8 kg energy corrected milk (ECM). Both mean daily milk and ECM yield were significantly higher when cows were fed SBM concentrate compared with the other treatments. However, there was no significant difference in milk composition between treatments and on the average, the milk contained 34.9 g kg^{-1} fat, 34.5 g kg^{-1} protein, 126.1 g kg^{-1} total solids and 27.4 g kg^{-1} DM casein.

Ibeawuchi and Ukanwoko (2014) in a feed trial determined the effects of cassava leaf meal diets on milk yield and composition of West African dwarf goats. The diets were designated A, B, C and D containing 0, 10, 20, and 30% of cassava leaf meal. Milk yield was measured and analyzed weekly for total solids, butter fat, crude protein (CP), solid-not-fat (SNF), lactose, ash and milk energy. The results revealed that milk yield (g/d) did not differ among treatment groups. But, numerically animals fed diet D had the highest milk yield (134.99g/d) followed by animals on diet C (133.07g/d), diet A (121.21g/d) and diet B (119.73g/d). There were significant differences in the total solids values among the treatment groups. Diet B had the highest TS values (12.81%) while diet D had the least (12.35%). There were no significant differences in the butter fat contents of the milk of goats that fed the different diets. There were significant differences in the lactose contents of milk produced by goats on the diets. The lactose contents in this study were close to the value of 4.29%.

Hans *et al*. (2000) conducted an experiment with four dairy cows to evaluate the effect of substituting cotton seed meal by cassava leaf meal (CLM) at levels of 0, 20, 40, and 60% in the concentrates on milk yield and milk composition. The composition of the concentrates was: (CLM_0) cereals with 40% cotton seed meal, (CLM_{20}) cereals with 32% cotton seed meal and 20% cassava leaf meal, (CLM_{40}) cereals with 24% cotton seed meal and 40% cassava leaf meal, and (CLM_{60}) cereals with 16% cotton seed meal and 60% cassava leaf meal. The basic diet was Napier grass (*Pennisetum purpureum*) offered *ad libitum*. The results showed that there were no significant differences in milk yield between the treatments. The fat content of the milk was highest on the high cotton seed meal diet and decreased with increasing proportions of cassava leaf meal in the diet. The milk protein content did not differ among diets.

2.13. Carcass characteristics of pork

Naturally, the carcass characteristics of animals and for that matter livestock are affected by the state and the type of ingredients used in feeding them (Aberle *et al*., 2001). According to Aberle *et al*. (2001) pigs fully fed on concentrate diet tend to produce more carcass fat and eventually are less efficient in converting feed to lean meat than pigs fed slightly below *ad libitum* energy intake.

Oduro-Owusu *et al.* (2015) in a feed trial used moringa to feed pigs at 0, 1, 2.5, 3.5 and 5% inclusion levels and discovered significant differences in the carcass dressed weights of the pigs in the dietary treatments. The carcass dress weight of 0, 1, 2.5 and 5% MOLM were similar but 3.5% MOLM was however higher than 0 and 2.5% MOLM. Significant differences were observed in the slaughter weight, carcass weight with hair, shoulder and back fat thickness of pigs in the different treatments. Similar back fat thickness was observed for 0, 1, 2.5 and 3.5% MOLM but 0% MOLM recorded a higher back fat thickness than 5% MOLM. No significant differences were observed in the carcass dressing percentage of all the treatments in the study. The weight of lungs, heart, spleen and kidneys expressed as a percentage of the body weight of pigs did not show significant differences between the dietary treatments. The weight of the liver for 0, 1, 3.5 and 5% MOLM were not significantly different from each other. There was no significant difference between the treatment means in terms of the weight of the full and empty gastro intestinal tract taken as a percentage of the total carcass weight.

Mukumbo *et al*. (2014) in a feed trial used moringa at an inclusion level of 0, 2.5, 5 and 7.5% MOLM to feed pigs and discovered no significant difference in the pH of the meat which ranged

from 5.9 to 6.1. No significant difference was also found in back fat thickness which ranged from 2.7 to 2.9cm. Olayeni *et al*. (2006) in an experiment used wild sunflower (*Tithonia diversifolia)* leaf meal to investigate the carcass characteristics of weaner pigs. The test ingredient was included at 0, 10, 15 and 20% inclusion levels. The findings revealed that the varying inclusion levels of the WSLM in the diets showed no significant differences on the relative weight of liver, heart and spleen while kidney weight for diet 3 and 4 were significantly heavier than diet 1 and 2. Nuhu (2010) investigated the carcass traits of weaner rabbit using moringa leaf meal as the test ingredient and discovered that the slaughter weight, hot carcass weight, dressed weight and dressing percentage increased numerically as the MOLM level was increased in the diets. Meat quality was improved by the test ingredient (MOLM) by increasing protein content and reducing fat level in the meat.

Dougnon *et al*. (2012) carried out a feeding trial at Cotonou, Benin to determine the effect of dietary pellets of *Moringa oleifera* leaves (PML) on the carcass characteristics of rabbits. The PML were substituted to the commercial feed at level of 0, 10 and 15% to formulate diets of PML0 (control), PML10 and PML15 respectively. The results revealed that carcass yield was higher (but not significantly different for PML10 and PML15 diets). The substitution of PML to commercial diet did not affect the weight of offal. There was no apparent effect on colour, consistency and odour of the carcass and offal.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and period of study

The Piggery Section of the Animal Science Farm, University of Education, Winneba (UEW), Mampong-Ashanti was used for the experiment. Geographically, Mampong-Ashanti lies between latitude 07º 04' N and longitude 01º 24' W in the transitional zone of the forest and savannah of Ghana. It has a bimodal rainfall pattern. The major rainfall season starts from March to July with 1000 mm of rainfall while the minor season starts from September to November with 350 mm of rainfall (Meteorological Services Department (MSD), 2008). Mampong-Ashanti is approximately 289.7 m above sea level (MSD, 2008). The average daily temperature is usually between 25˚C and 30˚C while the average relative humidity is about 91.5%. The experiment started on 5th of April, 2014 and ended on 17th April, 2015.

3.2 Sources of feed ingredients and experimental animals

All the feed ingredients: maize, tuna fish, soya bean, wheat bran, premix and salt that were used for the experiment were bought from commercial feed retailers in Kumasi. The moringa leaf meal, which was the test ingredient, was obtained from the established moringa plantation at the Animal Science Farm. The experimental animals (Large White weaner pigs) were obtained from a commercial Pig farmer at Agona-Ashanti. The weaner pigs were between 9-11 weeks of age and 11 kg each.

3.3 Processing of moringa leaves

The moringa leaves were harvested every six weeks and air dried under a shed for an average of fourteen days until they were crispy to touch, while maintaining the greenish colouration of the

leaves. The leaves were then milled using a hammer mill of sieve size 2 mm, to obtain the Moringa *oleifera* leaf meal (MOLM). The leaf meal was then stored in air tight sacks until incorporation into the diet. A sample of the moringa leaf meal was subjected to proximate analysis according to the procedure outlined by Association of Official Analytical Chemists (A.O.AC) (1990) to obtain the nutrient composition of the moringa leaf meal. Based on the results obtained, the five experimental diets were formulated and compounded to meet the nutrient requirements at the various physiological stages of the pigs (NRC, 1998).

3.4 Experimental design and management of animals

A total of twenty four (24) Large White weaner pigs, made up of twenty females and four males were used for the experiment. The weaner pigs were between 9-11 weeks of age.

The twenty female weaner pigs were balanced by body weight and randomly allocated to five (5) treatments with four replicates in a Completely Randomized Design (CRD). Each replicate had one animal (female weaner pig). Each animal (males and females) were housed in a single pen with concrete floor. At puberty (second heat), the boars were used to cross the gilts. Each boar was made to cross one gilt in each treatment. Thus male one crossed gilt one in treatment one, gilt one in treatment two, gilt one in treatment three, gilt one in treatment four and gilt one in treatment five. Male two crossed gilt two in treatment one, gilt two in treatment two, gilt two in treatment three, gilt two in treatment four and gilt two in treatment five. Male three crossed gilt three in treatment one, gilt three in treatment two, gilt three in treatment three, gilt three in treatment four and gilt three in treatment five. Male four crossed gilt four in treatment one, gilt four in treatment two, gilt four in treatment three, gilt four in treatment four and gilt four in treatment five.

A pig stall had the following dimension: Length 240cm Width 210cm and Height 120cm. Thus it had an area of 50, 400 cm^2. Feed and water trough had the following dimensions: Length 45cm, Width 30cm and Height 16 cm giving an area of 1,350 cm^2. Water was offered *ad libitum* in concrete water trough and feed was also offered in concrete feed trough in the morning but restricted. Pigs were given 3.30% feed of their body weight as recommended by Fasuyi *et al.* (2013). A daily routine of cleaning the pig stalls was keenly observed. Prior to the experiment, the pig stalls were cleaned and later disinfected with quincide, a broad spectrum disinfectant. The pigs were also dewormed using Piperazine (Dorpharma B.V. Ltd., The Netherlands). The piglets were also given 2ml of exogenous iron the third day after farrowing through injection in the neck.

3.5 Experimental diets

Five experimental diets were formulated and compounded to feed the animals. The diets that were used to feed the pigs from the beginning of the experiment were used for the same pigs throughout the experiment. Diet 1, was used as the control and contained soya bean meal, tuna fish meal, wheat bran, maize, premix and salt like all the other treatments but without moringa leaf meal. Soya bean meal and tuna fish meal served as the main protein sources while maize served as the main energy source. Diet 2, Diet 3, Diet 4 and Diet 5 contained moringa leaf meal at level 5, 7.5, 10 and 12%, respectively. Representative samples of the compounded experimental diets were analysed for their proximate composition according to the procedure outlined by A.O.A.C (1990). The proximate composition and the calculated analysis of the experimental diets are presented in Table.3.1, 3.2 and 3.3.

The composition and analysis of the experimental diets that were used to feed the pigs at the grower stage is shown in Table 3.1.

Table 3.1: Composition and analysis of experimental grower's diets

Ingredients	**% Composition of Ingredients per Treatment (As Is)**				
	0% MOLM	5% MOLM	7.5% MOLM	10% MOLM	12% MOLM
Maize	49	49	49	48	50
Tuna fish meal	6	6	6	5.5	5.5
Soybean meal	8.5	8	7	6.5	6.5
Wheat bran	35.5	31	29.5	29	25
Premix	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
MOLM	0	5	7.5	10	12
Total	**100**	**100**	**100**	**100**	**100**
Calculated levels of some nutrients and energy					
Crude protein	17.17	17.31	17.14	17.03	17.17
Methionine	0.33	0.33	0.33	0.32	0.41
Lysine	0.93	0.91	0.90	0.98	0.83
Crude fibre	4.61	4.95	5.08	5.3	5.43
DE (MJ kg^{-1})	12.78	12.67	12.57	12.42	12.48

The vitamin premix provided the following per kilogram of diet: Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, Se 0.2 mg, Co 0.6 mg, Senoquin 0.6 mg, retinal 2000mg, cholecalciferol 25 mg, α- tocopherol 25 mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamin 0.83 mg, riboflavin 2 mg, folic acid 0.33 mg, biotin 0.03 mg, pantothenic acid 3.75 mg, macin 23.3 mg, pyridoxine 1.33mg.

The DE energy was calculated using the DE values for the various ingredients as recommended by (N R C, 1998). The DE for the moringa which is the test ingredient was also calculated using the proximate values obtained after the analysis using the formula, DE (MJ/kg DM)=

17.47+0.0079CP+0.0158oil-0.0331ASH-0.0140NDF as recommended by (McDonald *et al.,* 1998).

The composition and analysis of the experimental diets that were used to feed the pigs during the gestation period are shown in Table 3.2.

Table 3.2 : Composition and analysis of experimental gestation diet

Ingredient	**% Composition of Ingredients per Treatment (As Is)**				
	0% MOLM	**5% MOLM**	**7.5% MOLM**	**10% MOLM**	**12% MOLM**
Maize	66	66	64.5	63	62
Tunafish meal	5	5	5	5	4.5
Wheat bran	24	19.5	19	19	19
Soya bean meal	4	3.5	3	2	1.5
Premix	0.5	0.5	0.5	0.5	0.5
MOLM	0	5	7.5	10	12
Total	**100**	**100**	**100**	**100**	**100**
Calculated levels of some nutrients and energy					
Crude protein	14.2	14.34	14.44	14.37	14.23
Methionine	0.29	0.29	0.29	0.28	0.27
Lysine	0.72	0.69	0.67	0.65	0.62
Crude fibre	3.67	4.01	4.28	4.57	4.81
DE(MJ/Kg^{-1})	13.29	13.03	12.81	12.60	12.40

The vitamin premix provided the following per kilogram of diet: Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, Se 0.2 mg, Co 0.6 mg, Senoquin 0.6 mg, retinal 2000mg, cholecalciferol 25 mg, α- tocopherol 25 mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamin 0.83 mg, riboflavin 2 mg, folicacid 0.33 mg, biotin 0.03 mg, pantothenicacid 3.75 mg, macin 23.3 mg, pyridoxine 1.33mg.

The composition and analysis of the experimental diets that were used to feed the pigs at the lactating period are shown in Table 3.3.

Table3.3: Composition and analysis of experimental lactating diets

Ingredients	% Composition of Ingredients per Treatment (As Is)				
	0% MOLM	**5% MOLM**	**7.5% MOLM**	**10% MOLM**	**12% MOLM**
Maize	49	49	49	48	50
Tuna fish meal	6	6	6	5.5	5.5
Soybean meal	8.5	8	7	6.5	6.5
Wheat bran	35.5	31	29.5	29	25
Premix	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
MOLM	0	5	7.5	10	12
Total	**100**	**100**	**100**	**100**	**100**
Calculated levels of some nutrients and energy					
Crude protein	17.17	17.31	17.14	17.03	17.17
Methionine	0.33	0.33	0.33	0.32	0.41
Lysine	0.93	0.91	0.90	0.98	0.83
Crude fibre	4.61	4.95	5.08	5.3	5.43
DE (MJ kg^{-1})	12.78	12.67	12.57	12.42	12.48

The vitamin premix provided the following per kilogram of diet: Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, Se 0.2 mg, Co 0.6 mg, Senoquin 0.6 mg, retinal 2000mg, cholecalciferol 25 mg, α- tocopherol 25 mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamin 0.83 mg, riboflavin 2 mg, folicacid 0.33 mg, biotin 0.03 mg, pantothenicacid 3.75 mg, macin 23.3 mg, pyridoxine 1.33mg.

3.6 Data collection

The parameters that were measured comprised growth, reproductive and carcass characteristics.

3.6.1 Growth parameters

The following growth parameters were measured: Initial body weight (kg/pig), final body weight (kg/pig), daily feed intake (kg), total feed intake (kg), daily weight gain (kg) and feed conversion efficiency.

3.6.2 Feed intake

Data on feed intake were taken on individual animals on weekly basis. Since feed was restricted the animals consumed all their daily allocations. The weekly feed intake therefore was the kilograms of feed given to the individual animal multiplied by seven days.

3.6.3 Body weights

Each animal was weighed at the end of each week. The final weight gain of each animal was then calculated by subtracting the initial weight from their final weights. Based on this, the mean weight gain per treatment was calculated as the difference between the final mean weights and the initial mean weights of each of the five (5) treatments. Arithmetically, Weight gain (kg) = Final weight (kg) – Initial weight (kg). Mean weight gain (kg) = Final mean weight (kg) – Initial mean weight (kg).

3.6.4 Growth rate

Growth rate was calculated as the ratio of total weight gain before pregnancy to the experimental period before pregnancy. This was expressed in kilograms (kg).

Arithmetically, Growth rate $= \frac{\text{Total weight gain (kg)}}{\text{Total experirmental period (days)}}$

3.6.5 Feed conversion efficiency

Feed conversion efficiency is the ratio of the total weight gain in kg throughout the experimental period to total feed intake in kg. It was expressed as gain to feed ratio. That is,

$\text{FCE} = \frac{\text{Total weight gain (kg)}}{\text{Total feed intake (kg)}}$

3.7 Reproductive parameters

The reproductive parameters studied were: Litter size at birth (first day), litter size at weaning, litter weight at birth (kg), litter weight at weaning (kg), pre-weaning growth rate (Gain, birth to weaning (kg/day)), age at weaning (days) and gestation period (days).

3.7.1 Gestation period and age at weaning (days)

Gestation period is the number of days that it took a sow from the day of mating to parturition and this was measured by counting the days from the day of mating to the day of parturition.

Age at weaning was measured by counting the days from the day of parturition to the day of weaning. In this present study the piglets were weaned on the 31st day after parturition (Weary and Fraser, 1997).

3.7.2 Litter size at birth and weaning

Litter size at birth was measured by counting the number of piglets born dead or alive to each sow in each treatment. Based on this, mean litter size at birth was calculated by adding all the litter in a treatment and dividing by the number of replicates in the treatment. Litter size at weaning was measured by counting the number of piglets alive to each sow in each treatment on the day of weaning. Based on this mean litter size at weaning was calculated by adding all the litter at weaning in each treatment and dividing by the number of replicates in the treatment.

3.7.3 Pre-weaning growth parameters

The pre-weaning growth parameters studied were: Pre-weaning weight (kg)/piglet on the first day of farrow, final weight at weaning (kg/piglet) on the day of weaning.

3.7.4 Pre-weaning body weights

The weights of the individual piglets in each treatment were taken on the first day of parturition using a digital scale. The individual weights of the piglets were added and divided by the number of piglets to get the mean weights of the piglets in each treatment. On the day of weaning, the weights of the individual piglets were also taken. The final weight gain of each piglet at weaning was calculated by subtracting the weight at parturition from their final weight at weaning. The individual weight gain were added and divided by the number of piglets at weaning in the treatment to get the mean weights. Based on this, the mean weight gain per treatment was calculated as the difference between the mean weight at weaning and the mean weight at parturition of each of the five (5) treatments. Arithmetically, Weight gain (kg) = Final weight (kg) at weaning – weight (kg)

at parturition. Mean weight gain (kg) = Final mean weight (kg) at weaning – mean weight (kg) at parturition.

3.7.5 Pre-weaning growth rate

Pre-weaning growth rate was calculated as the ratio of total weight gain to the total period taken to wean the piglets. This was expressed in kilograms (kg).

Arithmetically, Pre weaning Growth rate $= \frac{\text{Total weight gain (kg)} at\ weaning}{\text{Total period taken to wean piglets (30days)}}$

3.7.6 Milk composition analysis

Milk analysis was carried out at the Biochemistry Laboratory of The Kwame Nkrumah University of Science and Technology, on the following: Total solids, fat content, crude protein, lactose (milk sugar), water content and cholesterol concentration.

Milking was done in the morning before feeding. Milk was collected from three gilts per treatment at peak lactation thus on the 21st day. Before milking, the sows were injected with 5ml of oxytocin to aid milk let down and 5 minutes after milking was done by hand. The samples were then taken to the laboratory under cold condition (4^{o}C) for analysis.

3.8 Haematological and Biochemical composition of blood

Haematological blood analyses were carried out at the Midwifery clinic, Mampong-Ashanti, on the following: Haemoglobin, red blood cells, white blood cells, packed cell volume, neutrophils, lymphocytes and mean cell volume.

Biochemical blood analyses were also carried out at the Medlab laboratory in Kumasi on the following: Serum cholesterol, total protein, albumen and globulin.

3.8.1 Blood sample collection and analysis

Blood sample was collected when the gilts were 85 days in pregnancy (peak gestation) as suggested by Žvorc *et al.* (2006) and used for the analysis. Three gilts per treatment were sampled for both haematological and biochemical analysis. Prior to each of the blood sample collections the animals were starved of feed for 24 hours. A sterilized disposable vacutainer syringe was used to draw blood from the external ear vein into sterile vacuum tubes between the hours of 7.20 and 10.15 a.m. Preceding the blood sample collection, a cotton swab soaked in 70% ethanol was used to sterilize the surface of the ear to avoid infection and to dilate the vein. Blood samples of 1.5 ml that were used for the haematological analysis were collected into sterile vacuum tubes containing ethylene-diamine-tetra-acetic acid (EDTA) as anticoagulant and blood analysis was done within an hour after collection. The red blood cell (RBC) counts, total white blood cell (WBC) counts, haemoglobin (Hb) concentration, packed cell volume (PCV) and mean cell volume (MCV) were determined using a Haematological Auto Analyser (Cell-DYN 1800).

Another blood samples measuring 5 ml were collected into sterile vacuum tubes without anticoagulant were used for the biochemical analysis. The blood samples that were used for the biochemical analysis were centrifuged at 300 rpm (revolution per minute) using a table top clinical centrifuge for 5 minutes in a micro centrifuge to obtain clean serum for the biochemical analysis using a spectrophotometer (Available Commercial Kits produced by Sentinel, Italy) at a wavelength of 500 nm. The serum obtained was analysed colorimetrically for total protein (TP), albumin and cholesterol concentration using Auto Analyser (Cell-DYN 1800, Abbott Block Scientific Inc., United States of America). Globulin (Gb) concentration was computed for as the difference between total protein and albumin concentrations.

3.9. Proximate and pH determination of pork

Samples of pork were taken from the ham of the various sampled animals. Proximate analyses and pH of the pork were carried out at the Kwame Nkrumah University of Science and Technology, Biochemistry Laboratory. The pH analysis were done by chopping samples of pork into smaller pieces after which 5 grams of each sample was weighed using a digital scale into a beaker. Twenty-five milliliters (25ml) of distilled water was then added to each sample and stirred for five (5) minutes. The samples were then left to stand for fifteen minutes after which the pH was measured with a digital pH meter.

Proximate analysis of pork was also carried out on percentage protein, percentage fat, percentage moisture, percentage ash, carbohydrate percentage of meat and energy content of meat as recommended by A.O.A.C. (1990).

3.10 Carcass characteristics

Three gilts per treatment were sampled for the carcass analysis. After weaning the piglets, the sampled sows were slaughtered to assess and measure carcass characteristics. Before slaughtering, the pigs were starved overnight but had free access to water. After slaughtering, carcasses were gutted and weighed. Each carcass was halved and measurements taken from the left half as recommended by Eusebio (1980).

The following were the carcass parameters that were studied: Live weight, dressing percentage, visceral fat, back fat thickness, weight of heart, weight of lungs, weight of liver, weight of spleen, weight of kidneys, visceral with content, visceral without content, stomach with content and stomach without content.

3.10.1 Evaluation of carcass

Slaughtering of pigs

Each of the fifteen sampled sows was slaughtered after weaning its piglets and weighing the dam. The slaughtering was done at The Animal Farm of the University of Education, Winneba, Mampong Campus. A sharp knife was used to slit the anterior vena cava, jugular vein and the bicarotid trunk and the animal left to bleed. The animals were then scaled with hot water (80^0c) after bleeding.

To determine the slaughter weight the sows were allowed to bleed after which the carcass was weighed. Dressing percentage: The dressed carcass weight was expressed as a percentage of the live weight. Back fat thickness: A straight cut was made at the back of the carcass from the neck region to the tail. A rule was used to measure the thickness of the fat at three points, the first rib, the last rib and the rump area. The average of the three measurements was taken as the back fat thickness (Eusebio,1980). Visceral with content: The weight of the visceral with the content was weighed. Visceral without content: The visceral was emptied of its content and weighed. Stomach with content: The stomach was weighed with its content. Stomach without content: The stomach was emptied of its content and weighed. Visceral fat: visceral fat was weighed.

3.10.2. Weighing of some internal organs

The weights of heart, lung, liver, spleen and kidneys were measured separately using a digital scale.

3.11. Statistical analyses

Data obtained were subjected to the analysis of variance with the aid of Statistical Analysis Systems (SAS 2008) computer software. Differences among means were separated using least significant difference (LSD) at 5% significant level.

CHAPTER FOUR

4.0 RESULTS

4.1 Chemical analysis

4.1.1 Proximate analysis of moringa leaf meal (MOLM)

Table 4.1 shows the results of proximate analysis of the moringa leaf meal (MOLM) used in this study which contained crude protein, ash, crude fibre, ether extract, nitrogen free extract and moisture. NFE had the highest figure followed by protein, crude fibre, moisture, ash and ether extract.

Table 4.1: Proximate composition of moringa leaf meal (MOLM)

Parameters	Value (%)
Crude protein	22.00
Crude fibre	15.15
Ether extracts	2.75
Ash	9.00
Nitrogen free extracts (NFE)	36.35
Moisture	14.75

4.1.2 Chemical composition of experimental diets

The proximate composition of the experimental diets is shown in Table 4.2.

Table 4.2: Proximate composition of five experimental grower's diets

Proximate fraction	0% MOLM	5% MOLM	7.5% MOLM	10% MOLM	12% MOLM
Crude protein	16.4	15.8	15.7	15.9	16.2
Crude fibre	4.34	6.36	6.31	6.36	6.42
Ether extract	1.00	1.00	1.00	1.00	1.00
Ash	7.50	9.50	5.50	7.00	6.50
Moisture	12.00	12.35	12.00	12.17	12.17

The crude protein level for diets 0% and 12% MOLM were slightly higher than diet 7.5%, but diets 5% and 10% MOLM were similar. Crude fibre value for diet 0% MOLM was low as compared to the rest which were similar. Ether extract values were the same. Ash value for diet 5% MOLM was quite high compared to the others. The percentage of ash for diet 7.5 % MOLM recorded the least value. All the values for moisture content for all the diets were similar.

4.1.3 The proximate composition of experimental diets during gestation period

The proximate compositions of the five diets used for the experiment during the gestation period are shown in Table 4. 3.

Table 4.3: Proximate composition of experimental diets during gestation period

Proximate fraction	0% MOLM	5% MOLM	7.5% MOLM	10% MOLM	12% MOLM
Crude protein	14.34	14.38	14.42	14.32	14.41
Crude fibre	4.13	4.18	4.21	4.23	4.24
Ether extract	2.36	2.18	2.41	2.28	2.23
Ash	1.81	1.85	1.84	1.86	1.89
Moisture	8.38	8.29	8.42	8.22	8.27

There was not much variation in the analyzed percent crude protein. However, the crude protein levels for diets 7.5% and 12% MOLM were slightly higher than crude protein levels for diets 5%, 7.5% and 10% MOLM. The crude fibre values were similar for all the diets. However, the values increased slightly as MOLM inclusion levels increased. Ether extract values were also similar for all the dietary treatments but diet 7.5% MOLM was the highest. The analyzed percentage ash and moisture values were equally similar for all the diets.

4.1.4 The proximate composition of experimental lactating diets

The proximate compositions of the five diets used for the experiment during the lactating period are shown in table 4. 4

Table 4.4: Proximate composition of five lactating diets

Proximate fraction	0% MOLM	5% MOLM	7.5 % MOLM	10% MOLM	12% MOLM
Crude protein	16.4	15.8	15.7	15.9	16.2
Crude fibre	4.34	6.36	6.31	6.36	6.42
Ether extract	1.00	1.00	1.00	1.00	1.00
Ash	7.50	9.50	5.50	7.00	6.50
Moisture	12.00	12.35	12.00	12.17	12.17

There was not much variation in the analysed percent crude protein. However, the crude protein level for diets 0% and 12% MOLM were higher than diet 5%, 7.5% and 10% MOLM which were similar. The crude fibre value for diet 0% MOLM was low as compared to the rest of the dietary treatments. Ether extract values were the same for all the dietary treatments. The analysed percentage ash value for diet 5% MOLM was quite high compared to the others. The least value for ash was recorded for diet 7.5 % MOLM. All the values for moisture content at all the treatment levels were similar.

4.2. Growth performance of female pigs

The growth performance of gilts fed varying levels of MOLM in the experiment is shown in Table 4.5.

Table 4.5 Growth performance of pigs fed different levels of MOLM

PARAMETERS	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
I B W (kg)	11.00	11.00	11.00	11.00	11.00	0.01	3.53
D F I (kg)	1.03^{ab}	1.05^{a}	0.99^{b}	1.07^{a}	1.08^{a}	0.06	0.01
T F I (kg)	155.23^{ab}	155.65^{ab}	150.57^{b}	160.72^{ab}	166.37^{a}	15.47	5.00
F B W (kg)	50.25	50.25	50.25	50.00	50.05	0.73	0.23
T W G (kg)	39.25	39.25	39.25	39.00	39.05	0.73	0.23
D G R (kg)	0.26	0.27	0.26	0.26	0.25	0.02	0.006
F C E	0.25^{ab}	0.25^{ab}	0.26^{a}	0.24^{ab}	0.23^{b}	0.03	0.007

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE =Standard error of means

M =MOLM

NB: I B W = Initial body weight. D F I = Daily Feed Intake. T F I =Total Feed Intake. F B W = Final Body Weight. T W G = Total Weight Gain. D G R = Daily Growth Rate. F C E = Feed Conversion Efficiency.

The initial body weights of the weaner pigs at the start of the experiment were the same for all the dietary treatments (P>0.05). Daily feed intake for pigs fed diets containing 5%, 10% and 12% MOLM were significantly (P<0.05) higher than those fed diets containing 7.5% MOLM but similar (P>0.05) to those fed diets containing 0% MOLM. The daily feed intake values for pigs fed diets containing 0% MOLM were also similar (P>0.05) to those fed diets containing 7.5% MOLM (Table 4. 5). Total feed intake for pigs fed diets containing 12% MOLM were significantly (P<0.05) higher than those fed diets containing 7.5% MOLM but similar to those fed diets containing 0%, 5% and 10% MOLM. The total feed intake for pigs fed diets containing 7.5% MOLM were also similar to those fed diets containing 0%, 5% and 10% MOLM (Table 4. 5). Final body weights, total weight gain and daily growth rate for pigs in all treatments were similar

(P>0.05). There was significant (P<0.05) difference between feed conversion efficiency values, thus, feed conversion efficiency for pigs fed diets containing 7.5% MOLM were significantly (P<0.05) higher than those fed diets containing 12% MOLM but similar to those fed diets containing 0%, 5%, and 10% MOLM.

4.3.1 Effects of different levels of MOLM on the blood biochemistry of sows at peak pregnancy

The effects of different levels of MOLM on the blood biochemistry of sows at peak pregnancy are shown in Table 4.6.

Table 4.6: Effects of different levels of MOLM on the blood biochemistry of sows at peak pregnancy

Parameters	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
Serum							
Cholesterol(ml/L)	175.05^{a}	124.95^{ab}	132.65^{ab}	111.50^{b}	144.20^{ab}	55.58	14.76
Total protein (g/dL)	7.70	7.55	7.25	7.20	7.25	0.60	0.15
Albumin (g/dL)	3.60^{ab}	3.75^{a}	3.35^{ab}	3.35^{ab}	3.05^{b}	0.57	0.15
Globulin (g/dL)	4.10	3.80	3.90	3.85	4.20	0.98	0.25

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE =Standard error of means

M =MOLM

There were no significant (P>0.05) differences in total protein and globulin values among the dietary treatments. However, there was significant (P<0.05) difference in serum cholesterol and albumin values. Serum cholesterol for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than those fed diets containing10% MOLM but similar to those fed diets containing 5%, 7.5% and 12% MOLM. Serum cholesterol values for pigs fed diets containing 5%, 7.5% 10% and 12% MOLM were also similar (Table 4.6). Albumin values for pigs fed diets containing 5% MOLM were significant (P<0.05) higher than those fed diets containing 12% MOLM but similar to those fed diets containing 0%, 7.5% and 10% MOLM. Albumin values for pigs fed diets containing 0%, 7.5% 10% and 12% MOLM were also similar (Table 4.6).

4.3.2 Effects of different levels of MOLM on the haematology of sows at peak pregnancy

The effects of different levels of MOLM on the haematology of sows at peak pregnancy are shown in Table 4.7.

Table 4.7: Effects of different levels of MOLM on the haematology of sows at peak pregnancy

Parameters	0%M	5%M	7.5%M	10% M	12% M	L S D	S E
W B C (x 10^3/µL)	16.10^{d}	17.75^{bc}	20.30^{a}	16.75^{cd}	18.95^{ab}	1.65	0.43
R B C (× 10^6 µL)	7.04	6.33	6.62	6.81	6.51	1.18	0.31
H b (g/dl)	13.05^{ab}	11.95^{c}	12.30^{abc}	13.10^{a}	12.05^{bc}	1.02	0.26
P C V (%)	43.55	40.50	41.20	42.95	40.60	5.42	1.43
M C V (fL)	62.00	64.00	62.30	63.05	62.50	4.30	1.14
NEUT (10^3 µL)	4.70	5.85	4.70	5.95	5.95	1.35	0.35
LYM (10^3 µL)	10.20^{bc}	11.45^{ab}	13.15^{a}	9.15^{c}	10.50^{bc}	2.00	0.52

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE =Standard error of means

M = MOLM

W B C = White blood cells. R B C =Red blood cells. H G B = Hemoglobin. P C V = Pack cell volume. M C V = Mean cell volume. NEUT = Neutrophil. LYM= Lymphocyte.

WBC values for pigs fed diets containing 7.5% were significantly (P<0.05) higher than those fed diets containing 0%, 5% and 10% MOLM but similar to those fed diets containing 12% MOLM. The WBC values for pigs fed diets containing 5% and 12% MOLM were similar. The WBC values for pigs fed diets containing 0%, and 10% MOLM were also similar (Table 4. 7). The RBC values for all the treatments were similar (P>0.05). The haemoglobin values for pigs fed diets containing 10% MOLM were significantly (P<0.05) higher than those fed diets containing 5% and 12% MOLM, but similar to those fed diets containing 0% and 7.5% MOLM. The haemoglobin values for pigs fed diets containing 5%, 7.5% and 12% MOLM were also similar (Table 4. 7). No significant (P>0.05) differences were observed among the dietary treatments for packed cell volume values, mean cell volume values and neutrophil values. Lymphocyte values for pigs fed diets containing 7.5% MOLM were significantly (P<0.05) higher than those fed diets containing 0%, 10% and 12 % MOLM but similar to those fed diets containing 5% MOLM. The lymphocyte values for pigs fed diets containing 0%, 5% and 12% MOLM were also similar. The lymphocyte values for pigs fed diets containing 0%, 10% and 12% MOLM were similar (Table 4. 7).

4.4. Reproductive performance of sows fed different levels of MOLM

The reproductive performances of sows fed different levels of MOLM are shown in table 4.8.

Table 4.8: Reproductive performance of sows fed different levels of MOLM

Parameters	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
A at P (days)	188.75	191.75	179.75	189.50	178.75	37.63	12.21
G P(days)	116	116	116.25	115.5	115.25	1.20	0.39
P B W (kg)	1.10	1.19	1.14	1.22	1.10	0.21	0.05
L S B	6.25	8.00	8.25	7.75	8.25	2.41	0.70
L S W	5.75	5.75	7.25	6.00	6.75	2.56	0.83
W W (kg)	4.62	4.57	3.65	3.78	3.87	1.28	0.41
P G R (kg)	0.12^{a}	0.12^{a}	0.10^{ab}	0.08^{b}	0.10^{ab}	0.03	0.01
M R (%)	9.72	29.33	13.96	22.86	18.77	27.72	8.99

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE =Standard error of means

M =MOLM

A at P = Age at puberty. G P= Gestation Period. P B W = Piglet Birth weight. L S B = Litter Size at Birth. L S W = Litter Size at Weaning. W W = Weaning Weight. P G R = Piglet Growth Rate. M R = Mortality Rate.

There were no significant (P>0.05) differences among the various treatment means for age at puberty, gestation period, weight at birth, litter size at birth, litter size at weaning, weaning weight and mortality rate. There was a significant (P<0.05) difference among treatment means for piglet growth rate for the thirty days period. Piglets from sows fed diets containing 0% and 5% MOLM significantly (P<0.05) grew faster than those from sow fed diets containing 10% MOLM but similar to those from sows fed diets containing 7.5% and 12% MOLM. The growth rates of piglets from sows fed diets containing 10% MOLM were also similar to piglets from sows fed diets containing 7.5% and 12% MOLM (Table 4. 8).

4.5. Effect of different levels of MOLM on milk quality of sow

The effects of different levels of MOLM on milk quality of sow are shown in Table 4.9.

Table 4.9: Effect of different levels of MOLM on milk quality of sow

Parameters	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
Protein	7.42[a]	7.20[c]	7.19[c]	7.29[b]	7.09[d]	0.06	0.01
Fat	3.13[a]	1.76[c]	2.34[b]	1.35[d]	1.16[e]	0.05	0.01
Water	86.41	86.54	86.46	86.48	86.54	0.0.21	0.06
Cholesterol	0.71[a]	0.64[b]	0.53[c]	0.43[d]	0.30[e]	0.04	0.01
Total solids	12.26[b]	12.30[b]	12.25[b]	12.37[a]	12.30[b]	0.07	0.02
Lactose	7.15	7.15	7.15	7.15	7.15	-	-

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE = Standard error of means

M =MOLM

Significant (P<0.05) differences were observed among the treatment means for all the milk parameters measured on the pigs except for milk sugar (lactose) and water (Table 4.9). Protein percentage in the milk for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than those fed diets containing 5%, 7.5%, 10% and 12% MOLM. Protein percentage in the milk for pigs fed diets containing 10% MOLM was also significantly (P<0.05) higher than those fed diets containing 5%, 7.5% and 12% MOLM. However, those fed diets containing 5% and 7.5% MOLM were similar but significantly (P<0.05) higher than those fed diets containing 12% MOLM (Table 4. 9)**.** Fat in the milk for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than all the others fed diets containing MOLM (5% to12%). All the other pigs fed MOLM (5% to12%) were also significantly (P<0.05) different from each other (Table 4.9)**.** Generally, fat

content in the milk reduced significantly as MOLM inclusion levels increased. Cholesterol level in the milk for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than all the pigs fed diets containing MOLM (5% to12%). All the pigs fed diets containing MOLM (5% to12%) were also significantly (P<0.05) different from each other in cholesterol content in the milk (Table 4. 9)**.** Cholesterol levels in the milk reduced significantly as MOLM inclusion levels increased from 0% to 12% MOLM (Table 4.9). Total solids in the milk for pigs fed diets containing 10% MOLM were significantly (P<0.05) higher than all the other treatments while all the other treatments were similar (Table 4. 9)**.** There were no significant (P>0.05) differences among all the values for milk sugar (lactose). All the values for all the treatment means were the same (Table 4. 9)**.**

4.6. Effects of different levels of MOLM on pork quality of sows

The effects of different levels of MOLM on pork quality of sows are shown in Table 4.10.

Table4.10: Effects of different levels of MOLM on pork quality of sows

Parameters	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
Moisture (%)	68.70^{a}	68.37^{cd}	68.53^{b}	68.40^{c}	68.26^{d}	0.12	0.03
Protein (%)	18.83^{a}	18.62^{b}	18.42^{c}	18.45^{c}	18.40^{c}	0.17	0.04
Fat (%)	8.54^{a}	8.38^{b}	8.55^{a}	8.38^{b}	8.19^{c}	0.10	0.02
Ash (%)	0.84^{ab}	0.87^{a}	0.86^{a}	8.38^{b}	0.84^{ab}	0.04	0.01
Carbohydrate (%)	3.02^{d}	3.67^{bc}	3.55^{c}	3.93^{ab}	4.23^{a}	0.33	0.08
pH	7.27^{b}	7.39^{a}	7.30^{ab}	7.33^{ab}	7.32^{ab}	0.10	0.02
Energy (k/Cal)	685.44^{b}	688.58^{a}	689.91^{a}	690.29^{a}	685.22^{b}	2.81	0.74

Means bearing the same superscript in the same row are not significantly different (P>0.05)
LSD = Least significant difference
SE =Standard error of means
M =MOLM

The percentage of moisture in the pork was significantly (P<0.05) higher for pigs fed diets containing 0% MOLM than those fed diets containing the MOLM (5% to 12%). The values for moisture in the pork for pigs fed diets containing 7.5% MOLM were also significantly (P<0.05) higher than those fed diets containing 5%, 10% and 12% MOLM. The moisture values in the pork for pigs fed diets containing 10% MOLM were also significantly (P<0.05) higher than those fed diets containing 12% MOLM (Table 4.10). However, the values for moisture in the pork for pigs fed diets containing 5% and 10% MOLM did not differ. The trend observed indicates that moisture content in the pork generally decreased as MOLM inclusion levels increased (Table 4. 10). Protein levels in the pork were significantly (P<0.05) higher for pigs fed diets containing 0% MOLM than the rest of the treatment means. Similarly, protein levels in the pork for pigs fed diets containing 5% MOLM were significantly (P<0.05) higher than those fed diets containing 7.5%, 10% and 12% MOLM which were similar (Table 4. 10). It was observed that protein in the pork decreased slightly as MOLM inclusion levels increased. Fat in the pork for pigs fed diets containing 0% and 7.5% MOLM were significantly (P<0.05) higher than those fed diets containing 12% MOLM (Table 4. 9). Ash content in the pork for pigs fed diets containing 5% and 7.5% were significantly (P<0.05) higher than those fed diets containing 10% MOLM but similar to those fed diets containing 0% and 12% MOLM (Table 4. 10). Carbohydrate content in the pork for pigs fed diets containing 12% MOLM were significantly (P<0.05) higher than those fed diets containing 0%, 5% and 7.5% MOLM but similar to those fed diets containing10% MOLM. Further, carbohydrate content in the pork for pigs fed diets containing 0% MOLM were significantly (P<0.05) lower than those fed diets containing 5%, 7.5% and 10 % MOLM. Then those fed diets containing 7.5% MOLM were significantly (P<0.05) lower in carbohydrate content than those fed diets containing

10% MOLM. However, the carbohydrate content for pigs fed diets containing 5% and 7.5% MOLM were similar (Table 4. 10).

The pH in the pork for pigs fed diets containing 5% MOLM were significantly ($P<0.05$) higher than those fed diets containing 0% MOLM but similar to those fed diets containing 7.5%, 10% and 12% MOLM. Equally, pH for pigs fed diets containing 0%, 7.5%, 10% and 12% MOLM were similar ($P>0.05$) (Table 4. 10).

Energy levels in the pork for pigs fed diets containing 5%, 7.5% and 10% MOLM were similar but significantly ($P<0.05$) higher than those fed diets containing 0% and 12% MOLM which were also similar (Table 4. 10).

4.7. Effect of different levels of MOLM on the carcass characteristics of sows

The effects of different levels of MOLM on the carcass characteristics of sows are shown in Table 4.11. Apart from the D L W, all other figures for all the parameters were expressed as a percentage to the dams live weight.

Table 4.11: Effect of different levels of MOLM on the carcass characteristics of sows

Parameters	0% M	5% M	7.5% M	10% M	12% M	L S D	S E
D L W(kg)	65.^{ab}	72.5^{a}	59.5^{b}	68.5^{ab}	59.5^{b}	9.37	2.48
D P (%)	74^{a}	74^{a}	60.5^{b}	70.75^{a}	68.5^{a}	6.50	1.72
V F W (%)	0.51^{a}	0.19^{b}	0.20^{b}	0.20^{b}	0.16^{b}	0.14	0.11
H W (%)	0.31^{b}	0.42^{a}	0.30^{b}	0.42^{a}	0.34^{b}	0.07	0.01
L u W (%)	0.92^{a}	0.58^{ab}	0.59^{ab}	0.66^{ab}	0.54^{b}	0.35	0.09
L i W (%)	2.09^{a}	2.20^{a}	1.12^{bc}	0.96^{c}	1.87^{ab}	0.83	0.21
W S (%)	0.11^{bc}	0.18^{a}	0.08^{c}	0.14^{ab}	0.10^{bc}	0.05	0.01
K W (%)	0.49^{a}	0.23^{b}	0.22^{b}	0.28^{ab}	0.24^{b}	0.22	0.05
V + C (%)	13.49^{ab}	12.59^{b}	16.07^{ab}	14.65^{ab}	16.74^{a}	3.81	1.01
V – C (%)	4.18^{b}	3.54^{b}	7.08^{a}	4.88^{ab}	5.06^{ab}	2.46	0.65
S + C (%)	2.56^{d}	2.88^{cd}	5.79^{a}	4.13^{b}	3.87^{bc}	1.17	0.30
S – C (%)	0.93	1.33	0.74	1.77	1.26	1.06	0.27
B F T (mm)	3.05^{a}	2.78^{b}	1.55^{c}	1.25^{d}	1.00^{e}	0.11	0.02

Means bearing the same superscript in the same row are not significantly different (P>0.05)

LSD = Least significant difference

SE =Standard error of means

M =MOLM

D L W = Dams Live Weight. D P = Dressing percentage. V F W = Visceral Fat Weight. H W = Heart Weight. L u W = Lung Weight. L i W = Liver Weight. W S = Weight of Spleen. K W = Kidney Weight. V + C = Visceral with Content. V – C = Visceral without Content. S + C = Stomach with Content. S – C = Stomach without Content. B F T = Back Fat Thickness.

There were significant (P<0.05) differences among all the dietary treatments for carcass characteristics for the pigs except for stomach without content. Dams live weight for pigs fed diets containing 5% MOLM were significantly (P<0.05) higher than pigs fed diets containing 7.5% and 12% MOLM but similar to those fed diets containing 0% and 10% MOLM (Table 4. 11). Visceral

fat weight was significantly (P<0.05) higher for pigs fed diets containing 0% MOLM than all the pigs fed diets containing MOLM (5% to12%) which were similar. Heart weight for pigs fed diets containing 5% and 10% MOLM were similar but significantly (P<0.05) higher than those fed diets containing 0%, 7.5% and 12% MOLM which were also similar (Table 4. 11). Lung weight for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than those fed diets containing 12% MOLM but similar to those fed diets containing 5%, 7.5% and 10% MOLM. Similarly, pigs fed diets containing 12% MOLM were similar to those fed diets containing 5%, 7.5% and 10% MOLM in lung weight (Table 4. 11). Liver weights were significantly (P<0.05) higher for pigs fed diets containing 0% and 5% MOLM than those fed diets containing 7.5% and 10% MOLM but similar to those fed diets containing 12% MOLM. Again pigs fed diets containing 10% MOLM were significantly (P<0.05) lower in Liver weight than those fed diets containing 12% MOLM but similar to those fed diets containing 7.5% MOLM (Table 4. 11). Weight of spleen for pigs fed diets containing 5% MOLM were similar to those fed diets containing 10% MOLM but significantly (P<0.05) higher than those fed diets containing 0%, 7.5% and 12% MOLM. Also, pigs fed diets containing 0%, 7.5% and 12% MOLM were similar in weight of spleen (Table 4. 11). Kidney weight for pigs fed diets containing 0% MOLM were significantly (P<0.05) higher than those fed diets containing 5%, 7.5% and 12% MOLM but similar to those fed diets containing 10% MOLM (Table 4. 11). Visceral with content weight for pigs fed diets containing 12% MOLM were significantly (P<0.05) higher than those fed diets containing 5% MOLM but similar to those fed diets containing 0%, 7.5% and 10% MOLM. The pigs fed diets containing 5% MOLM were also similar to those fed diets containing 0%, 7.5% and 10% MOLM in visceral with content weight (Table 4. 11). Visceral without content weights were significantly (P<0.05) higher for pigs fed diets containing 7.5% MOLM than those fed diets containing 0% and 5% MOLM but similar

to those fed diets containing 10% and 12% MOLM. Pigs fed diets containing 0% and 5% MOLM were also similar to those fed diets containing 10% and 12% MOLM (Table 4. 11).

Stomach with content weight for pigs fed diets containing 7.5% MOLM were significantly ($P<0.05$) higher than all the other treatment means. However, pigs fed diets containing 0% and 5% MOLM were similar. Those fed diets containing 10% and 12% MOLM were also similar. Then those fed diets containing 5% and 12% MOLM were also similar (Table 4. 11).

There was no significant ($P>0.05$) difference among the treatment means for stomach without content. The treatment means for back fat thickness for pigs fed diets containing 0% MOLM were significantly ($P<0.05$) higher than all the pigs fed diets containing MOLM (5% to 12%). Back fat thickness for pigs fed diets containing 5% MOLM were ($P<0.05$) higher than those fed diets containing 7.5%. Back fat thickness for pigs fed diets containing 7.5% MOLM were significantly ($P<0.05$) higher than those fed diets containing 10% MOLM. Those fed diets containing 10% MOLM were also significantly ($P<0.05$) higher than those fed diets containing 12% MOLM (Table 4. 11). The pattern observed was that back fat thickness reduced significantly as MOLM inclusion levels increased.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical analysis of moringa leaf meal (MOLM)

The CP in the MOLM (22%) in this present study (Table 4.1) was higher than 16.00% reported by Gidamis *et al.* (2003) but it was similar to 22.42% and 23.27% reported by Sarwatt *et al.* (2004) and Noula *et al.* (2006) respectively. It was however, lower than 30.30% and 27.40% CP reported by Moyo *et al.* (2011) and Oduro *et al.* (2008), respectively. The crude fibre of 15.15% in the MOLM was lower than 19.25 % and 19.25 % reported by Oduro *et al.* (2008) and Nuhu (2010) in their findings respectively but higher than 11.1 % reported by Adeniji and Lawal (2012). The ether extract of 2.75% in this study was lower than 6.50% reported by Moyo *et al.* (2011) and 5.25% reported by Floidl *et al*. (2001). The ash content of 9.00% in the MOLM was similar to 9.00% observed by Oduro-Owusu *et al.* (2015), higher than 7.98% and 7.13% recorded by Ewuola *et al.* (2004) and Nuhu (2010) respectively but lower than 12.00 % reported by Gupta *et al.* (1989). The NFE value of 36.35% was lower than 88.75% and 76.53%, reported by Oduro-Owusu *et al.* (2015) and Oduro *et al.* (2008) respectively. Moisture content of 14.75% in the MOLM was lower than 30% and 88.75% reported by Adeniji and Lawal (2012) and Oduro-Owusu *et al.* (2015) respectively.

The variations in the nutrient content in this study (CP, CF, EE, NFE and moisture) possibly are as a result of differences in agro-climatic conditions and age of plants at harvest (Fuglie, 2005).

5.2 Proximate composition of experimental grower's diets

There were slight differences in the composition of crude protein in the various dietary treatments for the grower's diets even though there were no differences in the calculated values. The

variations could be attributed to the differences between tabulated nutrient values for the various feed ingredients used in the calculation and the actual nutrient values of the various ingredients used at the time of compounding the diets. The fibre content in the diets in this study increased as MOLM inclusion levels increased. This could be attributed to the high level of fibre in MOLM which in this study was 15.15% compared to other ingredients used for the control diet (0% MOLM). A similar trend was observed by Oduro-Owusu *et al.* (2015) in a feed trial for pigs when levels of MOLM were increased in the rations.

5.3 Proximate compositions of experimental gestation diets

The crude protein levels in the various dietary treatments in the gestation diets showed some differences despite there were no differences in the calculated values. The variations possibly could be assigned to the differences between tabulated nutrient content values used in the calculation and the actual nutrient values of the various ingredients used to compound the diets. There was an increase in the levels of fibre content in the dietary treatments in this study with corresponding increase in MOLM inclusion levels. This could be attributed to the high level of fibre in MOLM which in this study was 15.15 compared to other ingredients used to compound the control diet (0% MOLM). A similar trend was noticed by Gyebi (2014) when MOLM was fed to rabbits.

5.4 The proximate composition of experimental lactating diets

The various dietary treatments in the lactating diets showed little variations in the crude protein levels. The calculated values however, did not show any difference. The variations may be as a result of the differences in tabulated nutrient values of the various feed ingredients used in the

calculation and the real nutrient values of the various feed ingredients used to compound the diets. The fibre content in the dietary treatments in this study showed a trend of increment in fibre content as MOLM inclusion levels increased. This could be attributed to the fact that MOLM has a high level of fibre which was 15.15 in this study compared to other ingredients used for the control diet (0% MOLM). A similar trend was observed by Oduro-Owusu *et al.* (2015) in a feed trial for pigs when levels of MOLM were increased in the various diets.

5.5 Growth performance of pigs

The similarities in final body weight, total weight gain and daily growth rate indicates that the ingredient use (MOLM) did not have significant influence on the above growth parameters. The findings are in agreement with those reported by Mukumbo *et al*. (2014), when MOLM was fed to pigs. In that research no differences were observed in the above mentioned growth parameters. Olayeni *et al*. (2006) in a similar research fed weaner pigs using wild sunflower (*Tithonia diversifolia*) leaf meal and observed no difference in final live weight and weight gain.

Nuhu (2010) in another study used moringa to feed weaner rabbits and observed that the final body weight and the total weight gain increased with increasing levels of MOLM in the diets but they were not significantly different among the dietary treatments. Adeniji, and Lawal, (2012) however, investigated the growth performance of grower rabbits fed different levels of groundnut cake replaced with moringa leaf meal and observed differences in final body weight.

The differences in the total feed intake and the daily feed intake could be attributed to the high fibre content of the MOLM. According to Souffrant (2001), dietary fibre is a heterogeneous mixture of structural and non-structural polysaccharides and lignin and is not digested by

endogenous secretions by the pig. Fibre also dilutes dietary energy, increases bulkiness and reduces overall nutrient digestibility (NRC, 1998). The reduction in the energy concentration by the MOLM in the diets possibly made the animals to eat more to satisfy their energy requirement. However, Oduro-Owusu *et al.* (2015) in a feed trial used MOLM to feed pigs and observed no differences in total feed intake and daily feed intake among dietary treatments probably because the MOLM levels were comparatively lower. In that experiment the MOLM inclusion levels were from 1 to 5% MOLM which could not possibly dilute the dietary energy compared to the levels in this study which was from 5 to 12% MOLM which possibly diluted the dietary energy. The feed intake for the 7.5% MOLM was a little lower the rest of the MOLM diets possibly because its energy was a little higher than the rest. Similarly, Nuhu (2010) used moringa to feed weaner rabbit and observed no significant differences in the daily feed intake.

The differences in feed conversion efficiency could be attributed to the poor availability of nutrients to the sows in some of the diets. Díaz *et al.* (1997) and Díaz, (1998) reported that poorer availability of nutrients may result in a poor efficiency of feed utilization by animals. The FCE in this finding however did not show any particular trend. The result of this study is in agreement with the findings reported by Oduro-Owusu *et al.* (2015) when MOLM was fed to pigs. In that research, differences were observed in FCE among the treatment means which also did not show any trend. Similarly, Adegun and Aye (2013) researched into the effect of moringa on the performance of West African dwarf rams and observed differences in feed conversion ratio (FCR). Nuhu (2010) used moringa to feed weaner rabbits and observed that feed conversion ratio (FCR) values were improved with increasing levels of MOLM.

5.6 Biochemical and haematological components of gilts

5.6.1 Biochemical components of gilts

The levels of total protein, cholesterol, albumin and globulin in the serum taken from the pigs during the experiment were within the normal physiological ranges for pigs: 6.5-8.1(g/dL), 90.33-180.05(ml/L), 3.2-4.4 (g/dL) and 4.72-5.68(g/dL) for pigs respectively (Friendship *et al.,* 1984; Pratt, 1995).

The differences in these cholesterol levels in the blood of the pigs could be as a result of the anti-cholesterol factor in the MOLM which was able to reduce cholesterol in the blood of the sows from 5% to 12% MOLM. Ghasi *et al*. (2000) reported that when moringa juice were extracted at relatively low doses of 1mg/g and fed to Wister rats, cholesterol in the serum of the Wister rats were observed to reduce as the level of the MOLM juice increased. This result generally agrees with the findings reported by Oduro-Owusu *et al*. (2015) and Nuhu (2010) who observed that serum cholesterol levels decreased as MOLM inclusion levels increased in the diets when MOLM was fed to pigs and rabbits respectively.

The similarities in the serum protein and globulin levels in the blood of the sows could be an indication that the crude proteins in all the diets were similar. Akinola and Abiola (1991) reported that total serum protein is an indication of the protein retained in the animal's body. This study was in contrast with the findings reported by Oduro-Owusu *et al*. (2015) where difference were observed in serum protein among dietary treatments when pigs were fed varying levels of MOLM. Nuhu (2010) also observed an increase in serum protein with increased inclusion levels of MOLM when rabbits were fed varying levels of MOLM.

Albumen however, showed differences among the dietary treatments but there was no particular pattern observed for which to assign the differences to the MOLM or the 0% MOLM diet. In a related study, Ekenyem and Madubuike (2007) investigated the haematological and biochemical indices of pigs fed diets containing different levels of *Ipomoea asarifolia* leaf meal (IALM) and observed that increasing levels of IALM increased albumen values.

5.6.2 Haematological components of sows

All the measured haematological parameters in this study were within the normal physiological ranges reported for pigs: white blood cell (WBC)11-22x10^3/dl (Blood, 1995), red blood cells (5.0-8.0x10^6/µl), haemoglobin (10.14-16.90 g/dl), packed cell volume (20-50%), Mean cell volume (MCV) (50-68) (fl) neutrophils (3-10) (10^3 µL) and lymphocytes (4-13) (10^3 µL) (Swenson and Reece, 1993; Siegmund, 1998). There were no differences in red blood cell, packed cell volume, mean cell volume and neutrophil values. The white blood cells showed difference among the dietary treatments. However, there was no particular trend for which the differences could be attributed to the moringa or the control diet (0% MOLM). This finding agrees with the findings reported by Olayeni *et al*. (2006) who in a similar experiment used wild sunflower (*Tithonia diversifolia*) leaf meal (WSLM) to feed weaner pigs and observed differences in the white blood cells among the treatment means. However, Oduro-Owusu *et al.* (2015) observed no differences in the white blood cell values when moringa leaf meal was fed to pigs. Similarly Nuhu (2010) found no significant differences in the white blood cell when moringa leaf meal was fed to weaner rabbits. The packed cell volume (PCV) values were similar and this is an indication that there were little or no toxic substances in any of the diets. Oyawoye and Ogunkunle (1998) reported that the

reduction in the concentration of packed cell volume (PCV) in the blood normally suggests the presence of a toxic factor (e.g. haemagglutinin) which has adverse effect on blood formation. The red blood cells and packed cell volume were similar in values and within the range for pigs indicating that all the diets fed to the sows had similar and quality protein. According to Lindsay (1977), the reduction in packed cell volume and red blood cell values could be associated to low protein intake or mild anaemia.

There were differences in the Hb and lymphocyte values among the dietary treatments though, but there were no clear patterns for which the differences could be attributed to the moringa or the control diet (0% MOLM). Olayeni *et al*. (2006) and Oduro-Owusu *et al.* (2015) in their research did not observe differences in Hb values when wild sunflower leaf meal and moringa leaf meal were fed to pigs respectively. The similarity observed in the neutrophil values was in agreement with the findings of Oduro-Owusu *et al.* (2015) where no differences were observed in neutrophil values. But it was in contrast with a related research by Fasuyi *et al.* (2013) and Olayeni *et al*. (2006) who observed differences in neutrophil values when wild sunflower leaf meal were fed to pigs.

5.7 Reproductive performance of sows

There were similarities in ages at puberty, piglet's birth weight, litter size at birth, litter size at weaning, weaning weight and mortality rate for all the sows fed the various diets. These findings did not agree with the findings reported by Duyet *et al.* (2004), where sweet potato leaves, water spinach and fresh cassava leaf were used to replace soya bean meal to investigate the reproductive performance of pigs. In that research, differences were observed in birth weight and weaning

weight of the piglets. However, no differences were observed for litter size at birth and litter size at weaning which suggests that there was no deleterious effect of the MOLM on the piglets.

The differences in piglet's growth rate could not be attributed to the MOLM or the control diet since the difference did not show any particular trend.

The similarity in mortality rate in this study indicates that the moringa leaf meal did not have any negative effect on the piglets. This finding was not in agreement with that reported by Gyebi (2014) when moringa was fed to rabbit to investigate their reproductive performance. In his findings differences were observed in mortality rate of the kits.

5.8 Effect of varying levels of MOLM on milk quality of sow

The differences in the milk protein could be attributed to the high fibre in the MOLM diets which affected digestibility and the availability of protein to the sows. Díaz *et al.* (1997) and Díaz, (1998) in a research reported that high fibre affects digestibility and subsequent nutrient availability to monogastrics. The range of protein values in this present study was 7.10% to 7.32% as against 7.09% to 7.37% for rabbits as reported by (Gyebi, 2014). Reyes *et al*. (2005) in an experiment evaluated the effect of feeding different levels of MOLM to dairy cows on intake, digestibility, milk production and milk composition. It was observed that protein levels increased with increasing levels of moringa even though they were not significantly different. Possibly because they were ruminants and better utilized the fibre in the MOLM.

Mendieta-Araica *et al.* (2010) in a research evaluated the effect of using moringa leaf meal as a protein source in concentrate given to six lactating dairy cows fed a basal elephant grass diet on

milk yield, milk composition and ration digestibility. It was discovered that there were no differences in total protein of the milk.

The differences in the fat and cholesterol content of the milk could be attributed to the anti-fat and anti-cholesterol activity in moringa leaves which have the ability to reduce fat and cholesterol. Ghasi *et al*. (2000) reported that moringa juice extract at relatively low doses of 1mg/g reduced cholesterol in the serum of Wister rats. Moringa leaf is known to be a potent hypocholesterollemic agent when fed to Wister rat with relatively low dose of 1mg/g, when it was administered with a high fat diet daily for a period of 30 days. It was observed to reduce cholesterol in the serum (Ghasi *et al*., 2000). MOLM therefore was able to reduce fat and cholesterol levels in the milk of pigs due to the anti-cholesterol properties in the leaf. This finding agrees with what was observed by Gyebi (2014). In that experiment it was observed that both fat and cholesterol levels in rabbit milk reduced as MOLM inclusion levels increased. The range of fat and cholesterol levels in the milk in this study were 1.15% to 3.10% and 0.24% to 0.64% as against 2.28% to 2.48% and 0.17% to 0.27% respectively reported by Gyebi (2014). The range of fat in this study was lower than 4.77 to 4.92 in goat milk as reported by Ibeawuchi and Ukanwoko (2014).

There were differences in the total solid values but no pattern was observed for which the differences could be attributed to the moringa or the 0% MOLM diet. The total solid range in the milk in this study was 12.23% to 12.34% which was lower than 12.35% to 12.81% and 12.45 to 14.36% reported by Ibeawuchi and Ukanwoko (2014) and Ibeawuchi and Umoh (1990), respectively.

5.9 Protein, fat, moisture, ash, carbohydrate, energy and pH of pork

The differences in moisture and protein levels in the pork could be attributed to the high fibre in the MOLM diets which probably affected protein availability to the sows. Díaz *et al.* (1997) and Díaz, (1998) reported that high fibre results in poor availability of nutrients to monogastric since it affects digestibility. The range of protein content which was 18.40% to 18.83% for pork in this study was lower than 16.98% to 19.41% for pork reported by FAO (1969). It was also below the range of 20.2% to 24.6% reported by Oduro-Owusu *et al*. (2015). The protein levels in the pork in this study was lower than what was observed by Oduro-Owusu *et al*. (2015) possibly because of the low levels of MOLM in that study which was from 1 to 5% MOLM compared to the MOLM levels in this experiment which was from 5 to 12% MOLM. It is therefore possible that the fibre in the diets in this study comparatively resulted in the low availability of protein to the sows which are directly correlated to the protein in the meat. The range of moisture content of pork obtained in this present study was from 68.26% to 68.70%. The result obtained for moisture content was higher relative to moisture level of pork 42% reported by Singh and Ghosh (2004) but below 75% observed by Offer and Trinick (1993). However, it was lower than the range of 69.0% to 71.3% moisture content of pork reported by Oduro-Owusu *et al*. (2015).

The differences observed in the fat content of the pork could be as a result of the anti-fat activity in moringa leaf which has the ability to reduce fat in pork to give quality meat. According to Ghasi *et al*. (2000) moringa juice extracted at relatively low doses of 1mg/g reduced cholesterol in the serum of Wister rats.

The differences in the carbohydrate content of the pork could be attributed to the high fibre which pigs could convert at the hind gut into fatty acid (Bach and Jorgensen, 2001).

In this present study, the pH of the meat ranged from 7.30% to 7.39% which were lower than the range of 5.5 to 6.3 reported by Gardner *et al.* (1999) and Educational Technology (EUTECT, 1997) as the preferred pH of meat. This could be as a result of the time frame within which the meat was analysed, thus in less than 24 hours as recommended by Dransfield (1994). After every slaughter, the pork was taken to the laboratory the same day for analysis to be done which was less than the recommended 24 hours. According to Warriss *et al.* (1989), the pH in meat is dependent on the amount of glycogen available in the muscle at slaughter and this is normally attained when glycolysis ceases. The pH range in this study was lower than 5.9 to 6.1 reported by Mukumbo *et al*. (2014) when MOLM was fed to pig to evaluate meat quality, shelf life and fatty acid composition of pork. It was also lower than 5.2 to 6.2 the pH range reported by Oduro-Owusu *et al.* (2015) when MOLM was fed to pigs to evaluate their growth performance, blood chemistry and carcass characteristics. The pH in this study was lower than what was observed by Oduro-Owusu *et al.* (2015) possibly because the analysis of the pH in this study was done in less than 24 hours as explained above.

The difference in the energy of pork which was high for most of the MOLM treatments in this study could be attributed to the high carbohydrates and vitamins that are associated with MOLM. Fuglie (2001*)* reported that *Moringa oleifera* is a good source of proteins, carbohydrates, vitamins and minerals with its essential amino acids considered quality. High carbohydrates feeds are associated with high energy. On a contrary note, 12% MOLM was lower in energy content than

the other MOLM treatments possibly because at that inclusion level the fibre content was too high for the pigs (monogastric) to adequately utilize the feed. According to Souffrant (2001) dietary fibre dilutes dietary energy.

5.10 Effect of MOLM on the carcass characteristics of sows

The differences in dams live weight (DLW) could be attributed to the different weight at which the gilts attained puberty, the litter sizes that the dams had and the subsequent demand of suckling by the piglets which probably led to a slight loss of weight by some of the dams. This finding agrees with the findings reported by Miller *et al.* (2005) where in a related research, mulberry leaf meal was used to investigate the carcass characteristics of boars. The results showed that final body weight, hot carcass weight, fasted body weight and empty body weight were different. Oduro-Owusu *et al.* (2015) however, did not observe any difference in the final live weight of the pigs when MOLM was fed to pigs.

The dressing percentage (DP) showed a difference, however, the difference did not follow any trend to give a base for assigning the difference to the MOLM or the control diet (0% MOLM) This finding is in agreement with what was reported by Miller *et al.* (2005) when mulberry leaf meal was used to evaluate the carcass characteristics of boers. It was observed that the dressing percentage based on fasted body weight were significantly different. However, Oduro-Owusu *et al.* (2015) did not observe any difference in the dressing percentage of the pigs fed varying levels of MOLM diets.

The differences in visceral fat weight and back fat thickness among the dietary treatments could be assigned to the anti-fat effect of MOLM which has the potential to reduce fat in pork to enhance its quality. Ghasi *et al*. (2000) reported that juice extracts from moringa leaves was found to possess hypocholesterolemic agents. In a research conducted using Wister rats it was found that when moringa juice extracts was given at relatively low dose of 1mg/g, co-administered with a high fat diet daily for 30 days, cholesterol was found to reduce in the serum of the rats (Ghasi *et al*. (2000). This research was in agreement with the findings of Oduro-Owusu *et al.* (2015) whose finding revealed that back fat thickness in pork reduce with increasing levels of MOLM. Gyebi (2014) observed a similar trend in that visceral fat in rabbits fed varying levels of MOLM reduced with corresponding increase in MOLM levels.

The differences in kidney and liver weights among dietary treatments which showed that sows on the control diets had comparatively higher kidney and liver weights was an indication that there were no toxic substances in the MOLM diets. Abdel-Wareth, *et al.* (2014) reported that the liver is responsible for deamination in the body and the kidney is also responsible for detoxification in the body and in an attempt to deaminate or detoxify the kidney and the liver increase in weight respectively. Ahamefule *et al*. (2006) reported that the weights of some internal organs like liver and kidney of animals could be used in animal feeding experiments as evidence of toxicity. In that report higher kidney and liver weights were observed. This was attributed to the under-processed soya which possibly retained some anti-nutritional factors. The anti-nutritional factor could have accounted for the higher weights of the kidney and the liver in an attempt to detoxify the anti-nutritional factor in the feed containing the soya bean meal. Abdel-Wareth *et al.* (2014) in a related experiment used *Khaya senegalensis* leaves to evaluate the performance, carcass traits,

hematological and biochemical parameters in rabbits. Differences in weight were observed among the dietary treatment for liver and kidney. It was observed that at 35% of the leaf meal there was no deleterious effect on the animals. But at 65% of the leaf meal there was deleterious effect on the liver. Oduro-Owusu *et al.* (2015) in an experiment observed no difference in the weights of liver and kidneys expressed as a percentage of the body weight of pigs when they were fed diets containing graded levels of MOLM. Olayeni *et al*. (2006) also observed that the varying inclusion levels of wild sunflower leaf meal in the diets of weaner pigs showed no differences in the relative weights of liver, heart and spleen but kidney weight showed differences among dietary treatments.

There were differences among the dietary treatment in heart, lung and weights of spleen. However, there were no particular trends for which these differences could be assigned to the MOLM or the 0% MOLM diet. In comparison, Dougnon *et al*. (2012) and Oduro-Owusu *et al.* (2015) in their investigations observed no difference in the parameters mentioned above when MOLM was fed to rabbits and pigs respectively. Gyebi (2014) and Nuhu (2010) also in their investigations observed no difference in the weight of heart, lung and spleen when MOLM was fed to rabbits.

The differences in visceral with content did not follow any particular trend upon which the differences could be attributed to either the control diet or the MOLM diets. This finding is in contrast to the findings reported by Oduro-Owusu *et al.* (2015) where no differences were observed in the weight of the full gastro intestinal tract taken as a percentage of the total carcass weight. Similarly, Nuhu (2010) in his investigation observed no significant difference in the weight of full caecum when rabbits were fed moringa leaf meal.

There were differences among dietary treatments for visceral without content but without an apparent pattern for which to attribute the difference to the MOLM or the 0% MOLM diet. This finding is in contrast to the findings of Oduro-Owusu *et al.* (2015) who observed no differences in visceral without content when MOLM was fed to pigs. The differences in the weight of stomach with content revealed that the sows on the MOLM diets had higher stomach with content weight than sows on the control diet. This could be attributed to the bulky and fibrous nature of the MOLM. These led to the inability of the sows to digest the feed fully and to empty it before they were slaughtered. This resulted in the high weight of stomach with content for sows on the MOLM diets. Dietary fibre is a heterogeneous mixture of structural and non-structural polysaccharides and lignin and is not digested by endogenous secretions by the pig (Souffrant, 2001). Oduro-Owusu *et al.* (2015) however, observed no differences in the weight of the full gastro intestinal tract taken as a percentage of the total carcass weight.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The results of this present study have shown that:

- Moringa leaf meal (MOLM) could be used to improve the feed conversion efficiency of pigs at 7.5% MOLM inclusion level.
- Moringa leaf meal (MOLM) had little effect on piglet birth weight and other reproductive parameters.
- Moringa leaf meal (MOLM) could be used to reduce fat and cholesterol content in the milk of pigs up to 12% inclusion level.
- Moringa leaf meal (MOLM) has no adverse effect on both haematological and biochemical blood indices of pigs up to 12% inclusion level.
- Moringa leaf meal (MOLM) could be used to reduce visceral fat and back fat thickness in pork up to 12% inclusion level.

6.2 Recommendations

Considering the results, it is recommended that:

- Moringa leaf meal (MOLM) should be used to investigate the reproductive performance of pigs beyond the first parity. This is because at the first parity significant differences were not observed for the reproductive parameters in the sows.
- Moringa leaf meal (MOLM) should also be used to investigate the reproductive performance and carcass characteristics of small ruminants. This is because ruminants can

better use leaf meal and possibly show more differences in both carcass and reproductive parameters.

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