EFFECT OF REDUCED FEEDING ALLOWANCES ON THE NITROGEN RETENTION AND GROWTH OF INDIGENOUS PIGS

By

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ABSTRACT

Effect of reduced feeding allowances on the nitrogen retention and growth of indigenous pigs

The effect of reduced feeding allowances for pigs was investigated in two trials. Trial 1 was aimed at evaluating the effect of graded levels of energy on the nitrogen balance and growth performance of Mukota pigs. Graded levels of energy 0.11; 0.23; 0.34 and 0.45 MJ ME/kg$W^{0.75}$/day were used in the trial with the herbaceous weed wandering Jew (*Commelina benghalensis*) fed *ad lib* with the lowest energy diet. A digestibility and nitrogen balance trial was carried out in a 4 x 4 Latin square arrangement. Four growing Mukota pigs with an average weight of 10 kg were fed each diet for seven days for adaptation. Weight, urine and faecal samples were collected for 7 days after the adaptation period. Results showed that pig and dietary treatment had an effect on pig weight gain (P<0.05) but week had no effect (P>0.05). Week and pig had no effect on dry matter digestibility, nitrogen and feed intake (P>0.05) while dietary treatment had an effect (P<0.05). In relation to nitrogen retained as a percentage of nitrogen digested only the treatment had no effect showing that all diets including the one with *Commelina benghalensis* and a low level of energy (0.11MJ ME/kg$W^{0.75}$) can be fed without affecting the performance of growing Mukota pigs. None of the variables, however, had an effect on the feed conversion ratio.

In the second trial the objective of the study was to evaluate the effect of supplementation of growing Mukota pigs with a commercial growers' diet on farm. Ten farmers supplemented their animals with a commercial growers' diet at 300 g per pig per day while a further three acted as controls. All groups of animals were allowed to forage freely for the duration of the trial. The supplemented animals showed improved rate of weight gains than the control. There was a decline in the rate of gain in the rainy season due to the penning of the animals leading to a decline in the supply of feed.

The study showed that reducing the feed energy content of growing indigenous pigs has no effect on their growth performance and supplementation of growing pigs in rural production systems is feasible and leads to improvement of the performance of the animals.

Key words: Mukota, pigs, feeding, allowances, growth, supplementation, performance

369 words

DEDICATION

“in the hope of thereby preserving from decay the remembrance of what people have done,”

Herodotus

You and your people will wear yourselves out. This is too much work for you. You can’t do it alone (Exodus 18:18)

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The reticent do not learn; the hot-tempered do not teach.”Chapters of the Fathers 2.6

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CHAPTER 1

1 INTRODUCTION

The indigenous pig breeds of Zimbabwe are believed to have been introduced by European and Chinese traders about 300 to 400 years ago. The only truly indigenous pigs are probably the bush pig and warthog (Holness, 1991). Recent studies lend support to the assumption that the indigenous pigs are related to Chinese pigs (Ojeda et al., 2008; Ramírez et al., 2009). The indigenous pigs are predominantly black and brown, small, early maturing and hardy with shorter legs than the exotic pigs making them very mobile and good at foraging due to a large head, well-developed forequarter and relatively light hindquarter. In Zimbabwe, indigenous pigs were first characterised in the Mukota area of North Eastern Zimbabwe and are therefore called Mukota pigs.

Feed costs contribute about 70 to 80 % to production costs, which smallholder farmers cannot afford. This affects the ability of smallholder farmers to produce quality pork. However, pigs can be raised on unconventional feeds, such as agricultural by-products and locally available raw materials, which can lower feed costs and increase the profitability of smallholder pig production and efficiency of utilization of these resources (Halimani *et al.*, 2005; Chikwanha *et al.*, 2007). Presently, only a limited proportion of these materials are being utilised. This is due, in part, to lack of knowledge of their nutritional value.

Indigenous pigs are adapted to local conditions including the climate, disease challenges and feed resources. They can be reared under extensive and intensive conditions. The local pigs are, however, prone to high fat deposition, which affects their meat quality (Holness, 1991). The high propensity to deposit fat has been attributed to their slow growth and the feeding of diets containing higher protein and energy levels than may be required (Kerr and Easter, 1995; Weis *et al.*, 2004). There is, however, a need to determine the optimum protein and energy levels for the local pigs to increase the utilization of the local genotypes for commercial pork production. Appropriate diets would contain less energy and protein, than conventional diets, which will lead to better protein accretion and less fat deposition (Weis *et al.*, 2004). More importantly, knowing nutrient requirements will be useful in designing feeds based on locally available feed resources, feeds that the farmers can produce on their own and at a low cost. The pigs are normally free ranging, which has clear nutritional benefits comparable to intensive feeding (Lekule and Kyvsgaard, 2003), thus, it would be of value to simulate this in designing feeding strategies.

Indigenous pigs predominate in the small holder farming sectors of Zimbabwe and their ability to utilise high fibre, poor quality diets, excellent mothering ability and disease and worm infestation tolerance shows the potential contribution of these pigs to meat production and livelihoods of rural communities.

1.1 Justification

The potential of indigenous pigs to satisfy the demand for meat in the smallholder sector has not been realised (Mashatise, 2002; Ndindana *et al.*, 2002). This is mainly due to high feed costs, lack of knowledge on nutrient requirements of the local pig and the ineffective use of available raw materials to formulate rations and make feed.

It is, thus, justifiable to look into other alternative raw materials available to smallholder farmers and try to incorporate these into cheaper diets for local pigs. Examples of such raw materials include pumpkins, melons, hominy chop, various brans from cereal grains and common plants such as Wandering Jew. Lower energy and protein levels in a feed translate to lower feed costs, this also allows the incorporation of a larger variety of poor quality raw materials into the feed making the feed more palatable and allowing the effective use of available raw materials.

1.2 Objectives

The overall objective of this study was to determine the effect of reducing the National Research Council (NRC) recommended feeding allowances on the growth performance of indigenous pigs of Zimbabwe.

The specific objectives of this study were to:

i. Evaluate the effect of different daily dietary energy allowances 0.45; 0.34; 0.23 and 0.11MJ ME/kg$W^{0.75}$/day), representing 100; 75; 50 and 25% of maintenance recommendations (NRC 1998), on the growth performance and nitrogen balance of Mukota pigs.
ii. Evaluate the effect of *ad libitum* feeding of *C. benghalensis* together with the lowest energy diet on growth performance and nitrogen balance of Mukota pigs.
iii. Evaluate the growth performance of foraging local pigs supplemented with a 300 g/day pig grower feed, under smallholder farm conditions.

1.3 Hypotheses

The hypotheses being tested were:

i. Different daily dietary energy allowances (0.11; 0.23; 0.34 and 0.45 MJ ME/kgW$^{0.75}$/day), representing 25 %; 50 %; 75 % and 100 % of maintenance recommendations (NRC 1998), have no effect on the growth performance and nitrogen balance of Mukota pigs.

ii. Feeding *C. benghalensis ad lib* together with a low level of energy (0.11 MJ ME/kgW$^{0.75}$ /day) has no effect on nitrogen balance of Mukota pigs

iii. Pigs supplemented with 300 g/day pig growers mash show no improvement in growth performance under smallholder conditions.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Description of indigenous pigs of Zimbabwe

The indigenous pig breeds of Zimbabwe are believed to have been introduced by European and Chinese traders about 300 to 400 years ago. The only truly indigenous pigs are probably the bush pig and warthog (Holness, 1991). The indigenous pigs in Zimbabwe were first characterised in the Mukota area of North Eastern Zimbabwe and are therefore called Mukota pigs but are not yet truly classified as a breed. Genetic analysis is likely to give more definitive answers about the origin of the indigenous pig and its relationship to the wild Asian and European pigs. Two recent studies have demonstrated a relationship with Asian domestic pigs (Ojeda *et al.,* 2008; Ramirez *et al.,* 2009).

Indigenous pigs predominate in the small holder farming sectors of Zimbabwe. The large population of pigs in the communal areas shows the potential contribution of these pigs to meat production and livelihoods of rural communities.

The Mukota is a smaller pig with shorter legs than the exotic pigs; females reach mature weights ranging from 40 to 120 kg and can show oestrus as early as three months. The Mukota is mobile and good at foraging due to a large head, well-developed forequarter and relatively light hindquarter. The reproduction cycle follows an annual rhythm, with the peak farrowing season occurring during October, which may be due to the production system, where pigs are kept in pens for most of the wet season without access to boars (Holness, 1991, Chiduwa *et al.,* 2008). The feed conversion ratio (FCR) of indigenous pigs on commercial diets was estimated to be an average of 3.9 from 8-32 weeks of age. However, Ndindana *et al.* 2002 reported higher FCR values of 4.1 and 4.31 for indigenous pigs fed diets containing higher levels of fibre. The average daily gain of indigenous pigs is 0.41 kg /day between 8-32 weeks of age (Holness, 1991). There are many variations of coat colour but black and brown are most common and white is infrequent. The degree of hairiness varies, and both hairless and relatively long haired types are found. The indigenous sows exhibit excellent mothering ability resulting in low mortalities (Holness, 1991).

2.2 Management systems for indigenous pigs

The indigenous pigs are kept under free ranging conditions roaming freely, scavenging and searching for feed during the dry season and in pig houses or fold yards during the rainy season to prevent them from destroying crops (Mashatise *et al.*, 2005; Chikwanha, 2006). Even though the system has clear nutritional benefits (Lekule and Kyvsgaard, 2003) to the pigs it, however, exposes the pigs to high risks of predation as they scavenge and may consume intestinal parasite eggs in the course of foraging and muddy yards during the rainy season thereby increasing intestinal worm burdens. Low levels of mixed infections have been reported (Marufu *et al.*, 2008). Their survival under these conditions would testify to their disease tolerance. In addition, they have shown a greater tolerance to worms such as *Ascaris suum* than exotic breeds (Zanga *et al.*, 2003).

2.3 Factors affecting smallholder pig production

The major factor limiting productivity is inadequate feed resources in the smallholder sector due to limited land and low annual rainfall leading to the low crop yields which result in little or no surplus food for non-ruminant livestock. Frequent droughts and the limited development of water resources for livestock especially in the smallholder communal areas are compounding factors to the problems above.

There is also a limited number of improved indigenous breeds leading to the use of less appropriate exotic breeds being used in restocking programmes. The national systems of grading carcasses of pigs penalize the indigenous breeds due to their black hair follicles and thicker backfat and therefore discourage the use of indigenous pigs. This has also led to or been compounded by lack of formal markets for indigenous pigs (FAO, 2004)

The smallholder sector has little or no funds for herd health programmes leading to disease control and prevention through planned and scheduled activities, such as vaccinations, dipping, de-worming and record-keeping, being limited. Access to capital is a major limiting factor, especially in view of the high interest rates and the long-term nature of investments in breeding stock. Preston (1986) noted that farming systems in developing countries were difficult to change and that innovations have to be introduced gradually without inducing excessive risk which may, in the poor conditions of small farmers, directly affect the well being of the family. This was corroborated by Lekule and Kyvsgaard (2003) who pointed out that intensification of pig production has failed in Africa and the traditional production systems are resilient.

2.4 Possible coping strategies for improving smallholder productivity

To improve productivity in the smallholder sector the use of locally available feed resources such as crop residues, wild pods and home-grown forages to supplement foraging could be enhanced. Where possible, bought-in commercial feeds, can also be used where this is economically justified, as supplements to the foraging. Surface water is a major limiting factor to productivity but if better water-harvesting and conservation techniques such as pitting, brush cover, ridging and construction of small dams are employed; its availability can be improved making more water available to the animals and farming activities.

For the productivity of the smallholder to be enhanced further, markets should be available for indigenous livestock. Revising systems of grading live animals and carcasses can have a positive effect. This should enhance livestock production and marketing, deliberate programmes for training smallholder farmers on marketing of local pigs should be developed and implemented in order to enhance their participation.

Increased funding of the veterinary department, particularly provision of foreign currency for importation of veterinary medicines, drugs, vaccines and surveillance and control of notifiable diseases should be considered (FAO, 2004 and Peters *et al.*, 2005).Increased financial support to livestock development through provision of loans to female farmers at more affordable interest rates than currently available from the private financial sector should be availed as this will boost productivity and improved livelihoods.

2.5 Available ad Potential Feed Resources for indigenous pigs

While most domesticated pigs depend wholly on feed provided by the farmer, pigs under smallholder production, raised mainly on free range. The pigs depend mostly on foraging and part on their human caretakers for the provision of all the nutrients they require to sustain life (Ellis *et al.*,1997). However, feed resources are scarce in the smallholder sector and foraging alone in most cases is not adequate to meet all their requirements. Small holder farmers supplement this foraging with mostly agricultural by products, such as brewers' grains, leguminous feeds and kitchen waste (D'Mello, 1995). Agricultural by products, which form the bulk of the feed resources in most cases, are relatively high in fibre which limits their nutritional quality. Legumes, although being of a better quality, with higher protein content, can contain potentially toxic compounds or anti-nutritional factors (Mueller-Harvey and McAllan, 1992; Halimani *et al.*, 2005). These, among other factors, such as seasonal availability, can limit the use of these resources in the feeding and performance of indigenous pigs. Differences in performance can be explained on the basis of interaction and associated effects among nutrients and between nutrients and the site of digestion (Preston, 1986).

2.6 Nutritive value of alternative feed resources

The scarcity of conventional feed resources, due partly to cost and environmental conditions in the smallholder sector, means that alternative feed resources are continually sourced and utilised to feed indigenous pigs in the sector (Chikwanha *et al.*, 2007). In most cases little is known about the effect of the alternative feed resources on the overall performance of the diet and pigs themselves. In order to predict accurately the response in animal productivity to alternative feed resources, it is necessary to take into account the constraints to metabolism posed by the particular resource (Preston, 1986). Before any decision with regards an ingredient can be made, it is essential that the nutritionist knows everything there is to know about it. This means that the nutrient content should be known; that the physical structure or form of the ingredient is correct; that processing does not negatively impact the nutrient bioavailability; and that the biological quality in terms of any possible pathogen or toxin contamination can be assured. Once the complete knowledge of an ingredient has been determined, the economic value of the ingredient can be determined. Traditionally, there are three aspects that determine the value of an ingredient, these being; the price and nutrient content of the ingredient itself; the price and availability of the other ingredients; and lastly the diet in which it is to be used (Kleyn, 2009). However, in the smallholder sector the decisions are mainly determined merely by the fact that the feed resource is available.

Productivity is influenced primarily by feed intake, which in turn is determined by feed digestibility and capacity of the diet to supply the correct balance of nutrients required by the animals in different productive states.

2.7 Energy and protein utilisation by indigenous pigs

Most alternative feeds for swine are evaluated on the basis of their protein and energy. Some feeds have additional value from their mineral and vitamin content. However, these nutrients can be added economically from other sources and are thus not of primary value when evaluating alternative feed resources.

2.7.1 Energy utilisation

Apart from water, sources of energy are the most important food requirements of the pig and will most rapidly influence its survival if withdrawn (Holness, 1991). Energy nutrients are primarily carbohydrates and fats, although some protein may be used for energy. Energy is the most costly item in swine production and especially so to the smallholder who has to compete with the animals for cereals, which are the primary source of energy. It is necessary for all body action, including breathing, moving muscles and keeping the body warm; the excess energy is stored as body fat (Rea *et al.,* 2007).

Energy values are usually expressed as ME (metabolisable energy) or DE (digestible energy). Carbohydrates are separated into nitrogen-free extract (NFE) or crude fibre. The NFE portion includes the more soluble carbohydrates such as sugar, starch and some hemicelluloses which are all very digestible. Crude fibre contains cellulose, lignin and other complex carbohydrates, all of which are highly indigestible for pigs. The type of carbohydrate in a feed source determines its value as a source of energy for the pig. Cereal grains containing 60 to 70 percent NFE are the usual standard and are low in crude fibre (Rea *et al.*, 2007).

Total energy requirements can be distinguished between those required for maintenance and those for production. A state of equilibrium means there is no gain or loss of fat or protein. The environment, particularly temperature, affects maintenance requirements, as both the retention and loss of heat require an energy input. Energy requirements for production are strongly influenced by genotype than any other factor, which means that rations must be designed according to potential performance of the breed (Holness, 1991).

Kyriazakis and Emmans (1992) showed that increasing the energy intake resulted in increased live weight, carcass, protein and lipid gains of pigs. Recent studies suggest that pigs become fatter when they eat more or when they grow heavier, even if energy intake is insufficient to maximize protein deposition or lean tissue growth (Weis *et al.*, 2004). The quality of pork from indigenous pigs is affected by the predisposition of the pigs to put on too much fat on conventional diets. The target is thus to limit the amount of energy in the diet so that the energy requirements of the pig are met without supplying excess energy which would be used for fat deposition.

2.7.2 Protein utilisation

Protein makes up about 15 to 20 % of the total body weight of the pig and is vital for the growth of the pig lean flesh. The amount of protein per unit of digestible energy is more important than the absolute concentration of the protein in the ration. This is because efficient utilization of protein is dependent on the amount of energy available (Kerr and Easter, 1995). However, this ratio depends on a number of factors such as age and genotype of the pig. The optimum protein to energy ratio changes steadily as the pig grows, being high in young animals and lower in older pigs. The genotype of the pig determines their protein and energy requirement, which means different breeds may require different protein to energy ratios. Exotic pigs require higher protein to energy ratio than unimproved and indigenous pigs, because of a higher lean to fat ratio in their bodies (Holness, 1991).

The use of low crude protein diets supplemented with crystalline amino acids can reduce feed costs and nitrogen excretion in pig production. However, pigs fed low crude protein (CP) amino acid (AA) supplemented diets have been shown to have fatter carcasses as compared to pigs fed high CP diets (Kerr and Easter, 1995; Tuitoek *et al.*, 1997). The increased fatness in pigs fed low CP AA supplemented diets may partially be due to more dietary energy being available for fat synthesis as a result of reduced energy expenditure for catabolism of excess dietary protein. Excess CP intake has been shown to increase energy expenditure (Buttery and Boorman, 1976) and impact organ size and energy metabolism. (Yen, 1997; Nyachoti *et al.*, 2000). Noblet *et al.* (1987)

2.8 Fibre digestibility in indigenous pigs

Indigenous pigs are able to digest cellulose very well. The indigenous pig's gut contains a high population of cellulolytic bacteria and a longer caecum in comparison to most exotic breeds (Dzikiti and Marowa, 1997). These high numbers of cellulolytic bacteria in the pig's intestinal tract combined with a long residence time of ingesta in the intestine leads to increased fermentation in the hindgut resulting in significant quantities of cellulose being degraded.

Ndindana *et al.* (2002) compared the ability of indigenous pigs to digest fibre as compared to Large White pigs by feeding varying levels of maize cobs. Indigenous pigs showed better crude protein and dry matter digestibility when fed a highly fibrous diet than that of large white pigs. Indigenous pigs are better able to utilize fibrous feeds than the exotic breeds and this is an important adaptive trait particularly useful for the smallholder farming sectors. Local pigs raised mostly on free range, consume feedstuffs, such as grasses, tree leaves, pumpkins and cucumbers (Ndindana *et al.*, 2002), which are rich in fibre and other anti-nutritional factors.

The indigenous pig is susceptible to depositing a lot of fat due to inherent slow growth. This can be reduced by diet manipulation to reduce energy in diets so that there are no energy excesses (Kanengoni *et al.,* 2004; Weis *et al.*, 2004). Excess energy is partitioned towards fat deposition and thus a low-energy diet will ensure that the pig’s energy requirement is met without the excess, which will normally lead to more fat deposition. Fibre is used to dilute feeds and balance the nutrient profile of a feed but is thought to have adverse effects on growth performance of animals due to low digestibility. In pigs however hindgut fermentation means that fibre digestion occurs to a large extent and studies by Shriver *et al.*, (2003) showed that addition of fibre to diets had little effect on overall nitrogen (N) balance or growth performance, but tended to reduce slurry ammonium N concentration and shift nitrogen excretion from urine to faeces.

The effect of fibre on nitrogen retention depends on the method of inclusion in the diet and on the dietary protein to energy ratio Lenis *et al.*, (1996). If added to the diet, extra energy from the fibre may increase nitrogen retention; this suggests that diets to be developed should be used as supplements to locally available the high fibre feed resources.

Ndindana *et al.* (2002) reported that at higher levels of fibre, indigenous pigs produced higher net incomes than Large White pigs. The price of the feed per kilogram decreased with addition of maize cobs. This clearly suggests that it would be more economic to produce pork from the indigenous pigs at high levels of fibre and they could form part of a sustainable farming system, making use of cheap fibrous agro by-products.

2.8.1 Commelina benghalensis

C. benghalensis, commonly known as wondering jew, is a troublesome weed that needs removing from fields. Feeding it to pigs repays the labour involved and provides useful feed Chikwanha *et al.*, (2007). The integration of animal production using agricultural by-products ensures that animals play a complementary role, rather than a competitive role with man in meeting their feed requirements. The use of diverse feed resources will ensure that pigs are able to meet their feed requirements (Kyriazakis and Whittemore, 2006).

Commelina is a genus of almost two hundred species of evergreen herbaceous plants, generally called "dayflowers" due to the short lives of their medium blue flowers, of whose three petals two are blue and one withers. Several species, especially *Commelina benghalensis*, are eaten as a leaf vegetable in Southeast Asia and Africa. It grows in places with some sun exposure, especially with partial shade and growing well in moist soils needs. According to work by Chikwanha *et al.*, (2007) the plant can have CP levels up to 237g/kg which testifies to its suitability as an alternative protein source, the major problem being its high moisture content which makes storage difficult.

The relatively high CP content of *Commelina benghalensis* implies that this weed can be conserved for dry season of feeding pigs, and be used as protein supplements. This would require harvesting the weeds during the rainy season when they are abundant, then conserve them through silage or hay making. Chikwanha *et al.*, (2007) noted that the weed has a relatively low protein value, and under smallholder conditions it is fed fresh to the pigs. The only major limitation when fed fresh is the high water content, which can reduce intake (Ly, 1993). The study now assessed the performance when pigs are given the weed fresh, rather than dry.

2.8.2 Recommended feeding levels

No recommended feeding levels are available for the slow-growing local pigs, such that most of these pigs are fed on conventional diets designed for fast growing pigs. The National Research Council (NRC, 1998) recommends a crude protein level of 210 g/kg and an energy level of 14 MJ/kg DE for growing pigs. In addition, Whittemore (1998) recommends a CP to energy ratio of 15 g/MJ DE. This may not be appropriate for indigenous pigs. The aim of this study was not to develop feeding standards, as this would require more experiments and a higher budget, but to develop appropriate diets that are tailored for slow growth rate of the pigs and their ability to utilise fibrous feeds. The development of appropriate diets should take into consideration their propensity to deposit more body fat than their exotic counterparts. There is need to determine the performance of indigenous pigs fed diets with different levels of energy and protein.

2.9 Conclusion of literature review

The recommended CP and energy allowances for growing pigs are 210 g/kg and 14.0 MJ/kg DE respectively, and a protein to energy ratio of 15g CP per MJ DE, (NRC, 1998; Whittemore, 1998) however, these rates might be too high for growing indigenous pigs. There is, thus a need to reduce the quantity of protein and energy or alter the ratio in diets of growing indigenous pigs for sustainable production of the pigs. Another advantage of reduced energy and protein levels in the diets is that these levels can be met using locally available resources, which lower feed costs. This could lead to a more equitable ownership of livestock and sustainable use of available resources in local pig production.

CHAPTER 3

3 EXPERIMENT 1: EFFECT OF REDUCED FEEDING ALLOWANCE AND INCLUSION OF *COMMELINA BENGHALENSIS* ON NITROGEN RETENTION, DIET DIGESTIBILITY AND PERFORMANCE OF MALE MUKOTA PIGS

Abstract

The study was aimed at evaluating the effect of graded levels of energy on the nitrogen balance and growth performance of Mukota pigs. Graded levels of energy 0.11; 0.23; 0.34 and 0.45 MJ ME/kgW0.75/day were used in the trial with the herbaceous weed wandering Jew (*Commelina benghalensis*) fed *ad libitum* with the lowest energy diet. A digestibility and nitrogen balance trial was carried out in a 4 x 4 Latin square arrangement with four pigs and four periods. Four growing Mukota pigs with an average weight (mean ± SD) of 14.8 ± 4.52 kg were fed each diet for seven days for adaptation. Weight, urine and faecal samples were collected for 7 days after the adaptation period. Results showed that feeding graded levels of feed significantly ($P<0.05$) affected the nitrogen intake, nitrogen digestibility, nitrogen retention, dry matter digestibility and VFI of the animals but did not however affect faecal and urine output ($P>0.05$). There was a significant increase in nitrogen intake and loss as the feed allowance increased, nitrogen intake increased from 25.3 g/kg in treatment 1 to 45.9 g/kg in treatment 4. Nitrogen retention was lowest for treatment 2 at 21.8 % but was not significantly different between treatments 1 and 3. The study showed that feeding graded allowances of energy and the inclusion of *Commelina benghalensis* to growing Mukota pig diets improves both nitrogen retention and digestibility.

3.1 Introduction

Feed costs contribute about 70 to 80 % to production costs; this affects the ability of smallholder farmers to produce quality pork as they cannot afford to invest much without affecting their livelihood. However, pigs can be raised on unconventional feeds, such as agricultural by-products and locally available raw materials. This can lower feed costs and increase the profitability of smallholder pig production and efficiency of utilization of these resources (Halimani *et al.*, 2005; Chikwanha *et al.*, 2007). Presently, only a limited proportion of these materials are being utilised. This is due, in part, to lack of knowledge of their nutritional value.

Indigenous pigs are adaptable to local conditions including the climate, disease challenges and feed resources. They can be reared under extensive and intensive conditions. The local pigs are, however, prone to high fat deposition, due to their slow growth and the feeding of diets containing higher protein and energy levels than may be required (Kerr and Easter, 1995; Weis *et al.*, 2004). There is, therefore, a need to determine the optimum protein and energy levels for the local pigs to increase the utilization of the local genotypes for commercial pork production. Appropriate diets would contain less energy and protein, than conventional diets, which will lead to better protein accretion and less fat deposition (Weis *et al.*, 2004). More importantly, knowing nutrient requirements will be useful in designing feeds based on locally available feed resources, which the farmers can produce on their own at low cost.

There has been very little effective research in the tropics on locally available, non-conventional feed resources and their nutritional value as animal feedstuffs (Ly, 1993).

This is despite the fact that there is more potential in feed resources for pigs in the tropics than in the temperate regions. Undoubtedly, pig production has improved through a growing understanding of the mechanisms governing feed utilization and by the practical application of this new knowledge (Black *et al.*, 1986). Often valuable information resulting from studies in temperate countries requires proper interpretation before it can be applied in the tropics. And, although information concerning nutritional physiology has not always had a direct impact on animal performance, Rerat (1978) maintained that it was essential to any feeding strategy, while Braude (1979) pointed out that integrating information from studies of digestion and on-site feeding trials would result in improved performance and lowered costs.

Several workers (Ndindana *et al.,* 2002; Mashatise 2002 and Kanengoni *et al.*, 2004) have reported the suitability of including maize cobs in diets for pigs. There is potential of using maize cob meal to partially substitute for maize meal for all classes of pigs. This has been reported to lower feed costs by reducing the proportion of maize meal in the diets, diluting energy density while at the same time satisfying the welfare need for satiety.

It is, thus, justifiable to look into other alternative raw materials available to smallholder farmers and try to incorporate these into cheaper diets for local pigs. Examples of such raw materials include pumpkins, melons, hominy chop, various brans from cereal grains and common plants such as Mexican clover and Wandering Jew. In addition, the use of alternative raw materials and reduction of the inclusion levels of energy and protein sources will reduce direct competition between humans and pigs for grains and protein sources.

3.1.1 Objectives

The overall objective of the study was to evaluate the effect of giving different dietary energy allowances on the growth performance and nitrogen balance of growing Mukota pigs.

The specific objectives of this study were to:

i. Evaluate the effect of different daily dietary energy allowances (0.11; 0.23; 0.34 and 0.45 MJ ME/kgW$^{0.75}$/day), representing 25 %; 50 %; 75 % and 100 % of maintenance recommendations (NRC 1998), on the growth performance and nitrogen balance of Mukota pigs.

ii. Evaluate the effect of feeding *Commelina benghalensis ad lib* together with the lowest level of energy (0.11 MJ ME/kgW$^{0.75}$ /day) on nitrogen balance of Mukota pigs

3.1.2 Hypothesis

The hypotheses tested were that:

i. Different dietary energy daily allowances (0.11; 0.23; 0.34 and 0.45 MJ ME/kgW$^{0.75}$/day) do not affect performance and nitrogen balance of the indigenous pig;.

ii. Adding *Commelina benghalensis* to the lowest energy allowance (0.11 MJ ME/kgW$^{0.75}$ /day) has no effect on nitrogen balance of Mukota pigs.

3.2 Materials and methods

3.2.1 Study Site

The experiment was carried out at the Farm Teaching and Research Unit Piggery of the University of Zimbabwe, Harare, Zimbabwe. The area falls in Natural Region IIA which has an average annual rainfall of 760 mm and temperature range of 18 to 30ºC it is a predominantly grain producing area with some dairy farming.

3.2.2 Animals and Housing

Four intact Mukota male pigs with a mean (± SD) initial body weight of 14.8 (± 4.52) were randomly allocated to the four dietary treatments in a crossover design with a 4 x 4 Latin Square arrangement of treatments as shown in Table 3.2 below. Dietary treatment 1 included *ad libitum* access to *Commelina benghalensis* whose composition is shown in Table 3.1. The pigs were individually housed in metabolism cages which allowed for the separate collection of faeces and urine. The experimental periods were 14 days each of which 7 days was an adaptation period in which the animals got used to the diet and another 7 days in which urine and faecal samples were collected

3.2.3 Diets and feeding

Table 3.1 Levels of energy and nitrogen offered per day

	Energy (MJ ME/kgW$^{0.75}$/day)	Nitrogen (g/day)
Treatment 1+CB *ad lib*	0.110[a]	4[a]
Treatment 2	0.23	8
Treatment 3	0.34	12
Treatment 4	0.45	16

[a]This is the composition of the basal diet fed to the pigs without including the contribution of *C. benghalensis.*

Table 3.2 Chemical composition (g/kg DM) of *Commelina benghalensis*

GE(MJ/kg)DM	CP	ASH	EE	NDF	ADF
13.9	237.4	25.3	18.5	411.6	188.0

Table 3.3 Chemical composition of commercial diet

Chemical Analysis	%
Dry Matter	88.94
Crude Protein	16.50
Lysine	1.02
Methionine +cystine	0.78
Threonine	0.90
Energy (MJ/Kg)	11.56
Neutral detergent fibre	19.16
Ash	7.44
Calcium	1.50
Sodium	0.06
Phosphorus	1.03
Potassium	0.37

The complete diet supplied 0.45 MJ ME/kgW$^{0.75}$ (Treatment 4) of energy per day and the other diets supplied 0.34; 0.23 and 0.11 MJ ME/kgW$^{0.75}$ of energy being treatment 3, treatment 2 and treatment 1, respectively. The experimental plant *Commelina benghalensis* was fed *ad libitum* with treatment 1. The plants were harvested from a nearby maize field chopped into little pieces and fed fresh. The experiment was conducted in a 4 x 4 Latin square arrangement with four pigs and four treatments.

3.2.4 Sampling Procedure

Urine and faeces for each pig were collected separately, weighed and stored at -20°C. Urine was collected into a bucket with 50 ml of 25% sulphuric acid to prevent loss of nitrogen by evaporation. Urine and faeces from each animal were collected for seven days and at the end of the period the faeces were pooled for each animal weighed and dried in an oven at 60 °C, ground and a representative sample taken for analysis.

3.2.5 Laboratory analysis

The dry matter and nitrogen of the feed offered, refusals and that of faeces were determined according to (The Association of Official Analytical Chemists (AOAC, 1990). Nitrogen in urine was also determined using the same procedures.

3.2.6 Calculations

Feed conversion ratio is a measure of deficiency in the production process. It was computed by dividing the intake by weight gained. The FCR gives a figure of how many kilograms of feed have been used to produce each kilogramne of live weight gain. The estimated feeding allowance for the diet with *C. benghalensis* was computed based on nitrogen retained for the diet by fitting a regression equation on the data for the other three levels.

3.2.7 Statistical analyses

The data were analysed using the PROC GLM procedure of SAS (2000) using the following model:

$Y_{ijkl} = \mu + A_i + B_{(i)j} + C_k + E_{ijkl}$

Where:

Y_{ijkl} = Response variable (N retained, NI, DM, OM, CP, GE)

μ = Overall mean common to all observations;

A_i = Effect of i^{th} diet;

$B_{(i)j}$ = Individual animal effects;

C_k = Effect of the k^{th} period;

E_{ijkl} = Residual error distributed as N (0, $I\sigma^2_E$).

3.3 Results

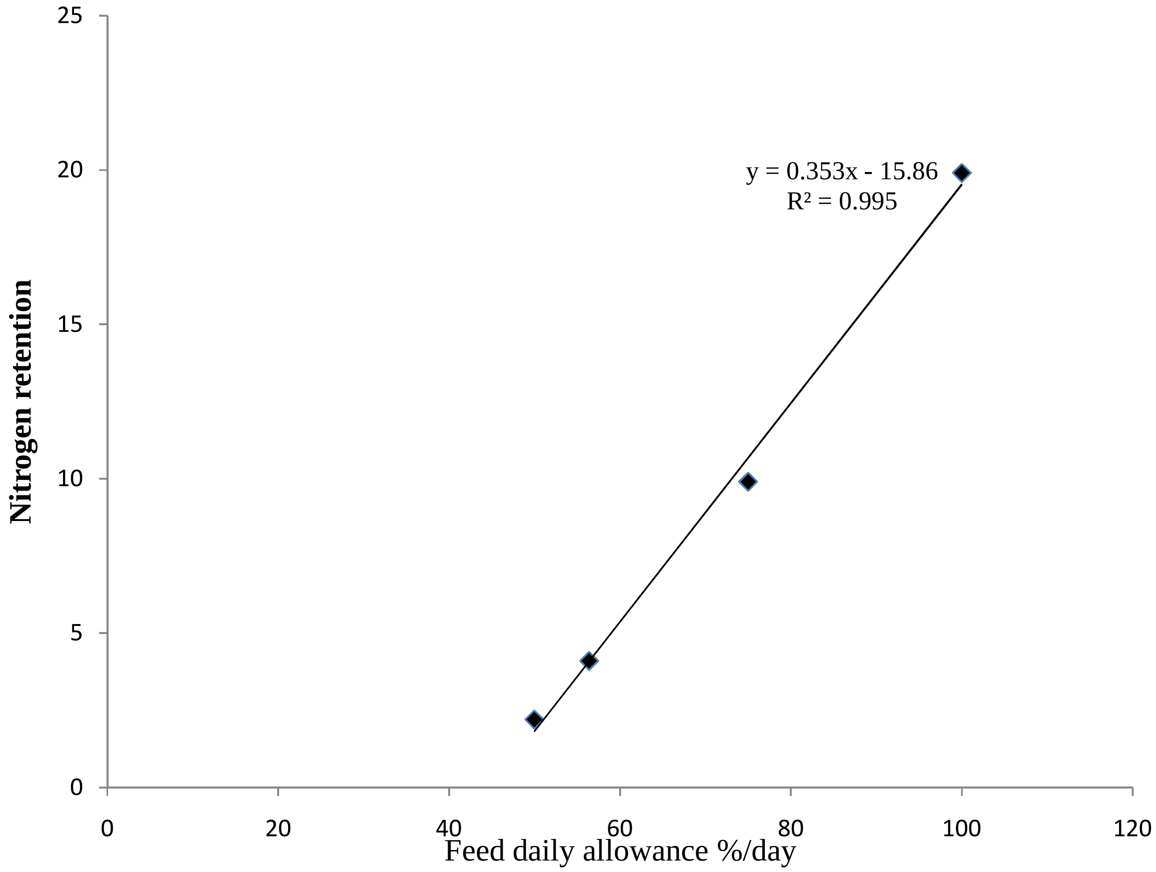
The feeding of graded levels of feed significantly (P<0.05) (Table 3.3) affected the VFI of the animal with the highest being treatment 1. However, this did not significantly affect the faecal and urine output, showing that there is no reduction in nitrogen output to the environment which of interest in terms of nitrogen pollution that pig production systems produce. The level of feeding also significantly affected (P<0.05) N intake, which increased with increase in daily feed allowance, N digestibility, N retention and DM digestibility these differences could be attributed to differences in crude protein content of the diets. Nitrogen intake and retention was not significantly different between treatment 1 and 2 but significantly different between treatment 3 and 4. There was a very low significance in the nitrogen lost as treatment 1 and 4 were the only ones significantly (P < 0.001) different. The estimated feeding allowance for the 25 % plus C. benghalensis diet was estimated at 56.44 % of maintenance (Figure 3.1).

Table 3.4 Effect of reducing daily energy and protein allowance on nitrogen retention

Parameter	Treatment					
	1	2	3	4	SEM	Significance
Nitrogen intake(g/kg)	25.3[c]	26.1[c]	34.1[b]	45.9[a]	1.34	***
Nitrogen lost	21.3[b]	23.8[ab]	24.3[ab]	26.0[a]	1.40	*
Nitrogen retained	4.1[c]	2.2[c]	9.9[b]	19.9[a]	1.69	***
Nitrogen digestibility	89.5[bc]	89.0[c]	91.3[b]	93.8[a]	0.70	***
% Nitrogen retained	45.6[b]	21.8[c]	49.4[ab]	69.2[a]	10.00	**
Dry matter digestibility	70.4[a]	14.8[d]	34.9[c]	49.4[b]	5.05	***
Weight gain (kg/day)	0.3	0.4	0.5	0.3	0.12	NS
Voluntary feed intake (kg/day)	1.5[a]	0.6[c]	0.7[c]	1.1[b]	0.08	***
Feed conversion ratio	4.7	1.8	1.6	3.6	2.76	NS
Faecal output(kg/day)	0.7	0.7	0.7	0.8	0.04	NS
Urine output(l/day)	0.6	0.9	0.6	0.8	1.28	NS

Values in the same row with different superscripts differ: NS; Not Significant, *; $P < 0.05$, **; $P < 0.01$, ***; $P < 0.001$Treatment 1 supplied 0.11 MJ ME/kg $W^{0.75}$ body weight + ad lib CB; Treatment 2 supplied 0.23 MJ ME/kg $W^{0.75}$ body weight; Treatment 3 supplied 0.34 MJ ME/kg $W^{0.75}$ body weight and Treatment 4 supplied 0.45 MJ ME/kg $W^{0.75}$ body weight.

Figure 3.1 Effect of adding C.B. to 25% daily feed allowance on nitrogen retention



3.4 Discussion

The present study showed that feeding graded levels of energy to growing Mukota pigs had an effect on the nitrogen balance of the animals. The differences in nitrogen intake could be attributed to differences in crude protein content of the diets. There is a linear relationship between N intake and retention (Cole, 1985), which explains the increase in N retention with increase in daily increase in N intake. According to McDonald *et al.*, (1995) there is an increase in the utilisation of ME as the feed allowance decreases, which explains why there was no effect on the performance of the animals as energy is the major limiting factor to pig growth.

Growth is usually depressed by low dietary protein intake to a greater extent in the more muscular, lean pigs than in the less muscular, obese pigs, although Davey and Bereskin (1978) did not observe such a difference. Dietary restriction by feeding alfalfa caused decreased gain in both lean and obese pigs. Studies by Mersmann and Koong (1984), have shown that restriction of dietary intake by meal feeding reduced the gain in lean but not in obese pigs. The Mukota is genetically obese explaining why the reduction in protein and energy allowances and addition of *Commelina benghalensis* at the lowest allowance had no effect on the daily gains of the animals.

Pigs with a higher tendency towards obesity are fatter and less muscular than lean pigs even when fed isocaloric-isonitrogenous diets. Compared to lean pigs, genetically obese pigs have smaller internal organs, less energy expenditure for maintenance and equal apparent digestibility of energy and nitrogen. This greater efficiency of the obese pigs in the storage of energy as fat is reflected in greater adipocyte size and greater capacity of the adipose tissue (*in vitro*) to metabolize glucose either by oxidation to CO_2 or by incorporation into lipids when fed *ad libitum* or diet restricted (Mersmann and Koong, 1984).

The adoption of *Commelina benghalensis* as a supplement in Mukota pig diets increased N intake and N retained. Similar results have been reported for trials with alternative feed resources for pigs in the tropics, Halimani *et al.* (2005; 2007) (legume leaves), Chimonyo and Dzama (2007) (maize cobs), Amaefule *et al.* (2006) (brewers' grains) and Hang (1998) (cassava leaves).

The addition of *C. benghalensis* had 31.44% improvement in nitrogen retention to the diet with 25% allowance. The overall diet was then equivalent to 56.44% allowance. Efficiencies of utilisation for bulky feed materials are generally lower due to the increased heat loss by heat of fermentation and energy used for work of digestion (McDonald *et al.*, 1995).

Since it is the accretion of lean tissue which makes the greatest contribution to overall growth it is thus important to predict the effect of the level of feed intake on the rate of tissue accretion not just weight gain. Carcass characteristics could have been evaluated to get the amount of lean tissue and fat tissue accrued in the period as this study does not agree with other trials where energy was lowered for example Kyriazakis and Emmans, (1992a, b) and Weis *et al.*, (2004).

Kyriazakis and Emmans (1992 a,b) and Weis *et al.* (2004) suggested that pigs become fatter when they eat more or when they grow heavier, even if energy intake is insufficient to maximize protein deposition or lean tissue growth. The latter has been represented mathematically in various pig growth models (Black *et al.*, 1986; NRC, 1998). Studies which seem to agree with findings of this study have been criticised by Weis *et al.*, (2004) as being inconclusive examples being, Rao and McCracken (1992) who reported no effects of energy intake on the empty-body lipid content. These apparent discrepancies can be attributed to the duration of the experiments because energy intake effects on body lipid are observed only after pigs are exposed to different energy intake levels for extended periods of time (Weis *et al.*, 2004).

Increases in body lipid content with BW in pigs on typical feed intake schemes (de Greef *et al.*, 1994; Bikker *et al.*, 1995; 1996) largely reflects increases in energy intake and since Mukota pigs are genetically obese pigs the body lipid content could have been measured to evaluate the effect of lowering energy on protein and fat accretion.

While most previous studies used isonitrogenous and isocaloric diets with the unconventional feed resource supplemented or substituting part or all of a conventional feed resource (Halimani *et al.*, 2005; Chimonyo and Dzama, 2007; Amaefule *et al.*, 2006; Stanogias and Pearce, 1985; Hang, 1998), the present trial used graded levels of energy with the intention of evaluating their effect on animal performance. In all of these trials the N intake was not biologically important and thus did not have an effect on the nitrogen utilisation of the animal. The unconventional feed resource was used as a supplement of the diet with the lowest dietary allowances of energy and protein this was to evaluate its importance in the development of a low quality but efficient diet that can be utilised by small scale farmers.

3.5 Conclusion

Feeding graded allowances of energy and the inclusion of *Commelina benghalensis* to growing Mukota pig diets has no effect on their performance but an effect on nitrogen balance improving both nitrogen retention and nitrogen digestibility. However there is need to develop isonitrogenous and isocaloric experimental diets including *Commelina benghalensis* supplying a key nutrient, energy or protein, at graded levels to detect its optimum range of inclusion. The plant has a high biomass yield especially in the wet season which means there is scope for its harvest and preservation as silage due to it high moisture content. It is therefore, possible to feed Mukota pigs a diet that has nutrient levels below the recommended NRC daily allowances without deleterious effects on animal performance.

CHAPTER 4

4 EXPERIMENT 2: THE EFFECT OF SUPPLEMENTING WITH A COMMERCIAL PIG DIET ON THE GROWTH PERFORMANCE OF MUKOTA PIGS UNDER FARM ENVIRONMENTS

Abstract

The objective of this study was to evaluate the effect of supplementation of growing Mukota pigs with a commercial growers' diet on-farm. Ten farmers supplemented their animals with a commercial growers' diet at 300g per pig per day while a further three acted as controls. All groups of animals were allowed to forage freely for the duration of the trial. The supplemented animals tended (P>0.05) to have improved rate of weight gains than the control. There was a decline in the rate of gain in the rainy season due to the penning of the animals leading to a decline in the supply of feed. The study showed that supplementation of growing pigs in rural production systems is feasible and leads to improvement of the performance of the animals.

4.1 Introduction

Farmers under communal production systems are plagued by perennial feed shortages and the challenge of maintaining their animal's condition and performance is intense especially in the dry seasons. Pig production plays an important role in the farming activities especially for small-holders. The pigs provide manure, meat and income. According to Hang (1998), the income from pig rising is very low and in some cases is negative because the pigs grow slowly and the cost of feeds is high. This might be due to the limited availability of feed resources in the dry and arid areas of Zimbabwe where the majority of the Mukota pigs are raised. Farmers do not afford to practise intensive pig production but provide all the feed needed in this production system so almost all the pigs are raised on free range with little or no supplementation. This is one of the reasons why intensification of pig production has consistently failed in African smallholder farming communities (Lekule and Kyvsgaard, 2003). Thus, there is a need to evaluate the effect of supplying some of the nutrients in a dietary supplement without disrupting the production system.

4.2 Objective

The objective of this trial was to test the effect of supplementation of diets fed by communal farmers with a commercial diet.

4.3 Material and methods

4.3.1 Study Site

The study was conducted with thirteen communal farmers from Chirumanzu Communal Area where pilot studies had been undertaken (Chikwanha *et al.,* 2007; Chiduwa *et al.,* 2008). The area is about 1300 and 1440 m above sea level, is in natural region three with an average annual temperature of 35-39°C and average annual rainfall of 450- 600mm; this can be termed a dry area with the dominating vegetation comprising of acacia trees.

4.3.2 Diets

Treatment 1 was a commercial pig grower diet with 16.5% CP and 11.56 MJ/kg ME (Table 3.3) supplemented at 300 g/day per pig to the diets that the communal farmers were giving which comprised mainly of kitchen waste, crop processing by-products.and weeds gathered from the fields.

Treatment 2 was the control which was no supplementation; the pigs were on the diet given by the farmers which comprised mainly of kitchen waste and other by products such as cereal brans, brewers' grains and weeds removed from the fields. Both groups were allowed to forage freely.

4.3.3 Animals and management

Farmers with at least two weaners were selected for the trial and these weaners were used in the performance trial. A total of thirteen farmers were selected from Ward 7 of Chirumanzu district of which three were controls. The pigs were housed in pens mainly made of rock walls and poles. The farmers gave a daily allocation of 300g of commercial feed per animal per day before releasing the animals for scavenging. This was designed to reduce disruptions in the production system. Animals in the control group did not receive any commercial feed supplementation.

4.3.4 Experimental design

Thirty six pigs were selected for use in the experiment in a nested design (animal nested in farmer and farmer nested in diet). Diet allocation was random with ten farms allocated diet 1; three farms were used as controls. The trial was run for 14 weeks with fortnightly measurements of body weight taken in the morning before feeding.

4.3.5 Measurements

Fortnightly weights were measured with a Salter ® hanging scale, the study lasted for 14 weeks from late October to early January which is the rainy season in the area.

4.3.6 Statistical analysis

All data was analysed using the GLM procedure of SAS (2000) according to the following model:

$$\mathbf{Y_{ijkl} = \mu + \beta_1 (inwt) + A_i + B_j + C_k + (Ai \times C_k) + E_{ijkl};}$$

Where:

Y_{ijk} = Response variable (Weight gain);

μ = Overall mean common to all observations;

β_1(inwt) = linear regression coefficient of initial weight on Y_{ijkl};

A_i = Effect of the i^{th} diet;

B_j = Effect of j^{th} animal nested in household farm;

C_k = effect of the k^{th} week;

(Ai X C_k) = interaction between diet and week;

E_{ijk} = residual error distributed as N (0, $I\sigma^2_E$).

Growth rate was analysed using the PROC MIXED procedure of SAS (2000) for repeated measures.

4.4 Results

4.4.1 Body weight gain

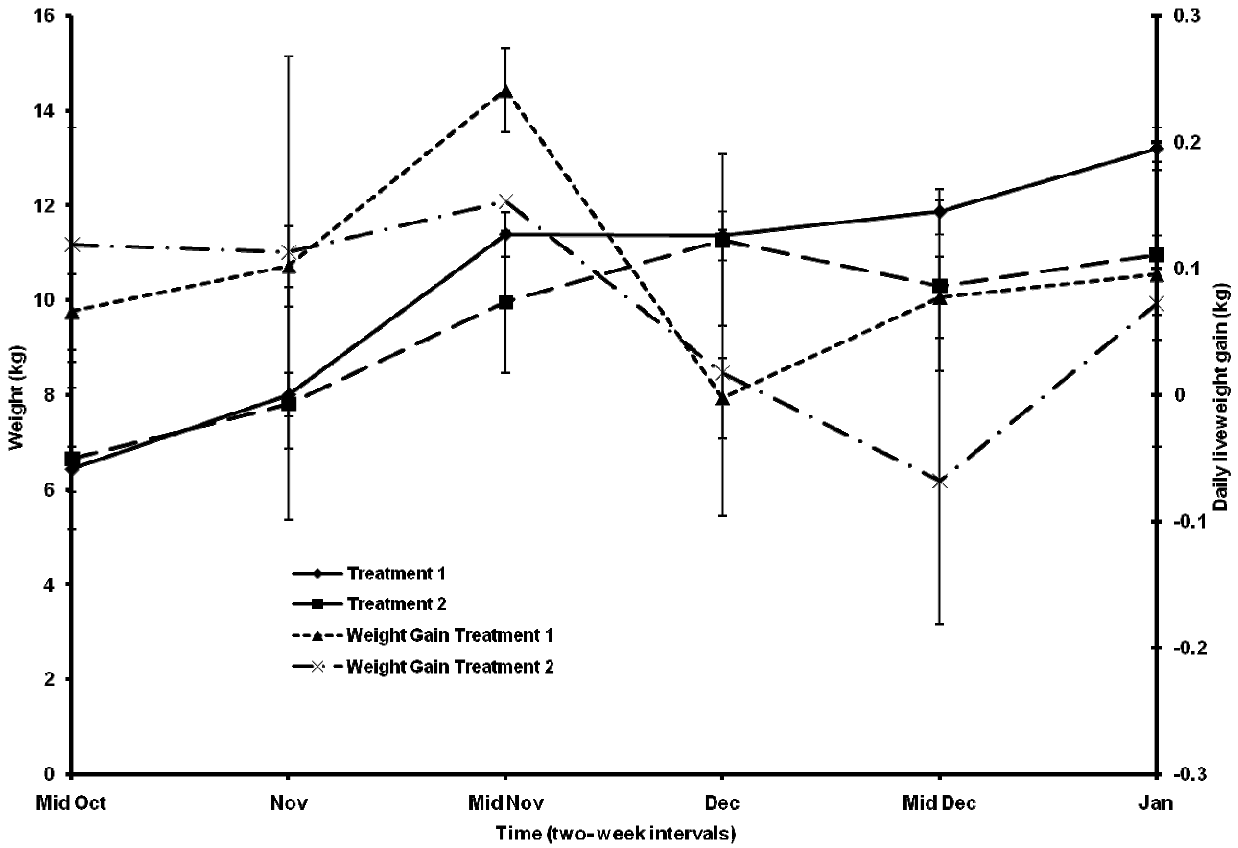
There was a general increase in live weight from an average of 6.4 kg to an average of 13.2 kg at the end of the trial period for animals in treatment 1 (Figure 4.1) however for animals in treatment 2 the live weight started off at approximately 6.7 kg and increased steadily up to an average of 11.3 kg and dropped to 11 kg at the end of the trial.

Treatment 1 reached the peak weight of 13.2kg at the end of the trial while treatment 2 reached peak weight of 11.26kg in early December then to drop to a final weight of 10.95kg in early January at end of trial. From Early December to end of trial animals in treatment 1 showed a continued rise in weight while animals in treatment 2 showed a general decline in weight. The initial weight had an effect ($P<0.0001$) on weight gain and rate of gain.

4.4.2 Daily Live Weight gains

Animals in treatment 1 started off daily with weight gains of 0.07 kg/ day and increased sharply to a peak of 0.24 kg/day in mid November, during the same period, animals in treatment 2 showed a gradual increase in daily weight gain from 0.12kg/day to 0.15kg/day. Both treatments showed reduced daily weight gains from Mid November to early December, with animals in treatment 1 recording a negative daily weight gain of -0.0026kg/day. In the following period from early December to early January animals in treatment 1 showed increased rates of daily weight gain to, however animals in treatment 2 (control) continued to show a drop in the rate of weight gain till Mid December where it then increased thereafter.

Figure 4.1 Effect of supplementing with a moderate amount of commercial ration on body weight gain in indigenous pigs



Treatment 1 is the communal diets supplemented with 300g of commercial growers' diet and treatment 2 is the control.

4.5 Discussion

The supplementing of foraging animals with a minimal amount of a conventional pig growers diet had a positive effect on the performance of Mukota pigs in Chirumanzu. This is because feed supplies are very low in this area as is the case with many smallholder farming areas and farmers cannot afford to buy feed for their animals (Kanengoni *et al.,* 2002). In Chirumanzu the majority of pig owners, being women, reported having acquired their stock through assisting other women in feeding their pigs, stressing the scarcity and importance of feed in the area (Chiduwa *et al.*, 2008). In Chirumanzu district, as in many other rural areas of Southern Africa, pigs scavenge for feed during the dry season and are confined during the rainy season to prevent them from destroying crops (Chikwanha, 2006, Mashatise *et al.*, 2005). This has a bearing on their performance in the dry and rainy season with the commonly held view that pigs get adequate nutrients during the rainy season (Chikwanha *et al.*, 2007) not applying in this situation

There was a general increase in live-weight as the trial progressed for both treatments as shown in Figure 4.1; this was because the animals were still growing, however the supplemented animals had a higher live-weight throughout the trial as compared to the control group which had started the trial at a slightly higher live weight.

The control group started with higher weight gains at the start of the trial, this can be attributed to a higher efficiency of utilisation and a heavier weight Weis *et al.*, (2004). Pigs with higher body weights will consume more feed than pigs with a lower body weight and this is expressed in a linear effect on energy intake. From early to mid November the supplemented group had increased rate of gains and peaked during this period. This period is also marked with a correlated increase in gains, although lower, in the un-supplemented group as this is the end of the dry season and beer brewing is at its peak in the area. At this time households brewing beer can produce an estimated 25 kg of brewers' grain which is a valuable feed source for pigs (Chikwanha *et al.*, 2007). The high nutritive value of brewers' grain, high protein, makes it an appropriate feed resource for farmers and will also reduce the competition for cereals between humans and pigs.

Mid November marked the start of the rainy season and the start of planting in the area. In this period the animals are penned to stop them ploughing in the planted fields and fed mostly kitchen waste, brewers' grains and some forage available in the fields. The rate of gain declined sharply during this period because of the limited amount of feed available as there is no more foraging and the owners are busy in the fields leaving in most cases children to feed the animals. This in most cases means the animals can go for days without a decent amount of feed, the condition is compounded by the fact that the fields have been ploughed and there is little forage. According to Chiduwa *et al.*,(2008) most farrowing occurs in the wet season., This also puts a strain on the available feed resources and sows which have to suckle their piglets at this time.

The rate of gain increased as the rainy season progressed and the amount of forage increased so more was available to the kraaled animals but was still lower than in the drier months. The decline in body weight gains can also be attributed to the lack of a diverse diet because the confined animals are fed mostly kitchen waste, foraging encourages cafeteria feeding which according to Mpofu, (2004), gives animals the opportunity to feed on a more palatable and nutritionally useful diet. These cycles in feed supply were noted by Chikwanha *et al.* (2007) and Chiduwa *et al.*, (2008) who evaluated body condition scores (BCS) and herd dynamics of pigs in the area. Chikwanha *et al.*, (2008) reported a marked decline in BCS values for lactating sows and Boars from October to December indicating a decline in nutrient supply in these months due to the confinement. It is common practice during this period for farmers to feed their pigs only once a day but in some instances pigs can to go for days without decent feeding. Chiduwa *et al.*, (2008) also noted an increase in farrowing during the rainy period as a strain on sows in a time of limited feed supplies.

However, although there was a continual gain in body weight for the pigs under supplementation, the drop in body weight of the control group from early December to early January can also be attributed to factors mentioned above.

Farmers have been feeding their pigs some amounts of commercial feed in the area, many in an attempt to practise some form of intensive production. Their hope is to get better gains and performance from their animals, by reducing worm burden among other conditions which come with intensive production. In many cases this has failed as the cost of feed proves to be to prohibitive for most, what this study has tried to do is improve the current production system without totally changing it as most extension and research workers have tried to do. Numerous attempts have been made to make shortcuts to increased animal production by the introduction of very intensive types of animal production, particularly the adoption of temperate breeds without consideration to the nutritional and management (Preston, 1986). This was also evident in Chirumanzu here other farmers had tried to raise imported breeds such as the Large white with little success. The current study aimed at developing feeding systems that optimised the utilisation of locally available feed resources and build on traditional practices, this was according to work by Preston, (1986). Preston noted that farming systems in developing countries were difficult to change and that innovation had to be introduced gradually without inducing excessive risk which may, in the poor conditions of small farmers, directly affect the well being of the family. The supplementing of foraging with a limited amount of commercial feed proved to be of benefit and with the numbers of animals kept, affordable.

4.6 Conclusion

Supplementation of communal farmers' diets, consisting of kitchen waste, crop residues and foraging, with a commercial diet can improve the performance of growing Mukota pigs. There is need to devise a way of matching the required amount of supplementation and the performance of the animals season by season.

CHAPTER 5

5 GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The present study shows that feeding reduced levels of graded energy allowances to growing Mukota pigs has an effect on the nitrogen balance of the animals. However there was no effect on performance of the animals in terms of weight gain and FCR.

The differences in nitrogen intake could be attributed to differences in crude protein allowance of the diets. There is a linear relationship between N intake and retention, (Cole, 1985) which explains the increase in N retention with increase in daily increase in N intake. According to McDonald *et al.* (1995) there is an increase in the utilisation of ME as the feed allowance decreases which explains why there was no effect on the performance of the animals as energy is the major limiting factor to pig growth.

Growth is usually depressed by low dietary protein intake to a greater extent in the more muscular, lean pigs than in the less muscular, obese pigs, although Davey and Bereskin (1978) did not indicate such a difference. Dietary restriction by feeding alfalfa caused decreased gain in both lean and obese pigs. Studies by Mersmann and Koong, (1984) have shown that restriction of dietary intake by meal feeding reduced the gain in lean but not in obese pigs. The Mukota is a genetically obese pig explaining why the reduction in protein and energy allowances and addition of *Commelina benghalensis* at the lowest allowance had no effect on the daily gains of the animals.

Findings in this trial give hope for the adoption of *Commelina benghalensis* as a supplement in Mukota pig diets. The efficiency of utilisation of *Commelina benghalensis* is however, unknown which means its effect on the efficiency of utilisation of the whole diet is not known.

The supplementing of foraging animals with a minimal amount of a conventional pig growers diet had a positive effect on the performance of Mukota pigs in Chirumanzu. This is because feed supplies are very low in this area as is the case with many smallholder farming areas and farmers can not afford to buy feed for their animals (Kanengoni *et al.*, 2002). In Chirumanzu the majority of pig owners are women and have reported having acquired their stock through assisting other women in feeding their pigs, stressing the scarcity and importance of feed in the area (Chiduwa *et al.*, 2008). There was a general increase in live-weight as the trial progressed for both treatments; this was because the animals were still growing, however the supplemented animals had a higher live-weight throughout the trial as compared to the control group which had started the trial at a slightly higher live weight.

Attempts by the farmers to raise the local pigs in an intensive production system has failed because the cost of feed proved to be to prohibitive for most, what this study has tried to do is improve the current production system without totally changing it as most extension and research workers have tried to do (Lekule and Kyvsgaard, 2003). In Chirumanzu other farmers had tried to raise imported breeds such as the Large white with little success. The current study aimed at developing feeding systems that optimised the utilisation of locally available feed resources and build on traditional practices, this was according to work by Preston, (1986).

5.1 Conclusion and Recommendations

The study proved that feeding graded allowances of energy and the inclusion of *Commelina benghalensis* to growing Mukota pig diets has no effect on their performance but an effect on nitrogen balance improving both nitrogen retention and digestibility. However there is need to develop isonitrogenous and isocaloric experimental diets including *Commelina benghalensis* supplying a key nutrient, energy or protein, at graded levels to detect its optimum range of inclusion. The plant has a high biomass yield especially in the wet season which means there is scope for its harvest and preservation as silage due to it high moisture content.

The current study confirmed that supplementation of communal farmers' diets, consisting of kitchen waste, crop residues and foraging, with a commercial diet can improve the performance of growing Mukota pigs. There is need, however, to devise a way of matching the required amount of supplementation and the performance of the animals season by season.

This study provided baseline information on local pig production and performance under small holder production. However more research can be conducted to allow adoption of the information for commercial pig production. The following areas can be investigated:

1. Pig diets with low energy can be developed and tested on farm for their performance.
2. More research into alternative feed ingredients needs to be done to improve their utilisation in diets for local pigs.
3. Methods of preservation and storage of alternative feed resources such as making silage.

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APPENDICES

Appendix 1 ANOVA tables for the statistical analyses carried out

ANOVA table showing the effects of week and treatment on the weight of pigs

	R-Square	C.V.	Root MSE	WEIGHT Mean	
	0.631061	65.12719	1.70416	2.61667	

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	16.87847	5.626157	1.94	0.2418
PIG	3	5.545139	1.84838	0.64	0.6231
TREAT	3	2.972222	0.990741	0.34	0.7974

ANOVA table showing the effects of week and treatment on the feed intake of pigs

	R-Square	C.V.	Root MSE	INTAKE Mean
	0.946513	16.35435	1.09644	6.70429

Source	DF	Type III	Mean	F Value	Pr> F

		SS	Square		
WEEK	3	11.21851	3.739503	3.11	0.1268
PIG	3	4.216238	1.405413	1.17	0.4087
TREAT	3	69.67195	23.22398	19.32	0.0035

ANOVA table showing the effects of week and treatment on the nitrogen retention of pigs

R-Square	C.V.	Root MSE	RETAIN Mean
0.621499	81.29262	7.33858	9.02736

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	290.2904	96.76346	1.8	0.1564
PIG	3	1685.339	561.7795	10.43	0.0001
TREAT	3	3605.262	1201.754	22.31	0.0001

ANOVA table showing the effects of week and treatment on the nitrogen intake of pigs

R-Square	C.V.	Root MSE	NINTAKE Mean
0.739997	17.65145	5.81237	32.9286

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	390.841	130.2803	3.86	0.0132
PIG	3	576.7869	192.2623	5.69	0.0016
TREAT	3	5206.742	1735.581	51.37	0.0001

ANOVA table showing the effects of week and treatment on the nitrogen loss in pigs

R-Square	C.V.	Root MSE	NLOST Mean
0.304977	25.50978	6.09714	23.9012

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	67.4438	22.48127	0.6	0.6142
PIG	3	815.6454	271.8818	7.31	0.0003
TREAT	3	217.11	72.37	1.95	0.1306

ANOVA table showing the effects of week and treatment on the nitrogen intake of pigs

R-Square	C.V.	Root MSE	INTAKE Mean

	0.894008	13.8619	210.275	1516.93	

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	469183.7	156394.6	3.54	0.0193
PIG	3	710859.7	236953.2	5.36	0.0023
TREAT	3	23245561	7748520	175.24	0.0001

ANOVA table showing the effects of week and treatment on the faecal output of pigs

R-Square	C.V.	Root MSE	OUTPUT Mean
0.342098	26.19435	192.269	734.009

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	399939.4	133313.1	3.61	0.0178
PIG	3	793814.2	264604.7	7.16	0.0003
TREAT	3	86899.36	28966.45	0.78	0.5073

ANOVA table showing the effects of week and treatment on the urine output in pigs

	R-Square	C.V.	Root MSE	URINE Mean	
	0.255835	76.60673	556.508	726.447	

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	5432307	1810769	5.85	0.0013
PIG	3	848615.4	282871.8	0.91	0.4394
TREAT	3	685078.6	228359.5	0.74	0.5335

ANOVA table showing the effects of week and treatment on the DM digestibility in pigs

	R-Square	C.V.	Root MSE	DMDIG Mean	
	0.590792	51.72583	0.21875	0.4229	

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	0.520887	0.173629	3.63	0.0173
PIG	3	0.897039	0.299013	6.25	0.0008
TREAT	3	3.131117	1.043706	21.81	0.0001

ANOVA table showing the effects of week and treatment on the nitrogen digestion in pigs

R-Square	C.V.	Root MSE	NDIG Mean
0.385906	3.335069	0.03033	0.90944

Source	DF	Type III SS	Mean Square	F Value	Pr> F
WEEK	3	0.004772	0.001591	1.73	0.1695
PIG	3	0.005823	0.001941	2.11	0.1073
TREAT	3	0.026466	0.008822	9.59	0.0001