The role forages in pig production systems in Uganda

Final report

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CHAPTER ONE: INTRODUCTION

1.1 Background to the consultancy

Recent studies in Uganda showed that access to productive assets, including all types of livestock, can provide rural households with tremendous opportunities to generate income and to move out of poverty, but also can deliver high quality protein and micro-nutrients that have the additional benefit of dramatically improving absorption of nutrients from plant-based foods. Supporting small-stock production naturally targets women with direct benefits to empowerment and infant health and nutrition; poultry and pigs are commonly owned by women, while cattle are mostly controlled by men.

The overall objective of the consultancy was to obtain an overview of the role that forages may play in pig production systems in Uganda. In this consultancy, forages were considered as grasses, legumes and all collected herbs (especially from Asteraceae or other botanical families), but not necessarily crop residues such as sweet potato vines or cassava leaves. The specific tasks of the consultancy are:

(a) Document in a desk study forages-related research and development in Uganda, emphasizing the action/study sites of the Smallholder Pig Value Chain Project (SPVCP) as well as pig feeding where ever possible.

(b) Produce an inventory of currently used forages for pig feeding in Uganda and their attributes.

(c) Review relevant scientific literature, including grey literature (e.g., unpublished project reports, university theses, among others), regarding the usefulness and effects of feeding forages to pigs, in particular

- challenges and limitations regarding pig production and reproduction,
- production system, swine management, labor, gender, costs and benefits,
- meat quality,
- effects on livelihoods or any other issue found relevant.

(d) Forage species used in pig feeding and their advantages and disadvantages.

(e) Ways of making forages more useful for pigs, like wilting, boiling, silage.

(f) Help identify researchable issues for feeding forages to pigs and derive recommendations for the forages component in the SPVCP.
(g) Compile and synthesize the information gathered on feeding forages to pigs in a concise report, part of which may be publishable.

1.2 Approach and methods employed

The above tasks were planned and accomplished using information and data from reputable national and international organizations such as National Agricultural Research Organization (NARO), Makerere University, Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), International Livestock Research Institute (ILRI), Smallholder Pig Value Chain Project (SPVC), and CIAT through discussions with scientists and review of literature published by these organizations (grey literature and journal papers) in relation to pig production. The team visited pig farmers in selected districts of Uganda. The visits were combined with other institute activities implemented in the districts. This means that no additional costs (fuel or per diem) were incurred.

CHAPTER TWO: CONSULTANCY REPORT

2.1 Livestock sector in Uganda

Agriculture is arguably the most important sector of the Ugandan economy. It contributes up to nearly 20 percent of Gross Domestic Product (GDP), accounts for 48 percent of exports (UBOS, 2009) and provides a large proportion of the raw materials for industry. The sector employs 73 percent of the population aged 10 years and older (UBOS, 2009). Agriculture will be the key determinant in the country's efforts to reduce poverty in the immediate years ahead.

Livestock and livestock products play a key role in raising incomes of households and providing a source of protein to many families. Indeed according to analysis of poverty trends using the Uganda National Household Survey time series data, households that included livestock in their enterprise mix tend to be generally less poor (UBOS, 2008). The Livestock Census (UBOS, 2009) estimates the national herd at 11.4 million cattle, 12.5 million goats, 3.4 million sheep, 3.2 million pigs and 37.5 million chickens.

2.2 Importance of the pig enterprise in livelihood improvement in Uganda

Pig production has increasingly become an important activity, especially among smallholder farmers in as evidenced by a dramatic rise in pig population from 0.19 million in 1980 to 1.7 million in 2002 and 3.2 million in 2008 (UBOS, 2009; FAOSTAT, 2011; Ouma et. al., 2013). This is linked to the rise in demand for pork due to preference changes among other factors.
Pigs are reared in all parts of Uganda and hence have a great potential to lift communities out of poverty if the hurdles to their production and marketing are removed. The Central Region has the highest number of pigs estimated to be 1.3 million (41.1%), while the Karamoja zone had the least number of pigs estimated to be 0.06 million (18.3%) (UBOS, 2009) (Table 1).
Districts of Masaka (236,150 pigs), Soroti (75,000), Pader (39,430) and Kibaale (153,510) have the highest number of pigs in the Central, Eastern, Northern and Western regions, respectively.

Table 1: Pig Ownership in Uganda

Region	Households (HHs) owning pigs, % of all HHs	HHs owning pigs, number	Mean herd size, all HHs	Mean herd size, pig-owning HHs
Uganda	17.8	1,135,130	0.5	2.8
Central	23.4	436,400	0.7	3
Eastern	16.3	262,360	0.4	2.7
Northern	9.3	105,070	0.3	3.2
Western	20.6	321,740	0.5	2.4
Karamoja zone	4.7	9,570	0.3	6.1

Source: Uganda Bureau of Statistics, Livestock Census report, 2009

The majority of pigs are kept in rural areas by smallholder farmers under extensive systems with small numbers of peri-urban small scale, semi-intensive farms and a few large modern intensive farms producing for commercial purposes (Tatwangire, 2012).

Pigs are highly cherished for their fast growth rates (reaching market weight at six months if well fed), highly prolific and have ready market regardless of production site (i.e, the rural markets for rural pigs, urban markets for rural pigs and urban markets for peri-urban pigs). In addition, pigs play a major role in recycling kitchen wastes and converting them into value protein products.

Pigs play a role in alleviation of food and nutrition security in Uganda. Of the total per capita meat consumption of 10 – 11 kg in Uganda, 3.4 kg are of pork, indicating a significant contribution to the nutrition security of Ugandans (Ouma et. al., 2013). In Uganda, it is only pig meat among other types of livestock meat products that is registering a steady increase in the level of per capita consumption and it is only second to beef in terms of production (Table 2). In fact, because of easy of slaughtering and ability to sell the entire carcass in a few hours, pork is the most consumed meat in rural areas.

Pigs play an important role in risk diversification and livelihood security of smallholder and poor households as they are important assets useful in generating income for school fees payment, purchase of farm inputs and covering emergency cash needs while the manure is used in fertilization of the crop fields. Pig farmers generate income from the sale of piglets and live adult pigs and thus a source of wealth.

Table 2: Meat production in Uganda

Type	Amount (tonnes)
Beef	96.6
Pig meat	77.4
Chicken meat	44.1
Goat meat	24.6
Sheep meat	5.3

Source: FAOSTAT | © FAO Statistics Division 2010 | 14 September 2010

Since imports and exports of meat products are negligible, this ranking also reflects the relative importance currently of pork in terms of meat consumption.

However, despite the key roles the pig enterprise plays in improving rural livelihoods, pig production is clearly not among the Uganda government priorities for development when compared to dairy and beef cattle, goats, poultry, and apiculture (Agricultural Sector Development Strategy and Investment Plan (DSIP) 2010/11 – 2014/15).

2.3 Existing pig production systems in Uganda

Production systems and management practices are dictated by the degree of dependence of the household on livestock products for income, cultural values, food supply and crop agriculture practiced in association with livestock under traditional and non-traditional practices. Pigs are kept under a range of management systems ranging free range (scavenging) to a fully confined system (intensive) depending on the location (rural or urban), land ownership, feed resource, investment ability, production goal and access to markets (Muhanguzi et al., 2012; Ouma et al., 2013). There are new trends in modern pig farming emerging though practiced at a relatively small scale by a few farmers and these include organic pig farming. Pig keeping in Uganda can be categorized based on three basic production systems, namely the: (i) intensive, (ii) semi-intensive, and (iii) extensive (small scale subsistence) production systems (Muhanguzi et al., 2012; Tatwagire, 2013).

(a) Intensive pig-production system

Pigs are kept under confinement all the time in structures of various size, shape and materials, ranging from brick and concrete to mud and wattle houses (Muhanguzi et al, 2013). Pigs are constantly provided with feeds, water, and protection from extreme weather (Mutetikka, 2009). This system is accounts for about 10% of pig production in Uganda and its complexity varies between rural and peri-urban farmers with the majority found in peri-urban areas due to increasing human population, land scarcity and need for commercial pig production (Tatwagire, 2013).

Under the rural intensive production systems, housing structures are mostly made of mud and wattle or timber and roofed with grass, with few brick – concrete and iron sheet roofed structures. This is dominated by smallholders with less than five pigs with majority of farmers using crop residues, forages and kitchen wastes as feeds. There is improved management practices compared to extensive systems under the same rural setting.

Under the peri-urban intensive production system, improved housing structures of brick and concrete are commonly used with producers being commercial oriented and keeping more pigs than under the rural intensive systems. Modern pig production practices are in place including improved breeds, hygiene and disease control. Because of the proximity to urban markets, this is a high input high output production system dependent on commercial feeds with limited or no forage use because of the limited land holdings that do not permit forage production. Under the peri-urban system, farms may be categorized as industrial (more than 500 pigs), large scale (31–500), medium scale (5–30) or small scale (less than 5) (Mutetikka et al., 2009). Majority of pig producers in Uganda are smallholders and are cherished for sustaining the pig industry in the country. However, smallholders are more challenged with parasites and diseases, poor feeding, slow growth and poor reproductive performance which result in low profits.

The intensive production systems are characterized by high demands for labour, inputs, significant amount of capital requirement and a highly functional marketing arrangement. Among the SPVCD project sites, the peri-urban intensive is most commonly practiced in peri-urban areas of Masaka district, while the rural intensive is found in all districts (Ouma et al., 2013). Because of peculiar location of majority of intensive systems in peri-urban and urban areas, the limited land holdings and the need for fast pig growth to match investment with returns, there is limited use of forages in this system. Where forages are used, they are used for the purpose of providing bulk and keeping pigs busy rather than for nutritional purposes.

(b) Semi-intensive pig-production system

In this system, pigs are partly housed and partly kept outdoors on the pasture (Mutetikka, 2009). This system is common in rural areas and peri-urban areas where producers have access to land. In rural production systems, pigs may be housed during the crop growing season to minimize crop damages and left to scavenge during harvesting time while in peri-urban areas, pigs may be allowed access to pasture for a few hours on a daily or weekly basis (Muhanguzi et al., 2012). This system provides opportunities to improve: pig feeding, growth rate, disease control, control of heat stress, enhancement of mating (*boars become active when not housed full time*), and to have better quality animals (Pezo and Waiswa, 2012). Pig farms that adopt this system also tend to invest in higher inputs (compounded feeds, agro-industrial by-products such as brewers; mash and mineral supplements), demand high amounts of labour, and enjoy relatively high farm output. This system is common in all the three SPVCD districts of Masaka, Mukono and Kamuli (Ouma et al., 2013). There is considerable use of forages in this production system, either through grass/forage collection and delivery to pig houses or through allowing pigs to pastures for some time. Because of the limited potential of producers in this system to entirely rely on commercial feeds and concentrates, the system provides an opportunity for development and utilization of forages in pig feeding.

(c) Extensive/tethered/small scale pig-production system

This system accounts for about 90% of pig production in Uganda and is associated with limited costs of investment, management and feeding (Mutetikka, 2009). Under extensive pig production systems, pigs are kept out-doors and on pasture all the time. The system involves tethering (where pigs are tied on a rope to restrict their movement), or keeping pigs on free range scavenging for food around the homestead, village or garbage collection centers. According to Pezo and Waiswa (2012), waste food and crop residues are usually provided to tethered pigs and labour input is needed to keep moving the animals from one place to another. Given the increasing human population and need to minimize crop damages under the mixed crop-livestock farming system, tethering is more common than free range. The tethering systems entails collection and delivery of food to the pigs and most crop residues (cassava leaves, sweet potato vines, peels), kitchen wastes and forages make up the bulk of the feeds. The major constraint in this system is the low quality of food and failure to provide for balanced rations in crop residues and forages.

Extensive system is often practiced in rural areas, by the very poor pig farmers, who tend to invest in a low cost and low output farming system, which characterizes subsistence production in Uganda's livestock sub-sector. The system is common in rural areas where land holdings are still big and is practiced in all rural areas in the SPVCD sites of Masaka, Kamuli and Mukono districts (Ouma et al., 2013).

There is over-reliance on crop residues, weeds and forages under the extensive production system both through collection and delivery to tethered pigs and through scavenging. Most of the farmers practicing this system mostly mind on the existence and number of pigs owned rather than the growth rate to reach market weights (low input – low output system). The large land holdings however provides an opportunity for development and improvement of forages with high nutritive value which can enhance the growth rate and profitability of pig farming in smallholder production systems that comprise the majority of pig production in the country.

2.4 Gender roles in pig production

Women and children provide the majority of labour in managing pigs under smallholder rural and peri-urban systems carrying out most of the management practices while male participation becomes more significant under the peri-urban intensive systems where medium and large scale production are common (Nanyeenya et. al., 2013; Ouma et al., 2013). It is therefore worth concluding that women and children are responsible for more than 90% of pig production in Uganda and thus development of technologies and innovations to alleviate the challenges encountered by women in children in pig production will significantly increase production.

Analysis of gender roles in daily and routine pig management activities in Uganda revealed that the bulk of day to day work in smallholder pig production systems is done by women and children who also own most of the pigs in the community (Table 3). Men's main responsibility is in buying drugs and ropes. They also contribute their labour mostly in looking for boars and castration.

Table 3: Gender roles in smallholder piggery management

Activity	Household Member involved	
	Men	**Women and children**
Cooking feeds		x
Tethering		x
Changing grazing area		x
Watering		x
Taking pigs under shades		x
Buy ropes	x	
Buy drugs	x	
Replace ropes		x
Fetch water (wallowing)		x
Look for boars	x	x
Castration	x	
Release from grazing		x
Marketing	x	x

Source: Nanyenya et al., 2013.

Decisions on selling of pigs are jointly taken and are timed to provide funds to planned expenses except in cases of emergencies. Proceeds of sales are often kept in custody of the women. According to Ochola (2013), women face many gender constraints as they participate in agricultural value chains and bridging the gender gap could therefore increase farm yields, increase total agricultural output and reduce the number of hungry people. Most of the activities performed by women are labour intensive than those performed by men and mostly rotate around provision of feed to pigs. It is therefore worth concluding that technologies and innovations for increasing feed availability in smallholder pig production systems should be on the forefront of improving pig production and reducing the burden of women and children.

One major strategy in increasing the feed resource base for pig production is increased production and utilization of high value nutritious forages. However, since women and children and mostly involved in cultivation and production, the introduction of forages should be well planned to reduce the burden of transporting over long distances and provide labour saving technologies in chopping and conservation of forages. Otherwise, if forage introduction is not coupled with labour saving technologies, the labour burden may increase for women and children leading to limited uptake of forage technologies.

2.5 Major constraints to pig production

Mutetikka et. al. (2009); Muhanguzi et. al. (2012); Nanyeenya et. al. (2013) and Tatwangire (2013) identified the following as some of the key constraints that limit the capacity of smallholder pig farmers and other value chain actors to produce and supply quality and differentiated pig products with desirable market traits. These constraints also enhance the inability of value chain actors to penetrate high value niche markets.

2.5.1 Inadequate and poor utilization of feeds

Feed remains the most important input in pig production, accounting for more than 70% of production costs in commercial systems (Kennedy, 1998; Mutettika, 2009) and is the single most important factor limiting pig production in Uganda (Muhanguzi et. al., 2012; Katongole et. al., 2012). The feed problem surfaces under differently in rural, peri-urban and urban production systems. Under peri-urban and urban production systems where farmers are dependent of concentrates, high cost of feeds, scarcity of feeds, poor quality and adulterated feeds are the major challenges (Muhanguzi et al., 2012; Katongole et al., 2012). In rural production systems that are dependent on kitchen wastes, crop residues, weeds and forages, seasonal availability, low quality and limited availability often leading to stuntedness are the major challenges.

Forage is a major feed resource in Uganda's pig feeding systems both by smallholders and commercially oriented farmers. However, the value attached to forage varies as majority of farmers using forages just to provide the bulk and keep pigs "busy", rather than utilizing the nutritional potential of forages to replace concentrates. Muhanguzi *et al*. (2012) found that more than 80% of pig farmers in Central Uganda allowed their pigs 2-5 hours of open foraging, while 24% of farmers fed their pigs on forages and grasses including *Pennisetum purpureum*, *Commelina benghalensis*, and *Bidens pilosa*. Peri-urban farmers in Uganda rate use of forages (natural and grown) low among strategies to cope with feed scarcity in pig farming (Katongole et. al., 2012), and this is mainly attributed to lack of knowledge in production and utilization of forages as well as lack of information on the role forages can play in pig production (Martens et. al., 2012). However, the increasing constraint of feed scarcity and high costs of commercial feeds make smallholder farmers more vulnerable and with limited choices to cope, hence the increased acceptability to adopt and grow forages for feeding their animals (Martens et. al., 2012; Mugerwa et. al., 2012). This therefore provides an opportunity for development of quality forages that can sustainably bridge the feed scarcity gap and increase pig production and profitability in Uganda.

2.5.2 Poor marketing systems

- The market for pig products is highly disorganized and unable to provide a win-win situation for all the players in the value chain.
- There is lack of linkage among value chain actors, including financial services providers. There is lack of efficient distribution systems for moving live pigs and pig products into mainstream markets.
- Limited access to market information and sources of vital technology. The cost of accessing inputs is high, often beyond the reach of most smallholders. Besides, most actors in the value chain don't have necessary skills; motivation to learn; value addition strategies; business skills, and reliable providers of good quality inputs and services.
- Traders offer low prices and are not always available to purchase pigs whenever contacted.
- The enterprise of pigs is not yet considered to be among major or priority10 enterprises selected for strategic investment and promotion in the country, hence the lack of targeted policy for the pig sub-sector. Nevertheless, pig production has continued to grow largely on its own, and is now a reliable instrument of poverty reduction and economic growth.

2.5.3 Limited capital for investment

- Limited access to credit and high cost of acquiring credit are major impediments for adoption of important technological and institutional innovation. The lack of finance, both short and long term, limits the ability to invest and procure and use productivity-enhancing inputs, thereby contributing to low and uncertain output.
- High transaction costs in terms of price risk and cash flow problems characterize the available markets of livestock products. And while these markets exist, they operate in a disorganized manner due to the many players in the value chain. Most of these value chain actors are quacks selling fake inputs and products to unsuspecting smallholder farmers.
- There is a low level of participation of cooperatives, associations and farmer groups. There is need for creativity when choosing a business model that can effectively organize smallholder pig producers, if they are to innovate and market good quality pork products in the country

2.5.4 Limited value addition

- Lack of widely accepted standards for pig products marketed in Uganda. This can be linked to the lack of knowledge and information among stakeholders, especially consumers.
- The failure to transform the raw foods into some form of processed, branded, easy to move products that can fetch better prices. There is need for capacity building among actors to enable the transformation of pig products in a way that takes advantage of prevailing infrastructure conditions.
- Lack of government investment in basic infrastructure such as roads, spot markets, and abattoirs. There is limited ability to transform the raw pork into some form of well processed, branded, and well packaged pork that can fetch better prices.
- Low desire to demand high quality pig products by consumers and for the pig producers' to maintain high grades and standards of pig products.

2.5.5 Parasites and diseases

The main challenging disease and risk to pig farming is African swine fever (ASF). This causes 100% loss of pigs on farms once it breaks out. ASF has no vaccine and treatment; it is only prevented by proper implementation of bio security measures. In developed countries quarantines are imposed on regions facing ASF outbreak and sometimes follows elimination by killing of all suspected pigs in the region. In Uganda, it usually takes some time for the responsible authorities to identify an outbreak in a given area. Even though identified and quarantines imposed, they are not implemented.

2.5.6 Poor breeds

- Majority of smallholder farmers still keep indigenous pig breeds which are characterized by low growth rates and small body size. However the use of crossbred and exotic animals has increased in the last 10 years.
- The main limiting factors for not using exotic and crossbreds are: costs of animals, susceptibility to diseases and the need for feeds to match higher nutrient demands as well as investment to provide appropriate housing facilities

2.6 Economic analysis of pig production in Uganda

A review of literature on pig production in Uganda shows that not much has been done to assess the profitability of pig enterprises under different production systems. There have been efforts to conduct economic analysis for intensive, commercial pig production systems especially in peri-urban areas (Table 4) but there are limited efforts for semi-intensive and extensive systems practiced by smallholders in rural areas.

2.6.1 Economic analysis for intensive peri-urban production system

Table 4: Budget for a 5-Sow pig unit

Budget for a 5 Sow pig unit									
					Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	Expenditure (A)	**Unit**	**Qty**	**Unit cost (‘000)**	**Value (‘000)**	**Value (‘000)**	**Value (‘000)**	**Value (‘000)**	**Value (‘000)**
1	**Building**								
	Stones	Trip	1	30	30				
	Sand	Trip	1	30	30				
	Cement	Bags	7	25	175				
	water				20				
	Timber off cuts	Pcs	60	4	240				
	Treated poles	Pcs	20	10	200				

	Iron sheets	Pcs	10	20	200				
	Nails				10				
	Labour				100				
	Sub total				1,005				
2	**Foundation stock**								
	Sow	No.	5	250	1,250				
	Sub total				1,250				
3	**Feeding 1 pig for 1 year**								
	Bran								
	Protein supplement	Kg	570	0.5	285				
	Vitamin supplement	Kg	190	0.4	76				
	Transport				100				
	Sub total				461				
4	**Feeding 5 pigs for 1 year**				2,305	2,305	2,305	2,305	2,305
5	**Veterinary costs**								
	Dewormer	Mls	100	0.5	50				
	Iron supplement	Mls	100	0.3	30				
	Antibiotics	Mls	100	0.2	20				
	Transport				10				
	Sub total				110	110	110	110	110
	Total expenses(A1)				5,670	2,415	2,415	2,415	2,415
6	**Labour for husbandry**	Mandays	1	100	1,200	1,200	1,200	1,200	1,200
	Total expenses (A 2)				**6,870**	**3,615**	**3,615**	**3,615**	**3,615**
	REVENUE (B)								
	Piglets		80	150	12,000	12,000	12,000	12,000	12,000
	Manure				150	150	150	150	150
	Culling								
	Sows		5	150					750
	Boars		1	200					200
	Total revenue				12,150	12,150	12,150	12,150	13,100
	EXPECTED PROFIT (B-A1)				**6,480**	**9,735**	**9,735**	**9,735**	**10,685**
	EXPECTED PROFIT (B-A2)				**5,280**	**8,534**	**8,535**	**8,535**	**9,485**

Assumptions: a mature breeding pig consumes 800 kg of a complete diet every year, breeding stock is sold off at the end of the fifth year. Expected profit (B-A1)= where labour is given zero value 2: Expected profit (B-A2)= where labour is valued at Ushs 100,000 per month: I USD = 2500 Ushs.
Source: (Mutetikka, 2009).

2.6.2 Economic analysis for rural piggery production systems

In a study conducted to assess the factors limiting the profitability of smallholder pig production in Kyabigambire sub-county, Hoima District, Uganda (Kabanda, 2011) it was found out that pigs are reared for eleven (11) months to reach slaughter weight of about 60 kgs live weight. Smallholder farmers were on average selling three porkers per year at 160,000 Ushs each and making a profit of about 400,000 Ushs (about USD 152) from the three pigs. Only cost of piglet (30,000 Ushs each) and drugs (about 10,000 especially dewormers) were offset from the revenue since home grown feeds, crop residues and kitchen wastes are used and labour provided by family members hence not valued by farmers.

On the other smallholder farmers who were keeping about four breeding sows to sell piglets to other farmers to raise porkers were making annual profits of 1,800,000 Ushs (about USD 720). Because of the need to keep breeding sows healthy and produce healthy piglets, farmers in breeding enterprise incur more costs in feed and medication compared to those producing porkers.

The major difference in profitability of breeding stock in peri-urban and rural production systems is in the price of piglets due to the breeds kept. Breeders in peri-urban areas keep fast growing pig breeds which fetch premium price (150,000 Ushs/piglet) compared to 30,000 Ushs/piglet for local breeds and crosses in rural areas.

The major factors identified in the study as limiting the profitability of smallholder pig farming were price fluctuation for porkers, lack of collective marketing, inadequate market information, poor market infrastructures, poor breeds and poor feeding systems. Since majority of smallholders were using home grown, crop residues, weeds, forages and kitchen wastes as pig feeds, there is need to develop and disseminate forages with high nutritive values that can improve the growth rate of pigs to increase the profits.

2.7 Common feed resources for pigs in Uganda

Low quality and limited availability of feed resources to maintain high level of pig growth and reproductive performance rate is one of the greatest limitations to pig production in

Uganda (Mutetikka et. al., 2009). A variety of feed stuffs exist to pig producers, ranging from commercial concentrates, agro industrial by products, home grown and wild forages (Tables 5 and 6). However, their utilization by farmers is largely dependent on cost, availability, knowledge in utilization and performance of animals. There is however paucity of information regarding utilization of forages in Uganda's piggery industry especially concerning nutritive values, processing, performance of animals and profitability as compared to commercial feeds (Mutetika, 2009).

Table 5: Common feed stuffs used in pig production in Uganda and their characteristics

Feed	Positive characteristics	Negative characteristics
Cassava - Meal	• Good energy source	• Very low minerals • Very low protein – 1% • Cyanide in tubers
Cassava - leaves	• Good protein – 21% • Rich in lysine • Good minerals	• Low sulphur aminoacids • Cyanogenic compounds • High fiber
Sweet Potato – meal	• Energy high	• Protein low • Low in sulphur aminoacids • Low Lysine • Trypsin inhibitor
Sweet Potato – leaves	• Good minerals • Good protein – 20% • Silage good for sows	• High fibre content (50%) • Highly degradable causing loose stool
Maize bran	• Low in protein	• High in fiber
Rice bran	• Low in protein	• High in fiber
Wheat bran	• Good protein, fat and fiber content	• Poor amino acid balance
Swill (from kitchen and restaurant wastes)	• Good protein and energy content	• Highly contaminated with pathogens including the risk of swine fever
Biogas Slurry	• Cheap	• Nutritional value not known • May be source of pathogens
Brewers waste	• Rich in proteins and energy	• May contain high salt • High in fiber • Difficult to handle (transport and storage)
Ground nuts	• Good fat 2x soya • Good energy • Good protein	• Low in methionine, lysine and tryptophan • Has tannins
Beans	• High protein 20% • Good lysine	• Low B vitamins • Has Trypsin inhibitors, Tannins

Feed	Positive characteristics	Negative characteristics
		and Haemaglutinins
Fish meal - Mukene	• High in protein, calcium, phosphorus, Lysine and source of energy • Very palatable	• May have high salt levels
Blood meal	• Rich in leucine • Rich in lysine	• Low in isoleucine
Greens – Amarathus, Cabbage, napier, lablab, mucuna, calliandra,	• High in water content • Good in vitamin C and A • Available and low cost	• High in fiber • Low in protein
Sunflower – meal	• Good protein • Good energy	• Poor lysine and tryptophan
Sunflower – leaves	• High in energy • Medium protein	• High fiber 17%
Banana	• Rich in potassium, Good B6, and Ascorbic acid	• Low protein and poor minerals
Banana silage	• Made in 4 days and lasts 6 months • Can replace 50% of grain	

Source: Mutetikka (2009)and Nelson and Carr (2008)

Table 6: Forages fed to pigs by smallholder farmers in SPVCP sites of Masaka, Mukono, and Kamuli Districts of Uganda and their attributes

Forage	Part used	Attributes
Cultivated forages		
Napier grass- *Pennisetum purpureum*	leaf and stem	• High biomass yield, easy to harvest and feed • Hairs on leaf itch during harvesting and carrying • Very palatable to pigs • Low *<11%) crude protein and high fiber
Brachiaria spp .	leaf and stem	• Crude protein content (10%) • Good biomass yield (29.5 tons/ha/year) in Mulato II • Easy to harvest and feed • Tolerates drought • High fiber content (33.5%) • Contains anti-nutritive factors (Saponins)
Giant Setaria	Leaf and stem	• Crude protein varies from 8 – 14% • High crude fiber (28 – 36%) • Not tolerant to drought • Contains anti-nutritive factors (Oxalates and Phytates)
Lablab (*Lablab purpureus)* cv. Rongai	leaf and stem	• Higher biomass yield than most forage legumes • Crude protein content (12%) • High crude fiber content (37.7%)

		• Not tolerant to drought • No re-growth after first harvest • Contains anti-nutritive factors (Oxalates)
Leucaena leucocephala	Leaf meal	• High crude protein content (23.3%) • Low crude fiber (19.9%) • Contains anti-nutritive factors (Polyphenolic compounds and toxic amino acids e.g Mimosine 12%)
Calliandra calothyrsus	Leaf meal	• High crude protein content (20 – 25%) • Contains high levels of condensed tannins (11%) • Low nitrogen digestibility levels (43%)
Russian Comfrey – (*Symphytum officinale)*	Leaf	• High crude protein (16%) • Perennial and grows fast after harvest giving 12 harvests a year and 40 tons/ha biomass • Higher mineral and amino acid levels than most tropical forages
Centrosema molle (syn. *C. pubescens*)	Whole plant	• High protein content (18.9%) • High crude fiber content (30.7%) • Low biomass yield
Crotalaria spp	Whole plant	• Good crude protein content (14.3%) • Very high crude fiber content (37.5%) • Good in soil fertility improvement • Not common
Mucuna pruriens	Whole plant	• High crude protein content (32.4%) • High crude fiber (30 – 40%) • Contains anti-nutritional factors
Neonotonia wightii	Whole plant	• Have good protein content • Contains anti-nutritive factors (Lectins)
Weed spp	**Part used**	**Attributes**
Amaranthus (different species)	leaf and stem	• Low crude protein (8%), • Low crude fiber (11.7%) • Contains anti-nutritional factors (Lectins and Saponins)
Wandering Jew (*Commelina benghalensis)*	leaf and stem	• Low crude protein (8%) • Low crude fiber (13.7%) • Reported to cause diarrhea in young pigs
Galinsoga parviflora	leaf and stem	• Very low crude protein (4%) -
Euphorbia heterophylla	leaf and stem	• High crude protein (27.9%) • Low crude fiber (17.1%) • Common in rain season
Black Jack –(*Bidens pilosa)*	leaf and stem	• Very low crude protein (3.8%) • High beta carotene content • High saponin content

Source: List of forages generated from farmer interviews. Nutritive attributes obtained from literature

2.8 Forages-related research and development in Uganda

Forage research and development in Uganda started in early 1900's with descriptive studies that led to the introduction, agronomic and nutritive evaluation and recommendation of forages for establishment in specific agro-ecological and farming systems of Uganda (Horrell, 1958; Ogwang, 1974; Ochodomuge, 1978; Sabiiti et. al.,1987; Byenkya, 1989; Sabiiti and Mugerwa, 1989; Sabiiti, 1990; Kabirizi, 1996). Prior to 1940's, forages were known as grass that could be used for grazing by ruminants or fallowing of land to regain fertility. However, following the introduction of pastures for evaluation and in 1906, and assessment studies, sparked the regarding of pasture as a true crop (Sabiiti and Mugerwa, 1990).

Experimental stations for pasture studies in Uganda were first established in 1912 at the Botanical Gardens in Entebbe followed by Bukalasa Agricultural College (1920); Serere Research Station in Eastern Uganda (1922); Makerere University Faculty of Agriculture (1922); Kawanda Research Station (1937); Animal Health Research Centre (1939); and the National Agricultural Research Organization (1992) (Byenkya, 1989; Byenkya et. al., 2012). To-date, a number of national and international research and development organizations are involved in the introduction, evaluation and dissemination of forages in Uganda with the leading institutions being the National Livestock Resources Research Institute (NaLIRRI) under the National Agricultural Research Organization (NARO), and Makerere University. Following the establishment of forage research stations, detailed investigative research work was conducted (Table 6) which was however interrupted by political instability and resumed in late 1980's.

Until up to 1947, grass in Uganda was typically used for resting land in the crop rotation system or shifting cultivation (Sabiiti and Mugerwa, 1988). Emphasis was laid on soil conservation rather than grazing as this was considered detrimental to the soil fertility and subsequent crop production. Fortunately, Kerkham (1947) found that the grazing of the "resting" land was beneficial. Later on Stobbs (1967) and (1969) and Stephens (1967) confirmed Kerkham's findings. Their data created a new awareness about pasture research that could be considered as a "true crop".

Table 7: Pasture research and development in Uganda

Year	Event
1906	Introduction of legume species primarily for vegetative cover and soil conservation (Sabiiti et. al., 1987)
1920	Establishment of specialized pasture experimental station in Serere Research Station (Stobbs, 1967)
1925	A collection of pasture grasses started by Maitland near Kampala
1930	Selected species from the 1925 planting were established in larger plots at Bukalasa Agricultural college for general observation on grazing and feeding
1931	Grass collections were started at Ngetta (Lira District) and later at Serere Research Station
1932	Continuous cultivation of arable crops even with green manures was shown to result in decreased crop yields compared to crop yields under shifting cultivation
1933	All government farms in Uganda changed their crop rotations to include a two – to four-year planted grass rest phase. This policy gave the first real impetus to research investigations with the local grasses.
1945	*Stylosanthes gracilis* was introduced in Uganda from Australia by Thomas and planted at Kawanda and later at Serere
1948	*Chloris gayana* was recommended as the best overall grass species for grazed temporary ley throughout most of Uganda. In some areas, elephant grass (*Pennisetum purpureum*) was also commonly used for the temporary ley phase but it proved difficult to eradicate from cropland. It required vegetative planting and it was better adapted as fodder crop than for direct grazing
1954	Detailed systematic work on grass and grass-legume mixtures was initiated at Serere by Horrell (1958).
1956 – 1958	Introduction of legume species for the forest area was initiated at Kawanda in addition to the earlier pasture herbarium and introductions at Kawanda by Thomas. These initial studies included over 100 different grass species, of both temperate and tropical origins and approximately 60 different tropical and temperate legumes.
1963	Horrell (1958) recommends 4 grass species for leys 2 grasses (Table 7)for dry season supplementary grazing, 2 grasses for lawns and 6 legumes in Eastern and Northern Uganda basing on experiments on persistence, production, habit, seeding ability conducted 1958 – 1963.
1963 – 1973	Experiments on use of fertilizers and incorporation of legumes on yields and persistence of grass swards and leys were conducted by Horrell and Brendon (1963), Stobbs (1969) and Olsen (1972).
	Chemical composition and nutritive value studies were conducted for a number of grass species especially *Pennisetum purpureum, Themeda triandra, Panicum maximum, Chloris gayana, Cynodon dactylon, Digitaria*

Year	Event
	spp., *Hyparrhenia* spp., *Melinis minutiflora, Setaria* spp and others (Juko and Brendon 1961; Reid *et al.*, 1973)
	Studies on forage evaluation through livestock productivity were conducted at Serere by Stobbs (1969).
1989	Recommended pasture species for *Pennisetum purpureum* zone in which the SPVC study sites of Masaka, Mukono and Kamuli District are found were *Pennisetum purpureum, Panicum maximum, Chloris gayana, Brachiaria ruziziensis* and *Setaria sphacelata* for grasses, and *Desmodium intortum, Desmodium uncinatum, Medicago sativa, Neonotonia wightii, Stylosanthes gracilis, Centrosema molle,* and *Macroptilium atropurpureum* for legumes (Byenkya, 1989).
1990 – date	Research in forage agronomy, conservation, disease control, feed formulation and animal performance (this has been mostly in dairy with no similar studies in pigs)

Although these studies provided good information regarding forage performance in Uganda and the ability for multiplication and utilization of forages, the country faced a decade of political instability that curtailed research, multiplication and dissemination of forage research findings to farmers, and this limited uptake and proper utilization of forages in animal production systems of Uganda. After the political turmoil, research on forages resumed in late 1980's (Byenkya, 1989; Sabiiti and Mugerwa, 1990). Introduction of new forage species with particular traits (such as drought tolerance, high biomass yield and disease tolerance), participatory evaluation with farmers, pest and disease control, forage conservation and animal performance commenced from 1990 (Kabirizi, 1996; Kabirizi, 2006; Mugerwa et al., 2012).

2.9 The potential of forages in pig feeding in Uganda

Despite the existence and good performance of many forage species in different parts of Uganda, there is limited research regarding utilization of forages in pig feeding systems in Uganda. Most of the research on pigs in Uganda is basically on socio-economic studies, health aspects, breeding and breed comparisons. Research on nutrition aspects is only on feed formulation using agro-industrial by products and the effect of formulated feed on growth rates, meat quality and economic benefits. There were three Masters' thesis obtained in Makerere University Animal Science Department with research topics on pigs. Two theses were concerning the effects of graded levels of different cereal brans and brewers waste on growth and meat quality and one was on efficiency of artificial insemination in pigs.

Discussion with Lecturers in the Department showed that there has never been any research conducted in the University concerning the roles, inclusion levels, and effects of using forages on performance, growth rate and meat quality.

There is generally limited research on pigs in Uganda on all aspects and there is a very wide research gap in use of forages in pig feeding and their effects on growth, meat quality and economic returns. However, the new trend of pig production (organic pig production), high costs of commercial feeds are pushing farmers to increase the levels of forages in pig diets although without prior scientific knowledge on optimum inclusion levels. Because of lack of research on forages in pig production in Uganda, literature search from other countries was used to inform and develop conclusions and recommendations on the future of forage research and utilization for pigs in Uganda.

2.9.1 Historical use of forages in pig production

The need for efforts in increasing the utilization of forages in pig production to competitively increase production was documented in first half of the 20th Century (Carroll, 1936). First attempts to describe use of forages in pig production stressed that forages should be leafy, tender, high in protein and have little fiber (Carroll, 1936). Probably, there was limited research on the inclusion levels and effects of dietary fiber, energy and crude protein on the physiology, performance and carcass quality of pigs (Bowden and Clarke, 1963; Pond, 1987). As such, early utilization of forages in pig production was mostly to provide bulk and appease the animal rather than exploiting their ability to replace concentrates and increase economic gains. Benefits of use of forages in pig production were first demonstrated in gestating sows with limitations in growing pigs (Carroll, 1936; Pickett *et al*., 1965; Phengsavanh *et. al*., 2010; Leterme et al., 2010; Fortina et. al., 2011).

Studies conducted in the UK (Jones, 2013; Stocks, 2013), USA (Baird et al., 2007) and Thailand (Jamikorn et al., 2007), however demonstrated benefits of forage feeding to all stages in swine production with reasonable performance at up to 100% replacement of grains with good quality forage. These studies were conducted on native breeds in each country apart from Thailand where crosses with exotics were used. The results may therefore not directly be translated to all breeds worldwide unless specific studies are conducted to prove this as it is known that tropical pig breeds have high forage utilization potential than temperate breeds.

2.9.2 Nutritive value of forages and their potential in pig feeding

The nutritive value of forages, particularly crude protein varies widely with up to 38.8% Dry matter (DM) in the leaves of forage legumes like *Crotalaria ochroleuca* (Sarwatt *et al*., 1990). These values are comparable to those of soybean grain, although the amino acid profiles are not similar (Martens *et al*., 2012). This therefore implies that use of forages in pig feeding must be accomplished by mixing of different feed stuff/forages if pigs are to obtain the ideal protein and amino acid levels for proper growth. When using forages the fast growth rates obtained in feeding systems based on commercial concentrates may not be necessarily achieved, but farmers can obtain profits since forages are of low cost compared to commercial feeds.

The use of grains in pig feeding only exploits the glandular system of the pig's alimentary canal without exploiting the potential of pigs to utilize forage in their large intestines. Therefore, incorporation of forage in pig feeding systems leads to the complete utilization of the pig's digestive system (Stocks, 2013). Forages can be effectively used to replace 50% of grain and supplements without affecting carcass characteristics of pigs hence increasing profitability margins since forages are of low cost (Kennedy, 1998; Stocks, 2003).

The fermentation of non-starch polysaccharides in the hindgut of pigs yields short chain fatty acids and lactic acid (Knudsen and Jorgensen, 2001) generating 17% of the total digestible energy derived from the diet in growing pigs and 25% in sows (Shi and Noblet, 1993). These end-products of fermentation can supply 24 to 30% of the energy needs for growing pigs and more in sows (Rerat *et al*., 1987; Yen *et al*., 1991). These studies thus demonstrate the potential of utilizing forages in pig feeding and the need for inclusion of forages in pig diets so as to maximize energy extraction and reduce costs of production. Although these studies were conducted in Europe and America using exotic breeds, the fermentation process in all pigs may be similar with differences in end products contributed by the type and quality of forages used. There is therefore a need to understand these dynamics using indigenous breeds in Uganda and available forages used in pig feeding.

2.10 Benefits of using forages in pig feeding

The conventional pig feeding systems involved use of high quantities of cereal grains and high value protein supplements. However, the direct competition with human nutrition for such feedstuffs and their increasing costs led to reduced availability and increased costs of production. Considerable efforts in finding substitutes for grain and high value proteins led to the utilization of fibrous feeds including crop residues and pastures. Because pigs are monogastrics, they have limited capacity to utilize fibrous feedstuffs and their use has impacts on digestibility, performance, meat quality, health and reproductive performance of pigs (Zoiopoulos, 1989).

Studies conducted on benefits of feeding pigs on forages in the USA showed indicated that forages simplifies feeding, increases milk flow of the sow, increases weight gain of piglets and improves the health of piglets (Zeller, 2004). Forages also lower the feed costs, allows pigs to attain similar weight gains to grain-based feeding systems if good forages is used, lower initial and annual costs of production, and reduce animal health problems (O'meara, 2006).

Dietary fiber is known to stimulate peristalsis in monogastric animals and addition of forages to a pig diet promotes peristalsis and appeases the animal's hunger (Jamikorn *et al*., 2007). However, pigs are better digesters of hemicellulose than cellulose and hence utilization of forages in pig feeding should be targeted at early plant maturity stages before lignification (Kephart *et al*., 1990).

Allowing pigs access to good green pasture or well cured green hay is very essential in swine production since green forages have abundance of vitamins and nutrients that lack in concentrates. Sows with no access to forage farrow fewer, weak and undersized piglets compared to their counterparts with access to good pasture (Pickett *et al*., 1965). High quality forage could therefore be an economical method of meeting the nutritional needs of piglets.

2.11 Impacts of forages on meat quality

There are studies indicating the influence of paragenetic factors, such as feed quality and quantity on the quality of pig meat (Barea *et al*., 2008; Millet *et al*., 2006). High crude protein levels increase carcass leanness, while low crude protein content leads to deposition of more fat and less meat tissues in pigs and, as such, forages with high crude protein content are preferred because of resulting in less fat and more muscle (Baird *et al*., 1975; Senčić *et al*., 2011). Pigs fed high fiber diets have proportionally heavier gastro-intestinal tracts than pigs fed low fiber diets (Rijnen *et al*., 2001; Yen *et al*., 2001).

2.12 Limitations of using forage in feeding pigs

A major characteristic of feedstuffs in smallholder pig production systems is being high in energy, low in protein and high in fiber with plant material being the main source of available protein. Pig diets are nutritionally imbalanced and performance is poor (Phengsavanh *et al*., 2010). Forages have high dietary fiber content, which greatly influences voluntary intake by pigs. Because of the low energy value of forages due to lower digestibility of dietary fiber, it becomes difficult for pigs to obtain their energy requirements from forages due to gut limitations (Close, 1993).

Different forages contain complex toxic and inhibitory factors, which affect their utilization by different animal species. Lectins found in *Glycine max*, *Amaranthus cruentus* (Grant, 1989; Makkar, 2007); polyphenolic compounds such as tannins found in shrub legumes (Jeroch *et al*., 1993; Cannas, 2008); saponins found in *Brachiaria decumbens, B. brizantha, Amaranthus hypochondriacus* (Cheeke and Carlsson, 1978; Brum *et al*., 2009); cyanogenic glycosides in *Phaseolus* and *Psophocarpus*, alkaloids in lupins (Acamovic *et al*., 2004); Phytates and oxalates in *Vigna unguiculata, Desmodium velutinum, Lablab purpureus* and *Setaria* (Weiss, 2009; Rahman *et al*., 2011) are among the common compounds that limit the effective utilization of forages in pig feeding as they often cause digestive and health disorders and may cause death.

2.13 Improving the nutritional value of forages for utilization in pig feeding

Because of the naturally occurring complex compounds in forages and because the pig's digestive system is not designed to depend entirely on forages, efficient utilization of forages in pig diets should be preceded by processing to enhance palatability, digestion, avoid toxicity and increase animal performance (Akande e al., 2010). Several processing methods can be employed depending on skills, labour, cost and other requirements, and the anti-nutritional factor to be reduced.

2.13.1 Heat treatment

Processing may be accomplished through boiling, sun drying or oven drying to reduce the content of heat labile anti-nutritive factors like cyanides and protein inhibitors. Drying of forages is known to reduce the volume and increase dry matter intake to more than double in pigs provided with adequate quantities of water (Leterme *et al*., 2010).

2.13.2 Grinding/milling

Grinding forages is important in reducing selectivity, mixing with other feed stuffs and reduces the volume of feed. Grinding also exposes plant cells for faster action of enzymes on the material once ingested (Mosenthim and Sauer, 2011).

2.13.3 Pelleting

Voluntary intake and utilization of feed is strongly influenced by texture. Pellets are more preferred by weaned pigs compared to meal (Laitat *et al*., 2000; 2004).

2.13.4 Chemical treatment

Treating forages with chemicals such as acetic acid and sodium hydroxide is known to increase the rate of nitrogen retention in pigs and hence improving performance (Echeverria *et al*., 2002). However, environmental concerns may override the use of chemicals like sodium hydroxide.

2.13.5 Fermentation

Ensiling forage is a good practice that not only enables conservation but also has advantages that enhance digestibility and reducing anti-nutritive factors through fermentation (Granito *et al.*, 2002). Lactic acid fermentation is known to reduce trypsin and α-amylase inhibitor activity and tannins (Azeke *et al.*, 2005; Reyes-Moreno *et al.*, 2004), reduces cyanogenic glycosides, alpha-galactosides and hydrogen cyanide (Borin *et al.*, 2005). However, good management of the ensiling process is necessary to avoid losses of lysine and tryptophane (Blandino *et al.*, 2003), or even benefit from increased lysine content (Gerez *et al.*, 2006). To date, there is information suggesting that pigs can thrive well on forages with good economic benefits to the farmers (Stocks, 2013).

Although silages have not enjoyed widespread usage in pig feeding, studies have shown that silage is a good source feed of pigs (Pickett et al., 1965; Stocks, 2013). When ensiling, there is need to get a proper mix of grass and legume forages so as to balance the energy and protein levels in the feed, but may still be necessary to supplement with vitamins and minerals and other feeds if silage is used (Pickett et al., 1965).

2.14 Advances in fodder solutions for improved pig production

Nalongo, a farmer in Katabi sub-county, Wakiso district has acquired a hydroponic system as a growing room that has been specifically developed to sprout grain and legume seeds for highly nutritious yet cost effective livestock feed. A selection of grains and legume seeds are spread onto the specialised growing trays and are watered at pre-determined intervals with overhead sprays (Figure 1).

Figure 1: *Fodder solutions system*

A set temperature is maintained inside the chamber to ensure the best growth and highest nutritional value fodder possible. Each day the farmer simply slides the feed out of the trays, rinse the tray, reseed and push the newly seeded tray into the other end. The system holds enough trays so your desired amount of feed is available every day. The sprouts grow on the Fodder solutions specially designed sprouting trays with no growing medium. **It takes six days to grow from seeding to feed out!** The farmer informed me that she feeds about 6 kg of the fodder per pig per day. The smallest unit is capable of producing over 14.5 tonnes of fresh green sprouts each year, regardless of the weather.

Fodder Solutions technology offers low operating costs and requires minimum labour. Depending on the system size, typical operation takes from only 15 to 60 minutes per day to harvest, clean and seed the Fodder Solutions system.

Conclusions and recommendations

Pigs have a greater ability to effectively utilize dietary fiber in forages because microflora in the large intestine of pigs contain all of the predominant ruminal cellulose degrading bacteria. In a world where use of cereal is becoming expensive and probably un profitable given that pork prices do not increase at the same rate as cereal prices, there is great potential for the pig industry to exploit the use of forages in meeting nutritional demands of pigs. The utilization of forages in pig production will however become attractive and increase when producers get to know the potential cost savings per unit of body weight gain. There is therefore need to conduct research in utilization of forages in pig feeding to generate information concerning inclusion levels, growth rates, and profit margins in comparisons to grain based feeding systems in Uganda. Such information is completely lacking in Uganda.

There is a large number of forages used for feeding pigs in Uganda, with good nutritional attributes but whose potential has not been exploited due to lack of nutritional characterization and knowledge on their incorporation into pig feeding. The extent of utilization of forages in feeding pigs under smallholder pig farming systems is also dependent on ecological conditions and forage production, labour and technical requirements in forage feeding systems as well as availability and cost of conventional feed resources.

Women and children provide more than 90% of the labour used in pig production and responsible for about 90% of pigs produced in Uganda. Forage development and utilization technologies should therefore be oriented at eliminating the challenges faced by women and children in collecting, preparation and management of forages. Since majority of the forages fed to pigs are gathered, with no specific establishment of fodder banks for pigs, introduction and establishment of fodder banks with high biomass yielding forages can save women and children from moving distances gathering weeds for feeding pigs.

The existence of a diversity of forages provides a challenge to smallholder farmers in selecting the best forage to use and the right mix of forages to balance the diet of different categories of pigs. The lack of knowledge and skills in forage agronomic, nutritional and anti-nutritional factors often leads to poor choices and results in poor pig performance. Literature reviewed suggests that there is a great potential to increase pig performance and profitability through efficient use of forages, but it requires a better understanding of nutrient utilization, voluntary intake and forage species that will give the optimum nutrients. Because of the low input requirements and need for land to grow forage crops, forage based pig production will be more acceptable by rural based smallholder farmers who have access to land for forage production.

From the literature reviewed, the following observations were made which could guide further studies on utilization of forages in pig feeding: crude fiber levels have no effect on growth rate of pigs provided the energy density in the feed is adequate; crude protein level has no significant increase in growth rate when pigs are fed equal and adequate energy levels but influences carcass leanness; efficient protein conversion occurs in low-protein but high-energy diets rather than high-protein, low-energy diets and that its energy density and not feed bulkiness that determine daily feed intake in pigs since pigs have the ability to eat until their energy requirements are met.

It can be recommended that research in utilization of forages in pig feeding should exploit ways of developing and incorporation of high-energy forage/pasture species into pig diets. A new Napier grass clone, Napier X sugarcane that has been screened in Uganda for tolerance to Napier stunt disease for use in dairy production may therefore provide a solution to utilization of forages in pig feeding since it has higher sugar levels than conventional Napier varieties. Research is needed in conducting nutritional assessments of this clone and incorporation into pig diets and monitoring their performance at different protein levels.

Recommendations for research

(a) There is need to develop and popularize forages that are fit for pig consumption in terms of nutritional requirements and with limited processing requirements. Since energy is a major limiting nutrient in pig production, forage research for pigs should exploit the use of a new Napier grass clone developed by crossing Napier and Sugar cane for its high sugar content. The clone has been evaluated by NaLIRRI for tolerance to Napier Stunt disease, giving fresh biomass yield of 182 tons/ha/year at a cutting frequency of 8 weeks and CP of 9.2%; but nutritional evaluation and feeding value have not yet been conducted.

(b) There is a need for characterization of forage species and developing a comprehensive guideline for utilization of individual or mixed forages in pig feeding systems for economic gains.

(c) There is need to determine the optimum inclusion levels of available forages and the best administration form in mixed rations.

(d) There is need to develop gender-responsive innovative ways of production, conservation, reducing anti-nutritive compounds and utilization of forages in pig feeding. Such innovations should be labour-saving, sustainable and economical to smallholders, especially women.

(e) Need to identify and promote forage crops that are environmentally friendly and sustainable.

(f) Determine the optimum stage of harvesting forages for pig feeding. Note that pigs digest hemicellulose better than cellulose and thus forages should be used at an early stage of maturity before they start to lignify.

(g) Determine the growth rate, meat quality and economic gains of pigs fed on different levels of forages in their diets.

(h) Need to identify, culture and introduce superior cellulotic microbes that that degrade cellulosic feedstuffs to a form that would provide more readily available energy for swine.

(i) There is need for research in integrating pig, crop and fish production so as to reduce conflicts for resource use and increase productivity and profitability (e.g. use of biogas slurry for feeding pigs – nutritional value and contaminations need to be checked)

(j) Need for research in developing novel feed production systems and guidelines for their utilization in pig feeding systems such as mussels and algae, duck weed and azolla.

(k) Need to increase access of low-income smallholder farmers to new improved forage germplasm and feed management practices.

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Annex 1: Farmers visited

Name	Sub-county/District	Contact number
1. Mr. Joseph Ekochu	Arapai sub-county, Soroti district	+256 779890273
2. Ms. Nalongo	Entebbe, Wakiso district	+256 701586613
3. Mr. Serunjogi	Busukuma sub-county, Wakiso district	+256 777598966
4. Mr. Peter Daaki	Mukungwe sub-county, Masaka district	+256 774864655
5. Mr.Peter Lubyayi	Kalungu sub-county/Masaka district	+256
6. Mr. Kato	Bunnanwaya, Wakiso district	+256 777122120
7. Mukono Zonal Agricultural Research and Development Institute	Mukono district	+256 4172090232
8. Kamenyamiggo District Agricultural and Information Centre (ZARDI)	Masaka district	+256 7724236070
9. Mbarara Zonal Agricultural and development Research Institute (ZARDI)	Mbarara district	
10. Mr. John Omoding	Gweri sub-county, Soroti district	+256 782065837

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