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Sweet potato wastes in major pig producing districts in Uganda: an opportunity for investment in silage technologies

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Abstract

This study was undertaken to assess the potential for sweet potato silage making business by estimating sweet potato vines and root wastage and assessing the economic feasibility of investing in sweet potato silage. Information was collected through key informant interviews, secondary data review, sweet potato root peeling and weighing, focus group discussions with pig and sweet potato producers covering a sample of 180 farmers. Semi-structured interviews with 240 respondents (120 sweet potato farmers, 60 pig farmers and 60 sweet potato traders) were also conducted. The results showed that sweet potato production is seasonal with substantial wastage of sweet potato components existing across the various nodes of the sweet potato value chain. The study concludes that there is an opportunity for investment in sweet potato silage business that has the potential to reduce wastage of sweet potato and bridge the feed scarcity gap faced by pig farmers.

Key words: *economic feasibility, ensiling, livestock feed, value chain*

Introduction

In smallholder farming systems in Uganda, pigs are fed on kitchen food wastes and crop residues, especially sweet potato vines (Dione et al 2015). However, the availability of vines is highly seasonal, leaving farmers with limited feed options during many periods of the year. Supplements based on commercial feed concentrates are expensive and generally unaffordable to smallholders. This dilemma presents an opportunity to invest in silage technologies that have the potential to reduce wastage of sweet potato residues in order to bridge the feed scarcity gap.

As sweet potato vines usually spoil within a few days from harvest (Peters 2008), they must be utilized for livestock feed immediately. An earlier study conducted in Uganda indicated that while farmers use sweet potato vines, peels and non-marketable roots, for animal feed, the potential for using these resources in this way was not being realised. (Bashaasha et al 1995; CIP 2012). Opportunities must therefore be created for their better exploitation.

Sweet potato silage is a viable alternative to fresh material (Lapar et al 2011; Peters et al 2006) as the vines and other materials can be processed immediately. Furthermore, ensilation enhances the nutritional value of these materials and their storage life, allowing farmers to feed their livestock a more regular diet based on sweet potato (Peters 2008). However, farmers in Uganda lack the necessary technologies to take advantage of this opportunity (Peters 2008). Sweet potato silage can be constituted either wholesomely using vines only with 5% maize bran added or both vines and root can be chopped and mixed in the ratio of 75%:20% respectively and 5% maize bran added. The 5% Maize bran added acts as a substrate that supports fermentation process and improves the nutritional value of silage (An and Lindberg 2004).

Sweet potato is the world's highest yielding food crop (Jata et al 2011) and in East Africa is commonly grown in and near densely populated areas. Uganda produces an estimated 1.8 Mt from an area of about 440000 ha (UBOS 2010); as well as for a household staple food, it is used as raw material for industrial processing into alcohol and starch and for livestock feed (Yanggen & Nagujja 2006). Unlike Uganda, China and other Asian countries have fully exploited its potential for feeding livestock and its production is positively associated with the number of pigs raised (Huang et al 2003). In Uganda, about 1.1M households raise an estimated 3.2M pigs, managed mainly by women and children as a backyard activity (UBOS 2009). The majority of these pigs are kept under extensive systems with a few under semi-intensive and intensive large modern farms (Tatwangire 2013). However, the use of marketable roots for livestock feed would not be economically viable in Uganda and also a threat to food security. Can sweet potato residues better support the provision of feed to smallholder pig enterprises?

This study was conducted to assess the potential for developing a sweet potato silage business. This was done by estimating sweet potato vines and root wastage and assessing the economic feasibility of investing in silage.

Materials and methods

The study was conducted in Masaka and Kamuli districts which are located in the Central and Eastern regions of Uganda respectively. The two districts were purposely selected because of their high levels of both pig and sweet potato production. Furthermore, a number of programmes aimed at boosting sweet potato and pig production have been implemented by the International Potato Center (CIP) and the International Livestock Research Institute (ILRI) in these districts under the framework of the EU-IFAD funded project “Expanding Utilisation of Roots, Tubers and Bananas and reducing their post-harvest losses” implemented by the CGIAR Research Program on Roots, Tubers and Bananas (RTB-ENDURE).

Primary data were collected through semi-structured interviews with value chain actors, Focus Group Discussions (FGDs), weighing of sweet potato roots and peels and interactions with key-informants. A multistage sampling technique was employed, whereby the sub-counties within the two districts to be visited were selected based on their involvement in the CIP and ILRI programmes. First, the two district production officers were approached as key informants and they provided information about sweet potato and pig production in their districts. The next stage involved selecting three sub-counties in each district and one village in each of them where the major focus of most farmers was either sweet potato growing or pig production. This gave a total of six villages for sweet potato farmers and six villages for pig producers. Local council officers from each village provided farmer lists from which a random sample of 120 sweet potato farmers (20 from each village) and 60 pig producers (10 from each village) were selected. Fifteen pig and sweet potato farmers from each village were also randomly selected from the lists provided to participate in the FGDs. A total of 12 FGDs were conducted in the two districts. From information provided by the FGD participants, 60 sweet potato traders (urban traders and local collectors/traders), 30 from each district, were also randomly selected and interviewed individually. The FGDs also provided background information on the production and utilisation of sweet potato in the two districts.

Individual interviews with each of the 120 sweet potato farmers yielded information on the area under sweet potato production, the vine and root yield, including the percentage of big, small and low quality roots, and their utilisation for food, planting material, animal feed, selling, manure, given to neighbours and discarded. Interviews with the 60 pig producers yielded information on the pig numbers kept, the purpose of pig rearing, feeding systems, seasonal feed availability, conservation and utilization. Other information gathered from pig farmers was pig feed/fodder production and trade, feed problems and potential solutions. For each sweet potato farmer, yield, was estimated from the numbers of either 150 or 200 kg sacks of harvested roots and either 40 kg sacks or bundles of vines. Root sizes, were estimated by asking farmers what average proportion out of every sack of was big, small and of low quality. Similarly, the percentages of roots and vines discarded were obtained by asking farmers what average proportion out of each harvested sack or bundle was discarded. The proportion and weight of peels was determined from peeled roots collected from random samples of the150 or 200 kg bags of roots. Only peels generated on farm were considered when apportioning their utilisation. The individual interviews with sweet potato traders, generated information on the quantity of sweet potato roots and vines traded and discarded on monthly basis. The later was obtained by asking how many kilograms out of every 150 or 200kg bag of their sweet potato root stock was discarded. The weight obtained was then expressed as the percentage of roots wasted by the trader. Data from the Uganda Bureau of Statistics, was used to obtain the overall area under sweet potato production for the two districts.

Data collected were coded where applicable and entered into the statistical package for social scientists (SPSS). The entered data were then transferred to STATA 12 for analysis. Percentages, means and frequencies were generated from these analyses.

T-tests were conducted to establish whether significant differences existed between districts in the amounts discarded. This was done by multiplying the overall acreage of sweet potato production by the mean vine and root wastage per acre of land utilised.

To examine the economic feasibility of ensiling discarded materials, three scenarios were examined. The first comprised a silage composition of 95% vines and 5% maize bran. In this scenario, all the vines available for ensiling represented 95% of the silage requirement. The second comprised 75% vines, 20% roots and 5%maize bran. In this scenario, the 20% represented all the available discarded roots to which the required proportions of sweet potato and maize bran were added. The third comprised all the vines and roots that would otherwise be wasted representing 95% of the silage composition with 5% maize bran added. The variable and fixed costs for ensiling and the calculation of expected revenues were based on current market prices. To calculate the fixed costs for ensiling, it was assumed that the Chopper machine used for processing produces 0.5 t h^{-1} silage material and works for 10 h per day. At full capacity, one machine produces 1825 t of silage per year. Additional material required the purchase of a second machine.

Results and discussion

Sweet potato production

Sweet potato growing was mainly the responsibility of women and children; 68.3% of sweet potato farmers were female. Men concentrated on coffee and sugar cane growing, which were the main cash crops in Masaka and Kamuli respectively. That sweet potato farming is a female-dominated activity is a common finding in Sub-Saharan Africa (Thiele et al 2009; Yanggen and Nagujja 2006).

The average land per farmer allocated to sweetpotato production was just under one acre (Table 1). There were usually two growing seasons per annum, April to June and August to October. Vines for planting were obtained from the farmers’ own fields except in situations of vine scarcity, usually following drought or natural calamities (Bashaasha *et al* 1995), when vines were borrowed or bought from neighbouring farmers or traders. Vines were planted on mounds or ridges, mostly using indigenous varieties.

Progressive or piece meal harvesting was the dominant system (Bashaasha et al 1995). Average root and vine yields for Seasons 1 and 2 were 2532 and 2476 kg per acre respectively. Vine yields were two times higher in the second than first season (Table 1). Lower vine yields in Season 1 were linked to drought that set in towards the end of the season and caused scorching. At this time, as root formation was already complete, root yields were unaffected. This finding concurs with those of Azevedo et al (2014) and Pedrosa (2015) who indicated that besides plant cycle other factors such as edafoclimatic conditions, vine fenological stage at harvest and crop location, had strong influence over fresh and dry mass of sweet potato vines and roots.

Table 1. Mean Sweet Potato Vine and Root Yields in Kamuli and Masaka District

Season	Average land allocated (acres)	Vine yield (kg/acre)	Root yield (kg/acre)	% Big roots	% Small roots	% Low quality roots
Season 1	0.95 (0.6)	1488 (1157)	2527 (1205)	54.6	27.7	17.7
Season 2	0.96 (0.4)	3465 (1311)	2537 (932)	48.5	32.0	19.5
Average	0.95 (0.4)	2476 (924)	2532 (898)	51.5	29.9	18.6

Note: figures in brackets are standard deviations

The high standard deviations in both root and vine yields (Table 1), were a result of variation in the yield of different sweet potato varieties grown by different farmers across the two districts. This finding is similar to that of Osiru et al (2009) and Junior et al (2012), who showed that there exists an overall sweetpotato yield variation among genotypes. But sharply contradicts with the findings of Figueiredo et al (2012), that showed there was no significant difference in productivity of green mass and dry mass among the genotypes of sweet potato.

Utilization of sweet potato components

There were three sweet potato products: roots, peelings and vines. To meet market requirements, roots were graded as either big, small or of low quality (Table 1). Big roots accounted for half the yield (Table 1) and two-thirds were used for home consumption, the remainder were sold (Table 2). Small roots were also used for home consumption and some for animal feed. Low quality roots were generally used for animal feed or discarded. The high proportion of roots consumed on-farm as opposed being sold, is consistent with sweet potato being a subsistence crop in Uganda (Engoru et al 2005).

Peelings, which constitute on average 30% of the fresh root weight, were most commonly used as animal feed, mainly for pigs, though small proportions were either discarded or used as green manure (Table 2). Vines were also used as animal feed for pigs. Around 30% were saved for planting material and about one-quarter were discarded. That wastage was so high is that many farmers are unable to store and conserve the vines ahead of planting in the next season (Peters 2008).

Of the roots that were sold, 44.1% were channelled to urban traders, 25.7% to local collectors/traders, 21.6% to individual consumers and 8.60% to institutions: schools, hotels and processors in rural and urban settings. Most farmers sold their roots directly at the farm gate or in rural markets. The common means of transport to these markets were motor cycles or bicycles.

Table 2. Utilization (%) of sweet potato components by farmers in Masaka and Kamuli District

	Food	Planting material	Animal feed	Sell	Manure	Given to neighbours	Discarded
Big roots	67.5	0.0	0.0	32.5	0.0	0.0	0.0
Small roots	72.6	0.0	21.3	3.0	0.0	0.1	3.0
Low quality roots	16.9	0.0	59.5	0.6	0.4	0.8	21.8
Peels	0.0	0.0	82.7	0.0	5.2	1.0	11.1
Vines	0.0	28.6	44.2	2.2	0.6	0.2	24.2

Source: survey data, 2015.

Estimation of sweet potato wasted by farmers and traders in Kamuli and Masaka districts

Farmers

Out of the 2476 kg per acre harvested, on average, farmers wasted 599 kg of vines per acre per season (Table 1 and 2), most during harvesting periods. Wastage was higher ($p \leq 0.01$) for farmers without than with pigs, 710 *vs*. 541 kg per acre per season, respectively. Kamuli district showed higher ($p \leq 0.01$) vine wastage than Masaka district, 676 *vs* . 522 kg per acre per season, respectively. This is probably linked to sweetpotato being grown on a larger scale in Kamuli than in Masaka. For roots, on average 4.95% of the total harvested per acre per season, 125kg were discarded by farmers (Tables 1, 2). This occurred mainly during the peak of the harvest seasons, when root supply exceeded demand for animal feed.

Traders

Wastage comprised mainly of stored roots which took on average about 4 days before spoilage occurs because of breakage and damage during transit. On average 3.75% of traders' root stock was discarded. The amount of wastage varied seasonally and was very high in February and September, the months when nearly half of the annual sweet potato crop is being supplied to the market (Figure 1). For vines, only 5% of the traders reported wastage. Based on their responses, it was estimated that about 1300 kg of vine was wasted annually, most occurred at the time of planting.

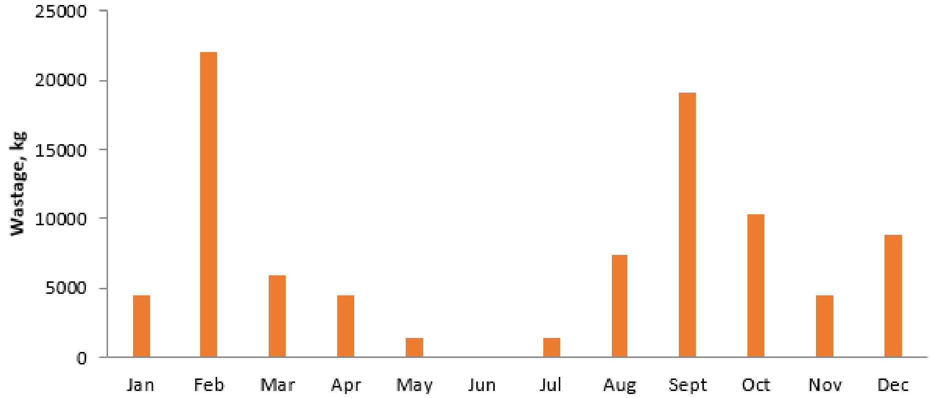

Figure 1. Root wastage by sweet potato traders in different months of the year.

Projected vine and root wastage for Masaka and Kamuli Districts

The total quantity of vines wasted per acre per season in the Kamuli and Masaka was projected to be 64887 t (Table 3). Wasted roots were 12536 t for the two districts combined. Wasted roots added onto the discarded vines gave an overall total of 77423 t of material that could potentially be ensiled. Under the third scenario for ensiling these materials, where all the 77423 t of discarded sweet potato root and vine were treated with 5% maize bran, this would translate into an overall 81498 t of silage produced per each of the two seasons for the two districts (Table 3).

Table 3. Projected overall vine and root wastage for Kamuli and Masaka districts

	Masaka	**Kamuli**	**Total**
Area under production (acres)	15353	84633	99985
Total vine production t	38013	209550	247563
Total root production t	38873	214289	253162
Estimated wastage			
Vines t	8014	56873	64887
Roots – small and low quality t	1925	10611	12536
Overall fresh vine and roots for ensiling t	9939	67484	77423
Estimated silage from vines and roots wasted t			81498#

#Assumes 95% sweet potato waste and 5% maize bran

Economic feasibility of ensiling the wasted roots and vines in Kamuli and Masaka districts.

Taking 100kg bag as unit cost for determining per unit value of sweet potato silage, entrepreneurs' variable costs would amount to Ugandan shillings (UGX) 188, 213 and 207 per kg of sweet potato silage with compositions of 95% vines and 5% maize bran, 75% vines, 20% roots and 5% maize bran and 79.6% vines, 15.4% roots and 5% maize bran respectively (Table, 4).

Table 4. Variable costs per kilogram of different sweet potato silage based diets.

Variable Items	**Quantity**			**Unit Cost (UGX)**	**Total Cost**		
	75% vines, 20% roots and 5% maize bran	**95% vines and 5% maize bran**	**79.6% vines, 15.4% roots and 5% maize bran**		**75% vines, 20% roots and 5% maize bran**	**95% vines and 5% maize bran**	**79.6% vines, 15.4% roots and 5% maize bran**
Vines (Kgs)	75	95	79.6	50	3750	4750	3980
maize bran (Kgs)	5	5	5	650	3250	3250	3250
Roots (Kgs)	20	0	15.4	174	3480	0	2680
Polythene tube (meters)	2	2	2	2800	5600	5600	5600
Labor (persons)	1	1	1	1500	1500	1500	1500
Petrol and oil (liters)	0.20	0.20	0.20	3500	700	700	700
Transport vines	75	95	79.6	29	2175	2755	2308
Transport roots	20	0	15.4	30	600	0	462
Transport maize bran	5	5	5	30	150	150	150
Sisal/strings for tying	1	1	1	50	50	50	50
Total					21,255	18,755	20,680
Cost per kg of silage					**213**	**188**	**207**

Additional to the variable costs, UGX 0.50 per kg of silage representing fixed costs would then be added. Thus, increasing the overall costs to 189, 214 and 207 per kg of the three different sweet potato silage compositions respectively (table 5).

Table 5. Fixed costs involved in sweet potato silage making

Fixed cost items	**Annual cost (UGX)**
Motorized chopper	350000
Maintenance cost	250000
Shed	216667
Weigh scale	16667
Wheelbarrow	40000

Tarpaulin	100000
Total fixed costs	**983334**

From the results, it is cheaper making silage from vines only than when roots are to be included. Unless the roots are free of charge, it is not economical to use them in the ensiling process as it will increase the production cost. According to CIP (2000), Silage of excellent fermentative quality is obtained from sweet potato foliage when no additives such as sweet potato roots, are used. Similarly, studies have revealed that addition of sweet potato roots had no noticeable effect on dry matter production, but increased acetic and butyric acid concentrations. Vine silage without additives, on the other hand, had acceptable characteristics (Farag and Ramesh 2017). Following these findings and the high costs attached to roots, it is therefore imperative that entrepreneurs focus on using only vines for silage making and use roots only if they are available free of charge.

Considering that the cost per kg of silage at that time was 400 UGX, this would translate to total revenue of 32.6 billion UGX, if the wasted sweet potato components are utilized to produce silage. However, to produce all this volume of silage, the entrepreneur would incur 16.9 billion UGX in variable and fixed costs resulting into a potential profit of 15.7 billion UGX. Thus, making investment in silage economically feasible (Table 6).

Table 6. Economic feasibility of investing in sweet potato silage making business

Parameters	Silage composition		
	95% (only all wasted sweet potato vines utilized) + 5% maize bran	**75% sweet potato vines, 20% wasted roots and 5% maize bran**	**95% (all vines +roots available) + 5% maize bran**
Potential volume of silage produced for 1 season t	68302	62680	81498
Price/kg	400	400	400
Potential total revenue (Billion UGX)	27.3	25.1	32.6
Costs			
Total variable costs (Billion UGX)	12.8	13.4	16.9
Total fixed costs (Billion UGX)	0.04	0.03	0.04
Potential profits (Billion UGX)	14.5	11.7	15.7

Conclusion

- Sweet potato cultivation in Uganda is a female dominated activity that is mainly carried out in two seasons within a year. Most farmers consume their sweet potato on-farm and only sell the excess.
- Sweet potato components are utilised as household food, planting material, livestock feeds, green manure, gifts to neighbours as well as sold to traders and other sweet potato value chain actors.
- Despite the various uses of sweet potato components, there is still a substantial amount that is unutilised in terms of vines and rejected roots.
- Taking into account the substantial wastage of vines and sub-standard roots, investment in Sweet potato silage technology which is an untapped business opportunity that can reduce wastage is recommended.
- Sweetpotato silage technologies can make use of the substantial sweet potato wastes, process them into a more stable product that can be fed to pigs as full or partial substitute of expensive commercial feed whose price peaks during off-season. Sweet potato silage-based diets have been validated in countries like China and Vietnam and were proved to be economically viable. However, being a new technology in Uganda, additional research is being conducted to assess farmers' acceptability and willingness to pay.

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Conflict of interest statement

Authors declare no conflict of interest

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