RESEARCH PROGRAM ON Roots, Tubers and Bananas

CGIAR

Technical report:

Economic analysis of sweetpotato silage based diets for smallholder pig farmers in Uganda

Expanding Utilization of Roots, Tubers and Bananas and Reducing Their Postharvest Losses

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IFAD
Enabling poor rural people to overcome poverty

A broad alliance of research-for-development stakeholders & partners

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The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is a broad alliance led by the International Potato Center (CIP) jointly with Bioversity International, the International Center for Tropical Agriculture (CIAT), the International Institute for Tropical Agriculture (IITA), and CIRAD in collaboration with research and development partners. Our shared purpose is to tap the underutilized potential of root, tuber and banana crops for improving nutrition and food security, increasing incomes and fostering greater gender equity, especially among the world's poorest and most vulnerable populations.

Executive summary

In Uganda, high feed costs (especially commercial feeds) have steadily become a major constraint of pig production representing 60 to 80% of the total production cost. Sweetpotato silage has been piloted as one of the interventions to reduce on feed cost in the framework of the CIP-led 'Expanding Utilization of RTB and Reducing Their Postharvest Losses" (RTB-ENDURE) project. Silage based diets have been tested to assess the performance of pigs, and the results seem promising. However the economic viability of such diets compared to current smallholder pig farmer practices has not been undertaken. The objective of this study is to assess the economic viability of feeding pigs on silage based diets compared to other commonly used diets and to recommend appropriate diets under smallholder pig systems.

Economic analysis was carried out based on data from longitudinal and cross-sectional surveys performed by ILRI and CIP in the framework of RTB-ENDURE project in Masaka and Kamuli districts located in Central and Eastern Uganda, respectively. For this analysis, only data from Masaka district has been used to enable comparison of on-station and on-farm trials that were carried out in the same district. On station and on farm feeding trials in Masaka were carried out on 48 and 24 pigs, respectively. In addition four farmers utilizing conventional feeding practices on three pigs (12 pigs in total) were included as control. Performance and feed intake data were collected for each pig over three months, from March to May 2016. The cross-section survey covering a sample of 210 sweetpotato farmers and 60 sweetpotato traders was used to collect data on prices and wastages of vines and roots from Kamuli and Masaka. In addition, a willingness to pay (WTP) survey was conducted on a random sample of 256 pig farmers to assess the demand for the silage based pig diets. For the economic analysis, the cost of weight gain per pig from the different diets were computed and compared to determine the economic viability of the diets.

Results show that, it is 32% more expensive to produce a kilogram of carcass weight using farmer conventional feeding practices compared to the 60% silage 40% maize soybean meal diet (60silage40MSM diet). Also, as the price of maize bran rises above Ug Shs 900 the 60silage40MSM diet becomes more economical with lower cost per kilogram of live-weight compared to the MSM diet. The results further show that the silage based supplemented diets are economical only if farmers prepare the silage themselves rather than purchasing at current market prices. However, the current price of silage would still ensure savings on feeding costs at times of the year when maize bran prices are particularly high.

This study concludes that use of supplemented silage-based diets is economically efficient in smallholder pig production settings especially during periods when the cost of maize bran is high. Furthermore, apart from the times of the year when maize price is very high, it is feasible only if farmers prepare silage themselves or if they purchase it at prices lower than the current market price. The sweetpotato silage market structure is largely oligopolistic, with few sellers and relatively high market price. The market demand for the silage-based diets is high, with buyers willing to pay at high price. This high demand has potential to attract several entrepreneurs and result in more competitive prices of marketed silage as players seek to lower cost of production and are willing to reduce the very high margin they currently benefit of.

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1 Introduction

In Uganda, high feed costs (especially commercial feeds) have steadily become a major constraint of pig production representing 60 to 80% of the total production cost (Lule et al., 2014). This is exacerbated by feed scarcity especially during dry season and poor implementation of quality assurance for commercial feeds (Ouma et al., 2014, Katongole et al., 2012; Ndyomugyenyi & Kyasimire, 2015). To counter these constraints, most farmers resort to using locally available feeds. Sweetpotato vines and roots are among the most commonly fed local feed resources for pigs.

Sweetpotatoes are seasonally available i.e. highly abundant during harvest period and scarce during dry season. The vines deteriorate within 2 to 3 days after harvest and roots last only 1-2 weeks in tropical developing countries (Rees et al., 2003). In Uganda, there are two sweetpotato harvest periods. During these periods the sweetpotato vines are in abundance and farmers use them to feed their pigs. But the quantities of vines exceed what can be fed to pigs leading to a high proportion being left in the field where they decay (Peters, 2008). Once the harvest season is over the vines become scarce.

Ensiling of sweetpotatoes enables farmers to utilize vines and roots that would otherwise have been wasted, especially during harvest period. Silage that is processed during the harvest season when vines are abundant has the potential to provide a nutritious basal diet for livestock during periods of scarcity. If properly kept in anaerobic conditions, silage can be stored up to six months without spoilage (Peters, 2008).

Furthermore, the fresh roots contain high levels of a trypsin inhibitor, a substance which makes it difficult for the pigs to digest and get enough protein, unless it is processed first. Pigs are therefore unable to get the most benefit from the feed, and cannot perform well (Peters, 2008). The trypsin inhibitors can be reduced through simple processing techniques such as cooking, drying and ensiling (Dione et al., 2015).

Studies have been carried out in Uganda to assess the performance of pigs on silage-based diets and the results have been promising (Ojakol et al., 2016). However, the economic viability of such diets compared to current smallholder pig farmer practices has not been evaluated. The objective of this study is to assess the economic viability of feeding pigs on silage-based diets compared to other commonly used diets and to recommend appropriate diets under smallholder pig systems.

2 Materials and methods

2.1 The data

Economic analysis of sweetpotato silage-based diets was conducted based on data from two longitudinal and one cross-section survey performed by ILRI and CIP in the framework of RTB-ENDURE project which has been implemented in Masaka and Kamuli districts. For this report only data from Masaka district has been used to enable comparison of on-station and on-farm trials that were carried out in the same district. On station and on farm feeding trials in Masaka were carried out on 48 and 24 pigs, respectively to collect performance and feed intake data over three months, from March to May 2016. Four diets were considered in the trials – see Table 1.

Table 1: Experimental diets

Diet*	Sweetpotato silage	Maize and Soy bean meal MSM	Feed intake (kgs)	Number of pigs
On-station trials				
60silage40MSM	60	40	84.9	12
80silage20MSM	80	20	77.5	12
100silage	100	0	70.7	12
MSM	0	100	63.0	12
On-farm trials				
60silage40MSM (on-farm)	60	40	103.9	24
Conventional farmer practice	0	0	107.8	12

*Source: Ojakol et al. 2016 & Mutetikka et al., 2016: MSM=100% Maize-soybean meal, 60silage40MSM= 60%silage and 40%Maize-soybean Meal, 80silage20MSM= 80%silage and 20%Maize-soybean Meal, 100silage= 100% silage Farmer practice= quantity of feed smallholder farmers use include, maize bran, weeds, sweet potato vines, etc.

For the farmer practice, data from a sample of 12 pigs were collected from four control farmers and used to determine the cost of feeding. Farmers were allowed to feed pigs based on their conventional feeding practices. The pigs were weighed on a biweekly basis and the farmers made a recall of the feeds that were given during the week including the prices. From the information collected, total costs were determined. For the conventional farmer feeding

practice, feeds that were fed to pigs depended on their availability on farm and those that were bought depended on farmers' access to financial resources. Details of cost of the diet ingredients are presented in Annex 1. Pig performance parameters that were collected from the trials included pigs' weight and the amount fed. Table 2 shows the pig performance results based on the four diets in the on-station trials (MSM, 60silage40MSM, 80silage20MSM, and 100silage), the diet in the on-farm trials (60silage40MSM), and farmer practice (the latter based on Ojakol et al., 2016 and Mutetikka et al., 2016).

The average daily gain (ADG) and the dressing percentage for the pigs in on-station trials were obtained. For the latter, for each diet, three pigs were sampled and weighed before (live weight) and after (carcass weight) slaughtering and the figures obtained were used to calculate the dressing percentage. No pigs under on-farm trials or farmer practice were slaughtered because farmers needed them to expand their herds. For the on-farm 60silage40MSM diet, the dressing percentage (62.7%) of the similar diet on station was adopted while for the farmer practice the average between the 80silage20MSM (59.5) and the 100silage (57.7) dressing percentages was used since the diets have a mixture of forages and cereals. The differences in the dressing percentages of pigs from the different diets was due to Feed Conversion Ratio (FCR) with the MSM having the lowest FCR while the 100silage had the highest FCR (Table 2). This is because the silage and farmer practice diets were more forage based and therefore more fibrous (Mutetikka et. al., 2016).

Table 2: Performance parameters for pigs fed on different diets

Parameter	**Diet**					
	60silage 40MSM	**60silage 40MSM**	**80silage 20MSM**	**100silage**	**MSM**	**Farmer practice***
	(On-farm trial)*		(On-station trials)			
Initial weight (Kg)	9.6	11.5	11.4	11.4	11.4	10.2
Final weight (Kg)	32.3	31.3	23.7	13.1	50.6	20.5
Live weight gained (Kg)	22.7	19.8	12.3	1.7	39.2	10.4
ADG (g^{-day})	252.2	220.1	136.6	18.4	435.5	114.7
FCR	4.6	4.3	6.3	41.6	1.6	10.4
Carcass w. gained (Kg)	14.2	12.4	7.3	1.0	25.9	6.1
Dressing %	62.7	62.7	59.5	57.7	66.0	58.6

Adopted from Ojakol et al. (2016) & Mutetikka (2016)

* Pigs were not slaughtered for carcass weights

The cross-section survey was used to collect prices and wastages of vines and roots from Kamuli and Masaka. A sample of 210 sweet potato farmers and 60 sweetpotato traders was used for the cross-section survey. Secondary data from key informants were used to collect information on other costs of silage preparations. The cost of silage production has been calculated in other studies by Asindu et al. (2016). Table 3 summarizes the production cost of silage. Details are presented in Annex 2.

Table 3: Production cost of silage

Silage composition	**Price per kg**
95% vines & 5% maize bran	188
75% vines, 20% roots 5% maize bran	213

A willingness to pay (WTP) survey was conducted on a random sample of 256 pig farmers to assess the demand for the sweetpotato silage based diet constituted by 60% sweetpotato silage and 40% MSM (60silage40MSM). Refer to Mutetika et al. (2016) for the description of the diet formulation and supplementation. The 60silage40MSM diet was recommended as a suitable low-cost silage-based diet for smallholder pig farmers based on pig performance experimental results by Mutetikka et al. (2016). Computations from the on-station trials presented in Annex 1, estimate the unit cost of the 60silage40MSM diet at Ug Shs 425 for the weight gains indicated in Table 2. Table 4 gives a summary of the unit cost of the diets.

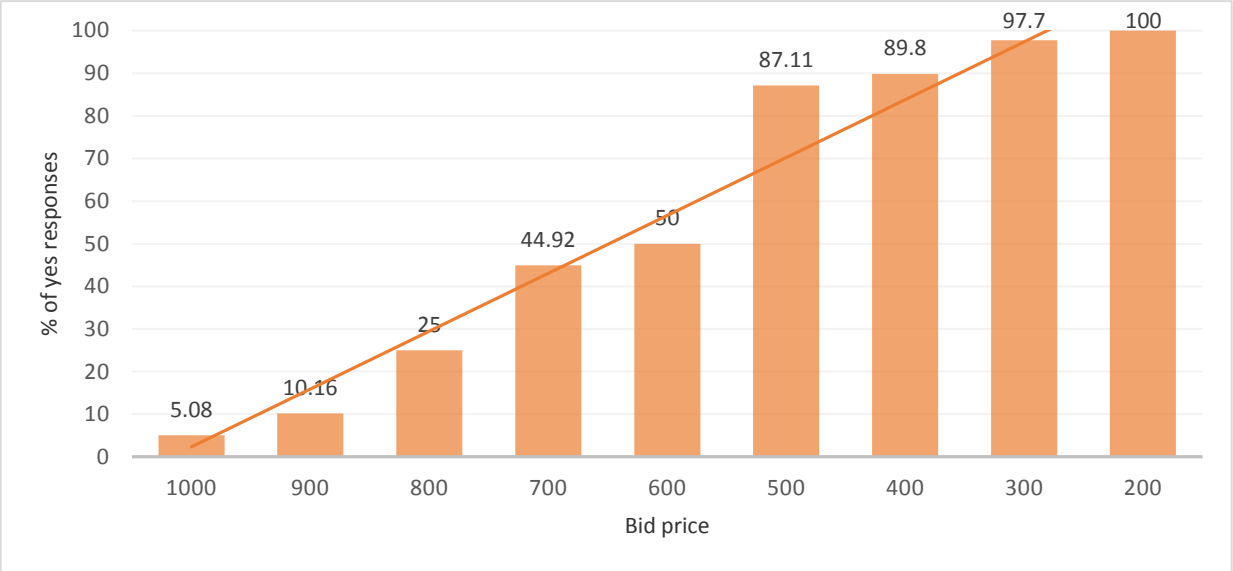
Table 4: Unit cost of the diets

Diet	**Unit cost of the diet/Kg (Ug Shs)**
60silage40MSM	425.2
80silage20MSM	318.6
100silage	188.0
MSM	1050.8
Farmer practice	213.9

The mean price that smallholder pig farmers were willing to pay (WTP) per kg of the sweetpotato silage based diet (60silage40MSM) was Ug Shs 668. This price was higher than

the cost of preparing the diet (Ug Shs 425), implying that the diets are potentially viable for entrepreneurs involved in silage making and sale of the diet. The current offer price of silage alone is Ug Shs 400 per kg. The cost of the 60silage40MSM diet for farmers who purchase both silage and MSM would be Ug Shs 579 per kg. This is still lower than the mean WTP.

A demand curve was also generated for the different bid prices (Figure 1). As expected, the results show that as the price per kg of sweetpotato silage based diet increased, the overall number of respondents willing to pay declined. This finding is consistent with the demand theory which shows that price is inversely related to quantity demanded of a particular commodity (Asindu, 2016). About 88% of the respondents were willing to pay amounts higher than cost of the diet of Ug Sh 425.



Source: Asindu 2016

Figure 1: Proportion of farmers willing to pay 60silage40MSM diet at different bid prices

2.2 Economic analysis

For the economic analysis, the cost of weight gain per pig from the different diets were computed using the unit cost of each diet in Table 4 and compared to determine the economic viability of the diets. In addition, two scenarios were simulated to assess the viability of the diets by taking into consideration seasonal variation of maize bran prices, a common component of the diets, and bid prices for the 60silage40MSM silage-based diet (Asindu et

al., 2016).

The first set of simulations were run on maize bran market prices. Maize bran prices were obtained from feed stockists in Masaka. The lowest maize bran market price for 2016 was Ug Shs 500 (period of adequate supply of maize) and highest price of Ug Shs 750 during scarcity. In 2015, the highest maize bran market price was as high as Ug Shs 1,100. The sensitivity analysis has therefore been conducted using maize bran price ranges from Ug Shs 500 to 1,100.

The second set of simulations were run on the prices of silage based diet (60silage40MSM). In this analysis, we have used a price range of Ug Shs 400 to 700 to cover two scenarios:

- If the farmer is producing silage (Ug Shs 188 per Kg of silage and Ug Shs 1,050 per Kg of MSM)
- If the farmer is purchasing silage at current market price (Ug Shs 400 per Kg of silage and Ug Shs1050 per Kg of MSM).

3 Results

3.1 Weight gains

From the Figure 2, pigs fed on MSM diet gained most weight (39.2 kg live weight and 25.9kg carcass weight) while those under 100silage gained the least amount of weight (1.7 kg live weight and 1kg carcass weight) at the end of the 90 day feed trial. Of the three silage based diets, pig performance under the 60silage40MSM is best in terms of live-weight gained.

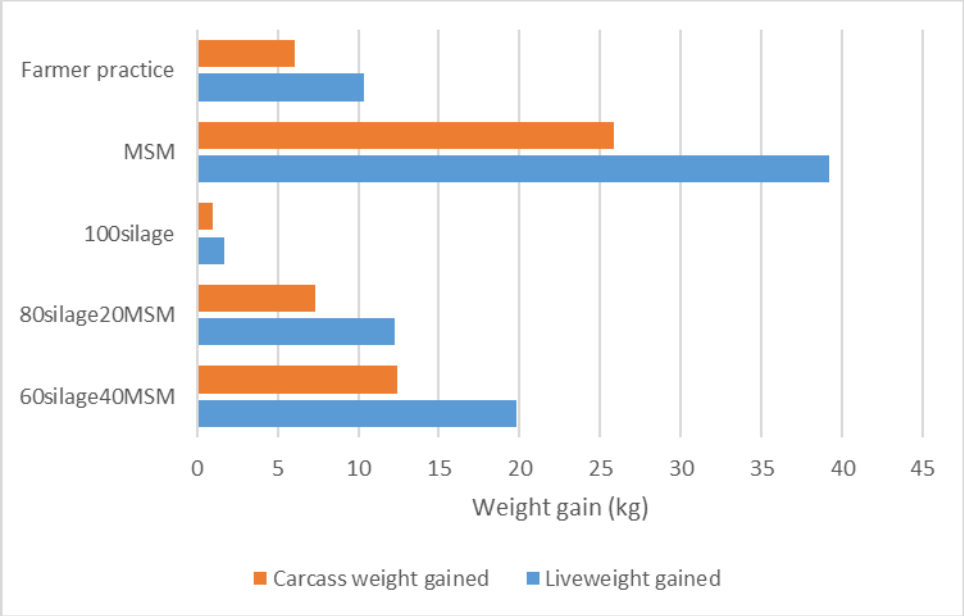


Figure 2: Total weight gain under different diets, for the 90 day feed trial

3.2 Cost of producing live weight and carcass weight of pig

Table 5 shows that over the 90 day period of the study, the MSM diet is the most expensive (Ug Shs 66,213) while 100silage diet is the least costly (Ug Shs13,292).

Table 5: Total diet cost for a pig in 3 months

Diet	Amount fed (Kg)	Unit cost (Sh/Kg)	Total cost (Ug Shs)
60silage40MSM (on-station)	84.9	425.2	36,099.5
60silage40MSM (on-farm)	110.9	425.2	47,154.7
80silage20MSM	77.5	318.6	24,691.5
100silage	70.7	188.0	13,291.6
MSM	63.0	1050.8	66,200.4
Farmer practice	107.8	213.9	23,058.4

Figure 3 shows the cost per unit of live weight and carcass weight gain under different diets. The results show that, despite its low cost, the 100silage diet is the least economical diet as it has the highest cost per live weight gain (Ug Shs 8,000). The MSM diet on the other hand is the most economical with the lowest cost per live weight gain (Ug Shs 1,689). Nevertheless, the MSM diet is the most expensive diet that maybe beyond smallholder farmers' reach. Compared to farmers' conventional feeding practice, the 60silage40MSM and 80silage20MSM are more economical, at Ug Shs 1,829 and Ug Shs 2,009 per live weight

gain, respectively. The 60silage40MSM may be more suitable for smallholders since it results in better live weight gain compared to the 80silage20MSM. It is 32% more expensive to produce a kg of carcass weight using farmer practices compared to the 60silage40MSM diet.

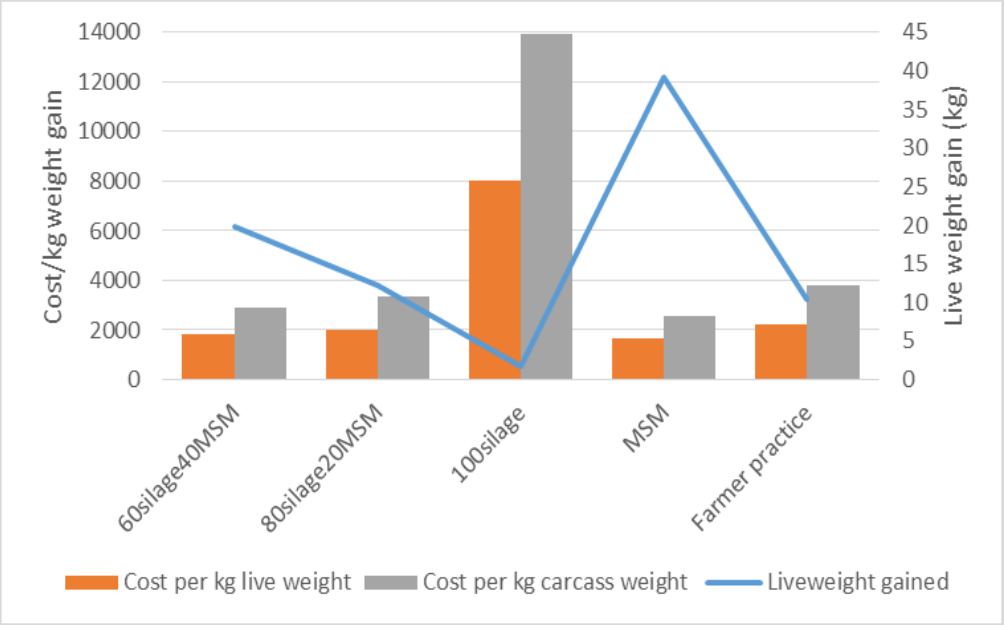


Figure 3: Cost incurred per kg of pig and pork produced under different diets

3.3 Effect of maize bran prices on the cost of producing pork

A sensitivity analysis was conducted to simulate an increase in maize bran price from the baseline (Ug Shs 500 per Kg) to assess its effect on the economic viability of the diets. Figure 4 shows the effects of an increase in maize bran price on the production cost of one Kg of live weight from the different diets, assuming that the farmers prepare the silage themselves. Figure 5 on the other hand shows the same effects if the farmers purchase silage at the current market price rather than preparing it themselves. The effect of maize bran price changes on the 100silage diet is not included in the results presented since the cost per kg of live-weight for the diet is constant at Ug Shs 8,000, as bran is not a component of the diet.

As expected, the price change effect is the highest for the MSM diet (containing about 74% of maize bran), as shown by the steeper slope of the line graph (Figure 4). Key to note is that when the maize bran price rises to Ug Shs 900, the cost per kg of live-weight from the MSM diet is equal to the 60silage40MSM diet if farmers are preparing silage themselves. With

price of maize bran higher than Ug Shs 900, the MSM diet becomes uneconomical relative to the 60silage40MSM diet, as additional live-weight gain from the MSM diet becomes very costly. At maize bran price of Ug Shs 1,100 the economic performance of the MSM diet is almost equal to the 80silage20MSM diet. Beyond Ug Shs 900 price of maize bran, the 60silage40MSM diet is the most economical diet compared to the rest.

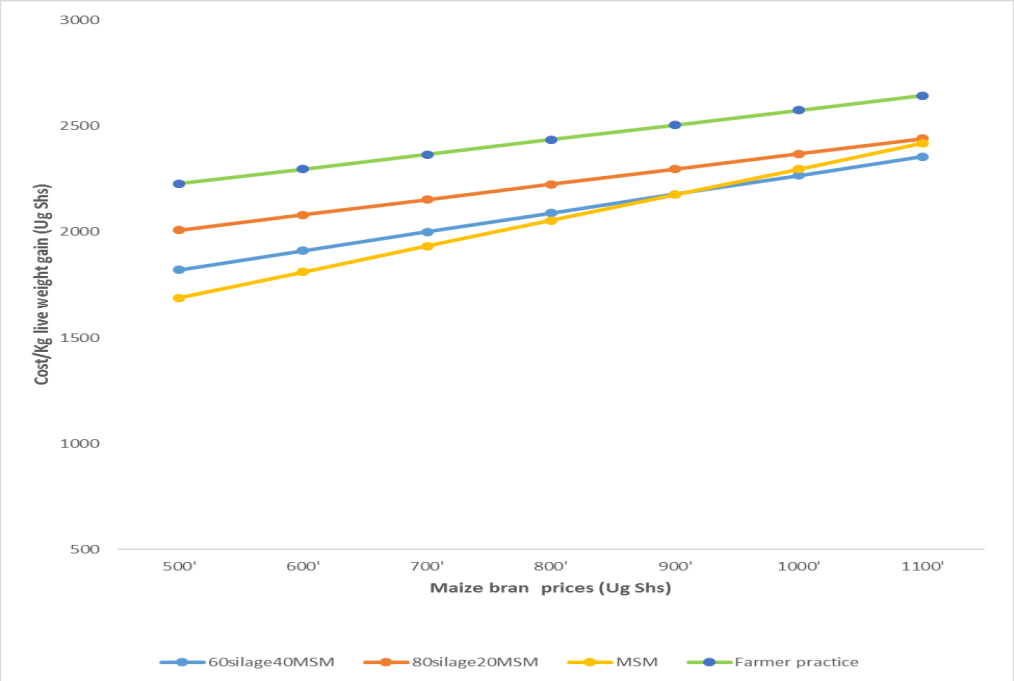


Figure 4: Feeding cost per kg of live weight in relation to changes in maize bran prices if silage is produced by farmers

If farmers purchase silage at the current market price of Ug Shs 400 per Kg, all the silage based diets become uneconomical, even in comparison to farmers practices (Figure 5). Under such a scenario the MSM diet is the most economical diet even when maize bran price substantially increase.

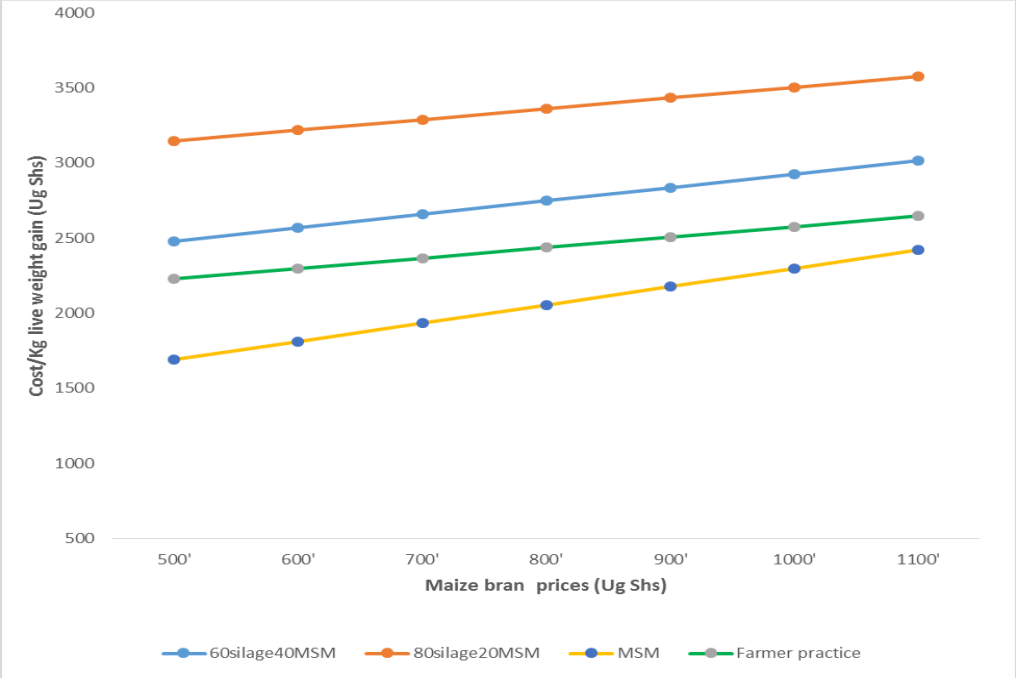


Figure 5: Feeding cost per kg of live weight in relation to changes in maize bran prices if silage is purchased by farmers at current market price

3.4 Effect of change in silage-based diet prices on the cost of production of pork

Figure 6 shows the effect of changes in silage-based diet prices on the cost of production of pork, assuming maize bran price constant at Ug Shs 500. At 60silage40MSM diet price of Ug Shs 400, the cost per kg live weight gain is equal for the 60silage40MSM diet and the MSM diet at Ug Shs 1,530, and it is more economical compared to farmer practice. However, as the cost of 60silage40MSM diet increases, it becomes more uneconomical relative to the other diets. At the price of Ug Sh 525, the economic performance of the 60silage40MSM diet is equal to farmer practice. If the price of 60silage40MSM diet is above Ug Shs 525, then the diet becomes uneconomical even compared to farmer practice. In fact, at prices higher than Ug Sh 525, it is more costly to produce pork from the silage-based diet than conventional farmer practice. Therefore, at maize bran price of Ug Shs 500, the maximum cost of the 60silage40MSM diet is between Ug Shs 400 and 525. As previously shown, when silage is produced by the farmers themselves, the price of the 60silage40MSM diet is Ug Shs 425 and therefore it falls in this range. However, the cost of the 60silage40MSM diet for farmers who purchase both silage and MSM is estimated at Ug Shs 579 per kg. This implies that, at current silage price of Ug Shs 400, the silage-based diet is not economically viable when

price of maize bran is as low as Ug Shs 500. At this price of maize bran, the silage should not be sold at a price higher than Ug Shs 325 per kilogram. However, the current price of silage would still ensure savings on feeding costs at times of the year when maize bran prices substantially increase.

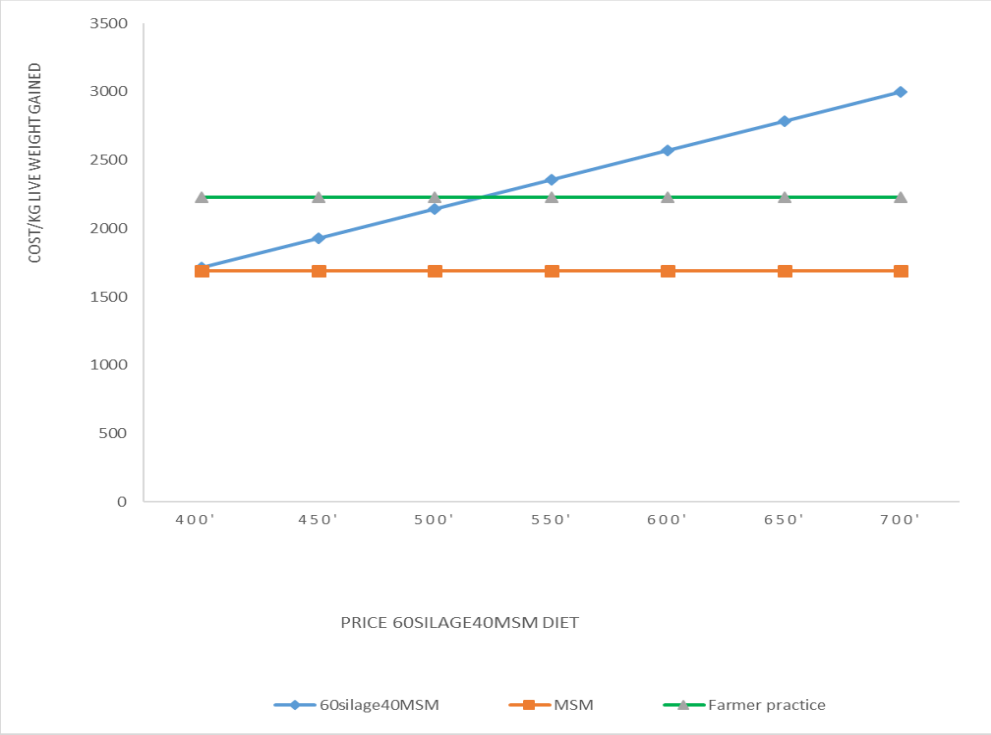


Figure 6: Cost of pig diets in relation to changes in price of 60silage40MSM diet

4. Discussion

From the above analysis it can be deduced that all the diets that were tested are more cost effective than the farmer practice if farmers prepare silage themselves. The MSM diet was the best both in terms of live and carcass weight gains as expected, since it is a cereal based diet and has a better feed conversion ratio compared to the rest. However, the MSM diet may be costly to smallholders, more so when price of maize bran rises. The results show that when the price of maize bran is low then the MSM diet is relatively economical. However, during periods of scarcity when maize bran prices are high, smallholder farmers are better off using the 60silage40MSM diet if they prepare silage themselves. When maize bran price rises to Ug Shs 900, the cost per kg of live-weight from the MSM diet is equal to the

60silage40MSM diet at Ug Shs 2,100 per Kg of live-weight gain. Beyond Ug Shs 900 (as is the case in some periods of the year in Uganda), the 60silage40MSM diet becomes more economical relative to all diets tested.

If farmers purchase silage at the current market price, then the diets become uneconomical. For instance, beyond the 60silage40MSM diet price of Ug Sh 525, the economic performance of the diet is worse than conventional farmer practice.

5. Conclusions and Implications

The MSM diet is often out of reach of small-scale pig farmers and it is economically feasible only at low maize bran prices. Maize bran prices above Ug Sh 900 per kg make the cost of producing one kilogram of live-weight higher for the MSM diet than the silage based diets. Therefore, the use of supplemented silage-based diets is economical, resulting in lower cost/live-weight gain, in smallholder pig production settings especially during periods when the cost of maize bran is high. Apart from the times of the year when maize price is very high, the silage based diets are economical only if farmers prepare the silage themselves or if they purchase it at prices lower than the current market price. The sweetpotato silage market structure is largely oligopolistic, with few sellers and relatively high market price. The market demand for the silage-based diets is high, with buyers willing to pay more than Ug Shs 600 per kg. This high demand has potential to attract several entrepreneurs and result in more competitive prices of marketed silage as players seek to lower cost of production and are willing to reduce the very high margin they currently benefit of.

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7. Annexes

Annex 1

Table 1: Cost and amount of feed consumed per pig on different diets during the trials.

Item	Diet (Kg)					Unit cost
	60silage40MSM	80silage20MSM	100silage	MSM	Farmer practice	
Maize bran	17.65	8.85	0	47.69	7.2	500
Soy bean	4.9	2.46	0	13.23	0	3000
Dicalcium phosphate	0.47	0.23	0	1.26	0	100
Vitamin mineral premix	0.12	0.06	0	0.32	0	5000
Salt	0.12	0.06	0	0.32	0	600
Lysine	0.07	0.04	0	0.19	0	4000
Silage	61.56	65.83	70.7	0	0	188
Banana peels	0	0	0	0	31.6	30
Sweetpotato vines	0	0	0	0	6.8	50
Homemixed	0	0	0	0	18.9	900
Swill	0	0	0	0	30.1	30
Weeds	0	0	0	0	13.2	20
Total amount fed (Kg)	84.9	77.5	70.7	63.0	107.8	
Total cost (Ug Shs)	36,097	24,700	13,292	66,213	23,058	
Unit cost for diet (Ug Shs/Kg)	425.2	318.6	188.0	1050.8	213.9	

Adopted from Ojakol et al. (2016) & Mutetikka (2016)

Annex 2

Table 2: Production costs of sweetpotato silage

95% VINES, 5% MAIZE BRAN			
Item	**Quantity**	**Unit cost (UGX)**	**Total cost (UGX)**
Vines	95	50	4750
Maize bran	5	650	3250
Polythene tube	2	2800	5600
Labor	1	1500	1500
Petrol and oil	0.2	3500	700
Transport cost vine	95	29	2755
Transport cost bran	5	30	150
Sisal/string for tying	1	50	50
			18755
Cost per unit of silage			**188**
75% VINES, 20% ROOTS AND 5% MAIZE BRAN			
Item	**Quantity**	**Unit cost (UGX)**	**Total cost (UGX)**
Vines	75	50	3750
Maize bran	5	650	3250
Cost roots	20	174	3480
Polythene tube	2	2800	5600
Labor	1	1500	1500
Petrol and oil	0.2	3500	700
Transport vines	75	29	2175
Transport roots	20	30	600
Transport bran	5	30	150
Sisal/string for tying	1	50	50
Total			21255
Cost per unit of silage			**213**

Adopted from Asindu et al. (2016)