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Roots, Tubers  
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## Technical report: Characteristics of Silage Based on Sweetpotato with Combinations of Local Feed Resources in Uganda

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



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## **EXECUTIVE SUMMARY**

A study to determine the characteristics and chemical composition of different silages based on sweetpotato vines in combination with several local feed resources was conducted in the Animal Science laboratory at the Makerere University Agricultural Research Institute, Kabanyolo (MUARIK). Sweetpotato vines from variety NASPOT 11 were used. Maize bran and cassava root were used as ferment starters (additives) during the ensiling process. The silages were analyzed for pH, moisture content, crude protein, neutral detergent fiber, ether extracts and ash, calcium and phosphorus. The results showed that sweetpotato vines can produce silage of acceptable quality even when no external ferment starter is added. However, addition of a solid ferment starter like maize bran served to absorb the moisture that would accumulate as effluent at the bottom of the silo and eventually lead to spoilage. The dry matter content of the silage was low (> 24%) and would not meet the requirements of young growing pigs. The resultant silage had crude protein content higher than 19 percent and would meet the requirements for growing pigs except for the balance of essential amino acids and low dry matter of the material. For efficient utilization, feeding sweetpotato silage diets would require supplementation to satisfy requirements for dry matter and essential amino acids.

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## INTRODUCTION

Smallholder pig production plays an important role in providing dietary animal protein and incomes in Uganda. Despite the opportunities that pig rearing offers to smallholder farmers the potential increase in pig production has been severely inhibited in many areas by scarcity and high cost of feeds. In the rural areas where the bulk of the pigs are reared, pig diets in the smallholder farms are inadequate in terms of quantity and nutrient supply, especially during the dry season (Ouma et al., 2015). Offering options for improved and economical feeding is key to increasing production and thus enhancing livelihoods of smallholder farmers. Elsewhere diets for pigs are based on cereals as a source of energy and the protein is usually supplied by fish meal, soybean meal, and by-products from oil seed production. These ingredients are scarce and costly in Uganda which creates a need to identify alternatives which are locally available and competitively priced. Previous studies have recommended using forages as a source of protein (Katongole and Mutetikka, 2016).

One of the forage most commonly used for feeding pigs in Uganda is sweetpotato vines (Dione et al., 2015). Uganda is the second largest producer of sweetpotatoes in the world and therefore a plentiful supply is available in certain seasons of the year. There is also the potential use of the non-marketable roots as a source of feeds since its estimated that 4.95% of roots are wasted on farm (Asindu, 2016). The challenge with the sweetpotato vines is that they are abundant in the rainy season and scarce in the dry season; yet they are also high in moisture content at the time of harvest and would keep for a very short period if left unprocessed. To mitigate this challenge farmers in South East Asia have resorted to ensiling the sweetpotato vines (An, 2004). The greatest challenge that farmers face when making sweetpotato silage is how to control the high moisture content in sweetpotato vines. Typically, sweetpotato vines (SPV) are wilted to reduce the moisture content prior to ensiling. However; farmers find it difficult to wilt sufficiently large volumes of vines which results in spoilage during ensiling. To mitigate this problem, a tube silo which eliminates the accumulation of effluent has been developed by the International Potato Center (CIP) and the International Livestock Research Institute (ILRI) in Kenya. This is achieved by installing an outlet pipe at the bottom of the tube. In this design molasses is used as the ferment starter. In Uganda, molasses is not widely available and is often not affordable to for the smallholder farmers. Moreover, the cost of making the tube silo with the drainage system for eliminating the effluent could be a factor limiting the adoption of the technology. There is

therefore need to develop a silage-making technology that is suitable for use under local conditions and which is also affordable to smallholder farmers in Uganda. Presently farmers harvest fresh forage on a daily basis for feeding the pigs. The daily harvesting of fresh SPV forage by the traditional “cut and carry” system is also posing problems, particularly when family labour is insufficient. Otieno, Onim and Mathuva (1999) demonstrated the feasibility of ensiling crop residues in synthetic gunny bags in Kenya. Until recently, little attention has been paid to conserve sweetpotato vines as silage using different low cost methods in Uganda. The development of an effective and low-cost forage preservation technique would contribute to improved smallholders’ pig production and incomes in the rural areas.

### **Objectives**

The major objective of this study was to determine the characteristics of SPV-based silage from a local sweetpotato variety, NASPOT 11. Specifically; the study sought to answer the following research questions:

- a) Can addition of solid ferment starters like maize bran or cassava flour produce silage of an acceptable quality?
- b) Does inclusion of sweetpotato roots or forage legumes affect the quality of silage?
- c) What is the chemical composition of SPV-based silage when different proportions of ferment starters, sweetpotato roots or legumes are used?

### **Justification**

In the framework of the RTB-ENDURE’s sweetpotato sub-project, research has been conducted to develop a low-cost forage preservation technique that may prove useful to smallholder farmers in increasing pig production and income. Use of a solid ferment starter would serve the double purpose of absorbing the excess moisture while providing the soluble carbohydrate that would enhance the fermentation process. The nutrients that would otherwise be lost in the effluent would also be preserved. In Uganda maize bran and cassava flour are two widely available resources that can serve as ferment starters in the ensiling of forages. Tropical forage legumes like Lablab and Gliciridia are widely available and could improve both the crude protein and calcium content of the silage if added at ensiling.

## METHODOLOGY

### Study site

The silage trial was set up in the Animal Science Laboratory located at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK). MUARIK is located 17 km to the North-East of Kampala. The area lies within the Lake Victoria Crescent with tropical climate. Average temperatures are 27°C.

### Study design

In this trial a total of nine different combinations of ingredients were tested for efficiency with which sweetpotato vines would ensile. Sweetpotato vines were collected from a field planted with the variety NASPOT 11 at MUARIK, chopped manually into pieces of approximately 2.5-3cm in length, and spread out to wilt for a minimum of 8 hours. After wilting, a ferment starter (additive) was added to the chopped vines in the ratios summarized in Table 1. A tenth treatment to which no additive was added, was used for comparison.

*Table 1: Summary of treatment structure for the micro-silos*

<b>Ingredients</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>	<b>VI</b>	<b>VII</b>	<b>VIII</b>	<b>IX</b>	<b>X</b>
Sweetpotato vines	100	80	95	97.5	95	97.5	72	64	72	64
Sweetpotato roots	-	20	-	-	-	-	18	16	18	16
Maize bran	-		5	2.5	-	-	-	-	-	-
Cassava flour	-				5	2.5	-	-	-	-
Lablab	-						10	20	-	-
Gliciridia	-						-	-	10	20
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### Experimental procedure

Fresh sweetpotato roots were bought from the market, washed to remove the soil, and chopped into fine pieces. Lablab and Gliciridia forages were collected from the field at MUARIK. The micro-silos comprised of plastic containers of 2kg capacity with a screw cap. The containers were filled with the material to be ensiled, and the material compacted to remove as much air as possible. The top of the container was covered using white polyethene then sealed using the screw cap. Each treatment was replicated three times. The packed silos were allowed to stand for a minimum of 45 days to allow the process of fermentation to come to completion.



### **Data collection**

The micro silos (containers) were opened after 45 days of ensiling. The pH was measured and recorded immediately. Organoleptic assessment was conducted on each replicate for organic acids like acetic, butyric and lactic, and NH<sub>3</sub>. These were scored as very low, low, moderate, high and very high. Physical characteristics such as colour, presence of moulds were observed and recorded, and mouldy silage was separated and weighed to determine the proportion of clean silage. Silage samples were oven-dried overnight at 60°C. The dried sample was ground with a micro hammer mill and sieved through a 1mm screen before chemical analysis.

### **Chemical analysis**

Silage samples were analyzed for: pH, Lactic Acid, Volatile Fatty Acids (VFAs), DM, CP, NDF, ADF, Ether Extract, Ca, P and Gross Energy. The pH was measured using calibrated pH electrode meter. Lactic acid was determined using a simple calorimetric assay according to Kimberly and Taylor (1996). VFAs (Acetic and Butyric) were determined by gas chromatography (flame ionization detector) as described by Weiß (2001). Dry matter, Crude protein, Ether Extracts, Calcium and Phosphorus were determined using the standard method of Association of Official Analytical Chemists (AOAC, 1990). NDF was determined using procedures described by Van Soest et al., (1991).

### **Statistical analysis**

Data were subjected to one way analysis of variance (ANOVA) using SAS (2003). Means were separated using LSD.

## RESULTS

Results of the chemical composition of the silage are summarised in Table 2.

**Table 2: Chemical composition of silage resulting from the different proportions forage and additives**

Parameter	Silage treatments									
	I	II	III	IV	V	VI	VII	VIII	IX	X
pH	3.94	3.98	3.83	3.95	3.94	3.92	3.90	3.94	3.93	3.95
Dry matter	21.98	23.23	24.63	25.26	26.74	28.10	26.69	26.68	23.50	23.62
CP (%)	19.71	17.38	19.58	19.88	17.38	17.24	18.42	19.10	19.40	19.63
NDF	31.86	24.76	27.33	25.38	23.53	23.65	25.96	30.46	20.49	24.51
EE	2.69	1.25	1.95	1.93	1.88	1.16	2.27	2.33	1.21	2.55
Ash	5.17	4.91	5.90	5.95	5.69	5.20	5.33	5.38	5.23	5.74
Calcium	1.27	0.83	0.96	0.87	0.95	0.86	0.99	1.00	0.98	1.10
Phosphorus	0.14	0.14	0.24	0.18	0.15	0.16	0.19	0.20	0.89	0.21

*Values on dry matter basis at 12 weeks of age.*

The pH of the silage ranged from 3.83 to 3.98 and was of acceptable quality in terms of odour and consistency. The results revealed that sweetpotato vines contain levels of easily available carbohydrates to support fermentation at a rate that would produce enough acids to reduce the pH to the point to preserve the forage. Adding maize bran or cassava flour tended to result into a product that was more firm with less moisture than when the forage was ensiled alone or with roots. Silos where sweetpotato vines were ensiled alone or with roots had some effluent at the bottom while the other silos did not have any trace of effluent. This indicated that the maize bran or cassava flour absorbed and bound the moisture of the sweetpotato vines to produce a firm and consistent product. Therefore, a silo could be designed without the need for modification to eliminate the effluent if a little amount of maize bran or cassava flour is added.

All silages were low in dry matter (DM), ranging from 220g/kg to 280g/kg. This implies that for young pigs with a limited stomach capacity their stomach would quickly fill without taking in enough dry matter for maximum performance. This would create a need to find ways of increasing dry matter intake.

The Crude Protein (CP) content of the silage was high for all mixtures. Growing pigs require 15-16 percent CP for optimum performance. Levels of CP ranged between 17.2% and 19.9% which would meet the protein requirements of growing pigs as long as the correct levels of essential amino acids are provided. Neutral Detergent Fibre (NDF), ether extracts and ash content were

within the acceptable ranges for feeding growing pigs. Sweetpotato silage would therefore form a suitable feed resource for pigs if the problem of low dry matter content could be overcome. The contents of calcium were low in the silage with a tendency of an improvement when legumes were included in the mixtures. Since growing pigs require 0.65 and 0.50 percent Calcium and Phosphorus respectively, a need for supplementation exists for maximum performance. Because at harvest there is a considerable content of rejected roots (because of small size, physical damage or infestation by weevils), the combination of 80:20 vines and roots was selected for the subsequent feeding trials. The limitation of low dry matter and deficiency of essential amino acids was addressed by supplementing the SPV silage with a complete concentrate.

## CONCLUSIONS

Use of maize bran and cassava flour in SPV-based silage eliminates the accumulation of effluent in the silo.

Mixing sweetpotato vines with roots at ensiling has no significant effect on the resultant quality of silage. Because at harvesting there is a considerable quantity of unmarketable roots that spoil, a combination of vines and roots is the recommended silage recipe for use by small-scale pig farmers in Uganda.

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