Theme 3: Fodder management and conservation

ENSILING SWEET POTATO VINES

A publication sponsored by the ICSIAPL project

GROWING AND ENSILING SWEET POTATO VINES

Learning Objectives

- Varieties of sweet potatoes grown for fodder.
- The best method of making silage from sweet potato vines.
- The stages of ensiling sweet potato vines (SPV)
- How to feed SPV silage to dairy animals.
- Benefits of using SPV silage as dairy feed.

Pic 2: *Field full of sweet potato vines.*

Introduction to Sweet potatoes

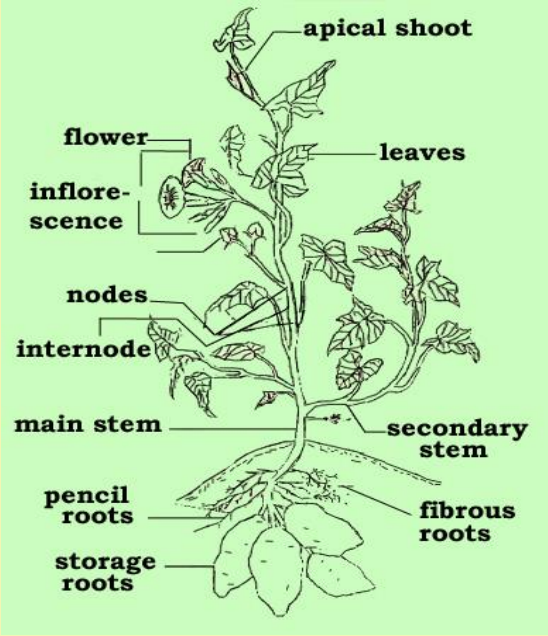
Sweet potatoes (*Ipomoea batatas)* are starchy root vegetables with elongated, tapered shapes of the roots. They come in various colors namely, bright green, red, purple, and black shades.

The vines are highly digestible resulting in high Metabolisable Energy (ME) and crude protein (CP) content . The vines are also rich in vitamin A & C, and potassium (K) a mineral. High ME and CP content in forages contributes to potential higher milk production in dairy animals and liveweight gain in beef animals

The main varieties of sweet potatoes grown in Kenya are:

- Maroko
- Wagabolige
- Ex. Mukurweini
- Saparo
- Kemb10
- KSB 20

The vines, vines and roots or vines and tubers can be used for fodder.



Pic 3: *Parts of a sweet potato plant*.

Sweet potato varieties grown for fodder in Kenya

The fodder varieties mature in 3-4 months, are drought tolerant, and yield more leaves and vines than other sweet potato varieties.

Dual-purpose varieties, are also grown in Kenya. Their tubers are used for human consumption and vines as fodder. These include*:

- Double double
- Mwavuli-1
- Shock 5

(*as per national crop variety list of 2022)

Wagabolige

Saparo

Maroko

Ex-Mukurweini

Pic 4: *Sweet potato varieties grown for fodder. (**Source** Sweet Potato silage making manual by CGIAR – Research Program On Root, Tubers and Bananas)*

Use of different parts of sweet potatoes plants as fodder

4.1 Sweet potato tubers

The tubers, containing carbohydrates (starch) are used as a source of energy in livestock feed. They can be fed raw, cooked, or processed into various forms such as pellets or silage.

4.2 Sweet potato vines and roots

The vines, leaves and roots of the sweet potato plant are chopped and fermented to create silage. They are rich in crude protein, vitamins, and minerals.

Growing sweet potatoes

5.1 Land selection and preparation

Choose a suitable location with well-drained soil and full exposure to the sun. Sweet potatoes prefer loose, loam or sandy soil. Prepare the soil by removing any weeds or rocks and loosen it to a depth of 20 to 30 cm.

5.2 Soil testing

Sweet potatoes prefer slightly acidic loam or very sandy soils.

The plants can tolerate a wide range of pH levels ranging from 5 to 7. However, the plants thrive at an optimum pH level of about 6.

Incase the soil is very low in nutrients; the farmer is advised to apply a handful of manure directly to the planting holes.

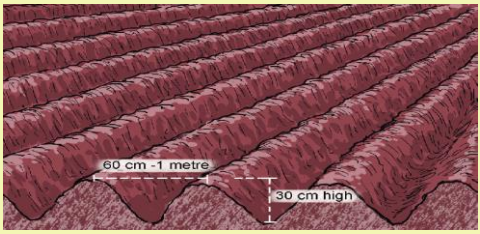
Pic 5: *Chopped sweet potato tubers and vines.*

Pic 6: *Testing soil to determine pH and the amount of lime needed.*

5.3 Creating Ridges

Sweet potatoes are typically grown on ridges or mounds to improve drainage and prevent waterlogging. As this would cause the root bulb to start rotting

Create raised rows of soil, about 30 cm high and 90 cm apart.



Pic 7: *Preparing ridges on land before planting sweet potato slips.*

5.4 Planting

Plant the sweet potato slips on top of the ridges, spacing them about 30 to 45 cm apart along the ridge.

5.5 Watering and mulching

After planting, water the sweet potatoes thoroughly to settle the soil. Maintain adequate moisture levels in the ridges by watering regularly.

Apply a layer of organic mulch, such as dry grass, along the ridges to conserve moisture and suppress weed growth.

Pic 8: *Ridges* set up before planting sweet potato slips.

5.6 Weed and Pest Control

Regularly weed the area around the sweet potato ridges during the early stages of growth.

To control pests when growing sweet potatoes, implement integrated pest management (IPM)* practices.

Other methods of pest control include monitoring the plants regularly for signs of pests, employing crop rotation or using biological controls.

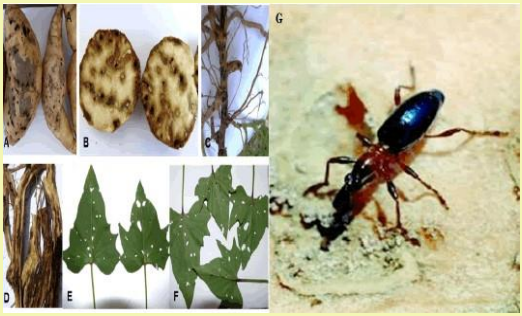
*__Integrated pest management (IPM),__ *is a broad-based approach that integrates both chemical and non-chemical practices for economic control of pests. IPM carefully considers all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.*

5.7 Harvesting

Sweet potatoes for fodder production are usually ready for harvest at around 3 to 4 months after planting.

It is important to harvest the fodder before it flowers because the feeding value is high.

The vines and leaves are usually giving a peak in green biomass at around this time, enabling the farmer to get plenty of forage for silage making.



Pic 9: *Weevil feeding damage on roots, stem, vines and leaves of sweet potato.*

Pic 10: *Sweet potato field ready for harvesting.*

Making sweet potato vine silage

Ensiling is a method to preserve the sweet potato vines (SVP) and roots in a succulent condition in a silo.

SPV silage is made by fermenting chopped vines and roots in the absence of air. It can then be stored for up to a year. Its protein content and good digestibility make it an excellent complement to tropical grasses in the cow's diet.
There are several methods farmers use to ensile sweet potato vines such as:
•Trench silo
•Stack silo
•Improved plastic tube silo (best method, see image on the right)

***Pic 11**: An improved plastic tube silo with internal drainage system for the silage tube. (source Sweet Potato silage making manual by CGIAR – Research Program On Root, Tubers and Bananas)*

Steps in silage making using an improved plastic tube silo

7.1 Chopping

Chop the vines into small pieces (1-2 cm long) using a chaff cutter or a panga. This facilitates good compaction and reduces air retention.

Chopping also increases the surface area of the vines and ensures that the forage ferments evenly.
The forage must not "sit" on a heap for more than 24 hours before chopping and ensiling to prevent heating in the heap, molding or excess drying. Which can all result in loss of nutrients.

Pic 12: *Chopping sweet potato vines with a chaff cutter. (source Mazingira Centre on Innovation Feeding Approaches for Dairy Farmers)*

7.2 Wilting

Spread out the chopped vines in thin layers on a clean plastic sheet, to wilt in the sun for about 1 hour. This reduces the moisture content of the vines.

7.3 Mixing

After wilting, the chopped vines can be mixed with maize stalk or Napier grass, though this will not enhance the nutritional quality of the SPV silage because digestibility and protein content of Napier grass and maize stalks are lower while fiber content of both ingredients is higher

7.4 Additives

A commonly used fermentable substrates for ensiling are molasses

Rice bran and/or maize bran are generally added to increase dry matter content and nutritional value of the silage.

Molasses should be mixed with water at the ratio of a 1-part molasses with 2-parts of water to make it easier to apply.

Sometimes live bacteria are added to the silage to promote efficient fermentation. An example is Ecosyl which contains *Lactobacillus plantarum*.

Other commercial additives are also used. They may contain enzymes and organic acids that aid in fermentation. Examples include inoculant blends, acidifiers, and aerobic stability enhancers.

Pic 13: *Adding molasses to chopped sweet potato vines.*

Pic 14: *Silage additive containing live bacteria Lactobacillus plantarum.*

Pic 15: *A 5 litres molasses bottle made from sugarcane in Kenya.*

7.5 Compaction

Compress the wilted material in an airtight container to eliminate any air pockets. This creates an oxygen-free environment, which is crucial for the fermentation process.

Each layer of chopped silage should be compacted to about 10-20 cm in size. Then sprinkle the molasses mixture on it until thoroughly wet after which a new layer is added.

7.6 Covering an improved plastic tube silo

Gather the excess tubing at the top and eliminate any remaining air to ensure the plastic is in close contact with the ensiled material.

Securely tie a knot using twine. The polyethylene covering to ensure the tube is airtight does not necessarily need to be in one piece.

To maintain, continuous compression during fermentation, place heavy stones on top of the silo or old concrete-filled tyres.

Pic 16: *Tightly compressing silage to remove air pockets.*

Pic 17: *Sealed plastic tube silo secured to the ground after ensiling.*

Pic 18: *Draining excess waste fluids from the silage tube.*

7.7 Fermentation

Open the drainage tap daily and leave open for the first 5 days. From week 2 to 4, open the drainage tap after every 4 or 5 days to drain any waste fluids.

Well-prepared sweet potato silage is bright or light yellow-green in color, has a strong smell similar to that of fermented milk and has a firm texture. Poor quality silage tends to smell similar to rancid butter or ammonia.

Challenges experienced during fermentation process of SPV

High moisture content: excess moisture can hinder anaerobic conditions and increase the risk of spoilage.
Low sugar content: insufficient sugar levels can result in slow or incomplete fermentation.
Low dry matter: high water content in sweet potato vines leads to low dry matter, diluting nutrients and fermentable sugars.
Insufficient compaction: inadequate packing can create air pockets, promoting undesirable microbial growth.
Poor sealing: improper sealing, not airtight, allows air entry, disrupting anaerobic fermentation and reducing silage quality.
Contamination: Soil or foreign matter during harvesting can introduce unwanted microorganisms.

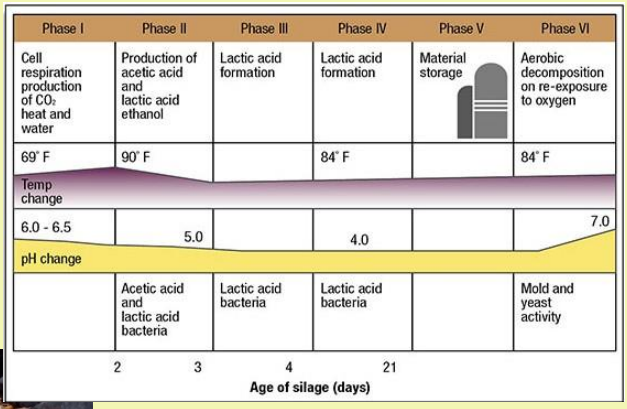


Table 1: *The six phases of silage fermentation and storage*.

Pic 19: *Perfectly fermented SPV silage*.

Lack of additives: absence of suitable additives may lead to uneven fermentation of silage which can shorten the amount of time it can be stored.
Insufficient fermentation time: inadequate time can lead to incomplete preservation of the silage. Silage requires a fermentation period of about 4 weeks.

Nutritive value of Sweet potato vines (SPV), Napier grass, Sweet potato vines-Napier mixture and silage

	DM	CP	ADF	NDF	EE
SPV	22.2	12.1	35.6	46.8	1.7
SPV silage	26.2	11.3	27.5	40.1	4.2
Napier	16.9	13.2	31.9	59.0	0.8
Napier silage	16.4	10.3	27.2	46.2	5.9
SPV-Napier	19.8	14.2	35.2	51.4	1.0
SPV-Napier silage	22.8	13.1	25.5	37.2	4.0

Table 2: *Nutrition quality of SPV vs Napier grass fresh and as silages*.

KEY:
- **Dry Matter (DM)** - *represents the concentration of nutrients in the silage*
- **Crude Protein (CP)** - *total protein content essential for animal growth & milk production*
- **Acid Detergent Fiber (ADF)** - *represents the indigestible fiber fraction in the silage*
- **Neutral Detergent Fiber (NDF)** - *is a measure of the fibrous content in silage which influences feed intake and rumen function*
- **Ether Extract (EE)** - *represents the fat content in the silage*

Feed-out

Feed-out involves the steps followed by dairy farmers to effectively incorporate the SPV silage into the diet of their cattle.

These steps ensure that the dairy animals get a balanced diet to maximize benefits of this feed resource.
Avoid wastage of silage during storage and feed-out.

Pic 20: *Introduction of silage in dairy cattle feed*.

9.1 Feed-out steps

Opening the tube:

Removal from storage: **si**lage is removed from the plastic tube silo as needed for feeding. Ensure proper handling and equipment to prevent contamination and maintain silage quality.

Unloading: transfer the silage from the silo to the feeding area.

Remove of spoiled portions: Any visibly moldy silage is discarded to prevent health issues in the livestock.

Closing the tube

Ration formulation and mixing: incorporate the silage into the daily ration of the dairy cattle. This may involve mixing it with other feed ingredients, e.g. supplement with Napier grass and/or concentrates to make a balanced diet.

Daily ration management: plan the daily rations including SPV silage based on each animals' requirements, (e.g., Live weight, production level, stage of lactation etc) and availability of other feed ingredients.

Pic 22: *Non-moldy SVP silage fit for feed-out* **.**

Pic 21: *Exposed moldy top-layer of silage during feed-out***.**

Feed monitoring: observe and preferably measure feed intake and behavior of the dairy cattle to ensure they get the right amount of silage, without spoiling it. Adjust the ration if necessary to meet their nutritional requirements and production level.

Feed safety and hygiene: clean out the feed troughs to prevent any silage from the previous day from molding and contaminating the new feed.

Feed waste management: avoid providing more silage than can be eaten by the cows to prevent wastage. Prevent silage spoiling from overexposure of the feed face of the silo and unused /collected silage in front of the feed face.

Feeding SPV silage to dairy cattle

Gradual introduction: **i**ntroduce the SPV silage gradually into the animal's diet to allow the animals to get used to it. Start with small amounts and gradually increase over a period of 7-10 days.

Feed analysis: if possible, analyze the dry matter content and protein (CP)and energy (ME) content in the dry matter. This makes calculation of the ration for each animal or animal category easier. In the absence of feed analyses, a quality assessment needs to be done based on values in feed databases such as feedipedia. (https://feedipedia.org/)

Feeding frequency: Dairy animals should be fed such that the ration is available 24 hours including SPV silage or to keep the feed in the trough fresh at least 2 to 3 feedings per day.

Quantity of SPV silage in a diets for dairy and beef cattle

Stock	Quantity (kg/day)
Lactating dairy cow	10-20
Dry cows	10-15
Dairy heifers	5-8
Beef breeding cows	12-20
Pigs (Sows)	2-5

Table 3: *Quantities of SPV silage in diets for different livestock categories. (source Sweet Potato silage making manual by CGIAR – Research Program On Root, Tubers and Bananas)*

Pic 23: *Removing sweet potato vine silage for feeding to cows*

Water availability: provide access to clean water at all times, as dairy animals consuming silage, which has a higher dry matter content, may have increased water requirements.

Animal health monitoring: observe feed intake, signs of digestive issues or nutritional imbalances and consult with a ruminant nutritionist if needed.

Challenges of using sweet potato vines silage as dairy feed

Nutrient composition: Sweet potato vine (SPV) silage may have variable nutrient composition depending on e.g. soil fertility, variety, season, cutting stage, leading to inconsistent and unbalanced diets for dairy animals, supplementation with other feed ingredients is recommended.

Dry matter content: Sweet potato vines (SPV) can have high moisture content, if not pre-wilted resulting in low dry matter content of the SPV silage . This can affect the overall ration formulation, feed intake and therefore nutrient intake of the animals.

Pic 24: *Cattle enjoying clean water after feeding on silage*.

Pic 25: *Spacing cattle during feeding to ensure maximum feed intake*.

Fermentation quality: inadequate fermentation or poor ensiling practices can lead to sub optimal silage quality, affecting nutritional value and palatability for the animals.

Palatability and acceptance: **s**ome dairy animals may initially find the taste and texture of sweet potato vine silage unappealing because they are not familiar with it, this can affect their intake and acceptance.

Digestibility: Late harvesting of sweet potato vines i.e. 5+ months, increases the chances of higher ADF (Acid Detergent Fiber is slow or difficult digestible fiber) levels in the silage. As a result, the lower digestibility of the silage hinders nutrient absorption by dairy cows.

Handling and storage: Silage requires proper handling and storage techniques to maintain its quality. Inadequate storage conditions can lead to spoilage, mold growth, or nutrient losses.

Pic 26: *Cool and dry storage of SPV silage***.**

Pic 27: *SPV silage stored in a dry shed***.**

Benefits of sweet potato vines (SPV) silage

Nutritional value: It provides energy, protein, and fiber for balanced nutrition and increased milk production in dairy animals.
Cost-effective feed: Making sweet potato vines silage during the growing (wet) season reduces feed costs during the dry seasons when forage can be scarce.
Easier to digest: In table 4 on the right, it shows that the digestibility of the ensiled vines & roots is higher as compared to the ensiled sweet potato vines. Cows can digest fermented forage quicker hence utilizing the feed more efficiently. This results in less waste in the undigested material that they excrete.

Nutritional value of fresh sweet potato vines vs SPV silage (Crude Protein and Neutral Detergent Fibre % on Dry Matter (DM) basis

	Dry Matter %	Crude Protein %	Neutral Detergent Fiber %	Metabolize Energy (MJ/kg DM)	Digestibility %
Sweet potato vines; fresh	13	16.0	46	8.3	60
Sweet potato silage; vines & roots	28	16.2	20	13.3	69

Table 4: *Nutritional values of fresh sweet potato vines and silage.*

Improved milk production: The nutrients in SPV silage can be combined with other forages e.g. maize silage and concentrates to make a balanced diet that can enhance milk yield and quality in dairy animals.
Requires less land to grow: Sweet potato vines offer more Crude Protein (CP) and Dry Matter (DM) per unit area on small land parcels, compared to other commonly used livestock feed grown in Kenya.

Pic 28: *SPV silage preparation*.

Disadvantages of sweet potato vines (SPV) silage as fodder

Limited availability: availability of sweet potato vines for silage production may be inconsistent in certain regions of Kenya but also on the farms, limiting its use as a reliable feed source.
Palatability concerns: dairy animals may exhibit varying acceptance of sweet potato vine (SPV) silage due to differences in taste and texture because they are not familiar with the feed.
Limited research: Compared to other forage crops, there is limited research and/or written information available on inclusion of SPV silage in cattle diets. This poses challenges in optimizing its inclusion in dairy animal diets.

Pic 29: *Sweet potato plantation in the sandy coastal region of Kenya*.

Pic 30: *Sweet potato plants growing in loam soil*.

Categories of animals that can benefit from SPV silage as feed

Dairy cattle: Sweet potato vine silage provides a source of energy, protein, and fiber. These nutrients, depending on the rate of inclusion in the diet, can increase milk production by up to 30% in some dairy cows.
Goats and sheep: Small ruminants like goats and sheep benefit from the nutritious forage that supplements their diet, especially during periods of forage scarcity.
Pigs : Sweet potato vine silage is best fed to pigs that are 3 months or older and weigh more than 25 kg. should constitute 60% of daily ration with 40 % provided by the supplement.

Pic 31: *Increased milk quality and production from utilizing SPV silage on feeds*.

Summary and key messages

Select splits from the sweet potato varieties developed for fodder by KALRO. They produce more vines and leaves which is ideal for silage production.

To achieve the best silage quality, aim for a Crude Protein (CP) content of around 12% to 16%, a Dry Matter (DM) content of 30% to 40%, and a pH below 4.5. These conditions can typically be achieved when sweet potato vines have undergone approximately 150 days of continuous growth.

Additives such as cassava meal, maize meal and molasses can be used during silage making to improve the silage quality.

Pic 32: *Dairy cows feeding on SPV silage.*

- END -

Ministry of Foreign Affairs of the Netherlands

About the ICSIAPL Project

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KALRO
Kenya Agricultural & Livestock Research Organization

SNV