Use of crop residue as feed for ruminant livestock

A guide for smallholder farmers

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Dry maize stover stacked under a tree on a farm in Moshi, Tanzania

(photo credit: ILRI/Margaret Lukuyu)

What is crop residue?

Crop residue is the portion of planted crops left over after harvesting human food crops or after processing of the main product. The quality of crop residues is generally poor since they are high in fibre and low in digestibility and crude protein. However, they form a big proportion of dry season feed for ruminants in smallholder farms in developing countries. Examples of such crop residues and indications of their quality are presented in Table 1.

Table 1: Indicative nutritive value of some common crop residues

Crop residue	Dry matter (%)	Crude protein (%)	Crude fibre (%)
Maize stover	91	6.0	42.0
Sugar cane bagasse	95	3.0	43.1
Rice straw	92	4.2	42.3
Cassava leaves (dried)	90	24.7	17.3
Wheat straw	86	4.0	42.0
Barley straw	86	4.0	42.0
Sugar cane tops	26	5.0	32.6
Sorghum stover	25	6.0	28.1
Banana stem	5	3.2	19.1
Bean haulms	90	8.0	37.1
Cowpea haulms	95	13.7	29.9
Pigeon pea hay	90	14.5	32.5

Source: Lukuyu et al. (2012)[1]

1 Lukuyu, B., Gachuiri, C.K., Lukuyu, M.N., Lusweti, C. and Mwendia, S. 2012. *Feeding dairy cattle in East Africa*. Nairobi, Kenya: East Africa Dairy Development Project.

Importance of crop residues

Crop residues are important for livestock production because they:

i. form a big proportion of maintenance diet for livestock in times of feed scarcity such as during dry seasons;

ii. are freely available on most smallholder farms after crop harvest or can be acquired at very low cost; and

iii. are mainly dry and, therefore, can be stored for a long time.

Factors affecting crop residue quality

Stage of crop at harvest

When a crop is harvested early—for instance, green maize harvested for roasting (Photo 1a)— the resultant residue is of higher quality compared to stover, which is obtained after maize is harvested after drying in the field (Photo 1b).

Photo 1a: Maize harvested at green stage produces high quality residue

Source: https://www.standardmedia .co.ke/article/2001304662/we-must-save-kenyan-maize-farmers

Photo 1b: Maize harvested at grain maturity produces low quality residue

Source: https://www.infonet-biovision.org/ AnimalHealth/Conservation-maize-stovers

Harvesting method

Harvesting of stover should minimize the loss of leaves as they are more nutritious than stems (Photo 2a). It is preferable to harvest crop residues in the morning when leaf shattering is low because of the presence of morning dew. The quality of crop residue is reduced when some of the plant parts are lost through shattering or breakage (Photo 2b).

Photo 2a: Maize stacked in the field in order to dry so that the grain can be harvested. The stover available for feeding livestock will be of better quality.

Source: https://www.infonet-biovision.org/AnimalHealth/Conservation-maize-stovers

Photo 2b: Maize stover left scattered in the field after grain harvest may lose the leaves and husks, which are of better quality, leaving the stem only.

Source: https://www.infonet-biovision.org/AnimalHealth/Conservation-maize-stovers

When crop residues are left in the field (Photo 3a) they are exposed to sun and rain, the nutrients are washed away, and they may decompose or be attacked by ants. Hence, the quality goes down. When stored for too long, the feed resource dries too much, loses colour and may decompose (Photo 3b).

Photo 3a: Maize stover heaped and left in the field is exposed to sun and rain and quickly deteriorates in quality.

Photo credit: ILRI/Margaret Lukuyu

Photo 3b: Crop residue stored for too long loses colour and may decompose and deteriorate in quality.

Source: https://www.infonet-biovision.org/AnimalHealth/Conservation-maize-stovers

Processing

Processing crop residues—e.g. chopping, soaking, urea treatment and ensiling—can improve the quality of crop residues in terms of palatability and nutritional value.

Smallholder farmers often harvest green maize at its milk stage to be sold for roasted cobs (Photo 1a.). In areas where irrigation is practiced, irrigated maize is usually harvested while green in order to maximize the benefits from irrigation such as the ability to do multiple cropping. Such cropping systems allow production of green and fresh stover, which is more nutritious and palatable for livestock than dry stover. The green maize stover may be processed using a mechanical feed chopper and conserved as silage. This reduces wastage, allows mixing of homemade rations, conserves nutrients in the green residue and improves palatability.

How to store crop residues

Traditional storage

In many farms, maize, sorghum and millet stovers are often left in the field and animals are let out to graze on them. Although the method is low cost, it results in losses of up to 50% of dry matter from trampling and spoilage (Photo 4a). This method is more applicable in areas where stover is plentiful. In other cases, the stover is gathered into a heap and left in the field (Photo 2b) or under a tree (Photo 3a), only to be collected when being fed to the animals. This method also results in heavy losses due to the effects of weather and decomposition.

Photo 4: Cows grazing maize on stover left in the field after harvest

Photo credit: ILRI/Margaret Lukuyu

Baling

Crop residues can be gathered and baled using a manual box baler and stored in a raised shed (Photo 5).

Baling has the following advantages:

- It reduces the cost of transportation.
- It reduces the space required for storage.
- The feed resource remains intact (no shattering of leaves and husks).
- It is easy to measure the quantity to feed.

On the other hand, baling involves higher capital expenditure in terms of labour (for cutting, gathering and compacting), equipment and construction of a storage facility.

Photo 5: Baling crop residues makes it easy to store in a small raised shed.

Photo credit: A. Mwilawa

Platform

A platform on the ground or raised and constructed using local materials (Photo 6a and b) may be used to protect crop residues from becoming mouldy and being attacked by ants.[2] However, since the feed resource is exposed to rain and sun, it will quickly deteriorate in quality.

Photo 6a: Low platform used to store crop residues

Photo credit: A. Mwilawa

Photo 6b: Raised platform used to store crop residues

Adapted from: S. Panigrahi et al. 1995.

Improved shed

A roofed shed constructed using local material will protect crop residues from the effects of rain and sun (Photo 7a), thus preserving the quality. Improvement of the shed can be done by replacing the grass thached roof with corrugated iron sheets and putting a wall on the shed (Photo 7b). While the iron sheets may protect forage against the rain, the cost may be beyond what most smallholder farmers can afford. It may also reduce insulation against too much heat during the day.

Photo 7a: Improved roofed shed for storing crop residues constructed with locally available materials

Source: S. Panigrahi et al. 1995.

Photo 7b: Improved shed constructed using iron sheets and with walls is more efficient in protecting crop residues from effects of weather.

Photo credit: A. Mwilawa

Storage in bags

Chopped residue can be stored in bags (Photo 8). It is advisable to place the bags under a shade or inside a roofed structure and off the floor to prevent the material at the bottom from becoming dump and rotting.

2 S. Panigrahi, P.W., Wareing, S., Ncube, T.S. and Huq, M.S. 1995. *Benefits of storing fibrous feed residues for ruminant livestock – and human health*. DFID's Livestock Production Programme.

Photo 8: Chopped crop residues stored in a bag. Make sure the bag allows for air circulation so as to prevent mouldiness.

Source: https://www.infonet-biovision.org/AnimalHealth/Conservation-maize-stovers

Improving the quality of crop residues

Chopping (e.g. straws and stover)

Un-chopped crop residues can be difficult for animals to eat (Photo 9). Although chopping crop residues such as stover or straw to 5 cm or a little longer before feeding may not significantly affect the nutrient content, it offers the following advantages:

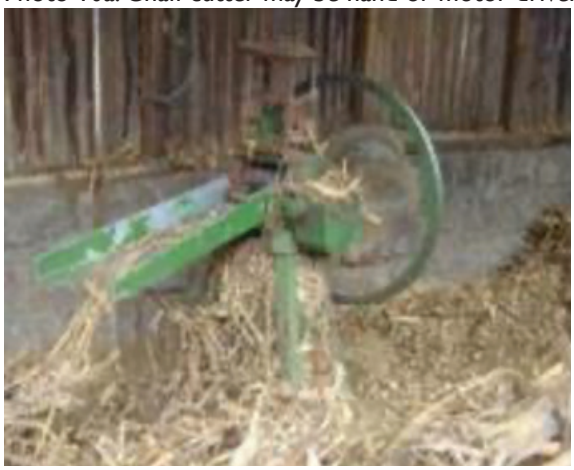
- It increases intake by the animals (leading to increased milk output).
- It reduces feed wastage.
- It makes it easy to mix with other feed components to make homemade rations.

Photo 9: A cow struggling to eat unchopped maize stover. The result is low intake (hence low milk output) and feed waste.

Source: https://www.infonet-biovision.org/

Crop residues may be chopped using a manual chaff cutter or motorized forage chopper (Photo 10 a and b).

Photo 10a: Chaff cutter may be hand or motor driven.



Source: https://www.infonet-biovision.org/

Photo 10b: Motorized feed choppers can serve groups of farmers. Here, a youth group in Ethiopia is chopping green maize stover.

Source: LIVES project 2014

A motorized feed chopper offers the following advantages:

- reduces waste by promoting more efficient use of feed materials
- reduces manual labour for chopping often assigned to women
- minimizes cost for purchasing feed by offering alternative local feed sources
- encourages shift to zero-grazing based systems
- saves labour in the production of mixed feed rations
- cuts cost of purchase and maintenance by creating interest in farmers to get organized in groups to share forage choppers
- leads to generation of employment opportunities for youths who assist farmers, particularly women, in transporting and operating the machines.

On the other hand, capital is required to purchase motorized feed choppers. There is also need for training in operation and maintenance of the equipment.

Soaking with or without salting

Chopped straw may be sprinkled with or soaked in plain water or a dilute salt or molasses solution before feeding. Farmers who have practiced it reported that it led to increased feed intake (Lukuyu et al. 2016).[3]

Urea treatment

Treating crop residues with 4% urea solution at 45–50% moisture improves the nutritive value by increasing the digestibility, palatability and crude protein content. Although the process is simple and farmers can easily practice it, care must be taken in order to avoid urea poisoning. Follow the procedures below.

i. Weigh 100 kg of material and spread on a polythene sheet or tarpaulin.

ii. Mix urea and water in a watering can or garden sprayer at the rate of 4 kg urea (fertilizer grade) in 100 litres of water (4%), i.e. 400 g urea should be mixed with 10 litres of water, (Urea readily dissolves in water).

Photo 11: Sprinkling water urea mixture onto chopped crop residue

iii. Sprinkle the solution on the material on the ground (Photo 11), then mix thoroughly by hand or use a shovel.

iv. Compact material firmly inside a polythene or plastic bag, preferably the thicker gauge (1.5 to 2 m in size, tied at lower end with sisal twine).

v. Repeat steps 2, 3, 4 and 5 until the polythene bag is filled up. Tie the polythene to ensure it is air-tight (1.5 to 2.0 m bag can hold about 150 to 200 kg feed material). After 21 days, the urea treated material is ready for feeding to the animals.

Supplementation

Supplementing crop residues with fresh grasses, legumes or concentrate feeds significantly improves feed intake and animal performance. Mixing with urea, molasses, yeast and salt provides both energy and nitrogen to the microorganisms in the rumen, improving the digestion of crop residues. One mature dairy cow can be fed 10 kg of chopped wheat straw or maize stover mixed thoroughly with a mixture containing 2 kg molasses, 150 g urea, 10–15 g yeast and 200 g salt, all dissolved in three to five litres of water in a plastic bucket. The liquid mixture is normally sprinkled on the chopped material using a watering can and then thoroughly mixed (Kashongwe et al. 2017).[4]

3 Lukuyu, M., Njehu, A., Mwilawa, A., Lukuyu, B., Omore, A. and Rao, J. 2016. *A study to understand fodder markets and fodder trading patterns in MoreMilkiT sites and other selected regions in Tanzania*. Nairobi, Kenya: ILRI.

4 Kashongwe, B.O., Bebe, B.O., Ooro, P.A., Migwi, P.K. and Onyango, T.A. 2017. Integrating characterization of smallholders' feeding practices with on-farm feeding trials to improve utilization of crop residues on smallholder farms. *Advances in Agriculture*. https://doi.org/10.1155/2017/6952407

Diets based on wheat straw or maize stover supplemented with urea and molasses or treated with urea only and supplemented with 2 kg dairy concentrate can support milk yield up to seven litres per cow per day.

Ration formulation

Rations formulated based on local feed resources have a huge potential to improve milk production on smallholder farms at a lower cost. The wide variety of locally available crop residues can enable the formulation of 'best bet' rations for farmers to choose from depending on what is available in their locality. Examples of crop residue-based rations are given in Table 2.

The choice of ration will usually be based on a cost-benefit analysis which takes into account:

- availability of ingredients locally
- cost of ingredients
- milk price

Table 2: Daily crop residue-based rations for dairy cattle and expected milk yield

	Quantity (kg) of ingredient in the ration					
	Ration I		Ration II		Ration III	
Feed Ingredient	Fresh	DM*	Fresh	DM	Fresh	DM
Maize stover (85% DM)	5.0	4.3	3.4	2.9	1.9	1.6
Bean haulms (92% DM[5])	2.5	2.3	2.9	2.7	3.2	2.9
Natural collected grass (30% DM)	9.6	2.9	10.0	3.0	8.0	2.4
Sunflower cake (90% DM[6])	1.1	1.0	1.9	1.7	2.5	2.3
Maize bran (85% DM)	0.9	0.8	1.3	1.1	2.6	2.2
Total feed	19	11.2	20	11.4	18	11.4
Expected milk yield (litres/ cow/day)	10		15		20	

*Weight on dry matter basis

One or several crop residues may be included in a ration depending on availability. Where only one crop residue is available, recommended proportions in the total ration are given in Table 3.

Table 3: Recommended proportion of different crop residues in complete rations of ruminants

Crop residue	Percent in complete ration
Maize stover	30–70
Sugarcane bagasse	20
Sorghum straw	20–45
Dry mixed grass	30–75
Sunflower straw	30–50
Sunflower heads	35–50
Wheat straw	50
Mango leaves	30–60
Rice straw	40–50
Cotton straw	45

Source: FAO 2010[7]

Problems that may be experienced when feeding crop residues

i. **Bloat**: this is not common but may occur where crops have a regrowth. Sorghums are known for this problem.

ii. **Mineral deficiency:** when animals graze crops of the cabbage family (cabbage, cauliflower and kales) continuously for a long time, they may suffer iodine deficiency. Symptoms include abortion and death of young animals.

iii. **Poisoning**: some crops such as potatoes tubers (unmarketable tubers after harvest), turn green when exposed to light and may cause poisoning. Feeding of potato leaves should also be limited.

iv. **Choking**: livestock can choke on tubers, maize cobs and other large pieces of food. Blockage of the oesophagus in ruminants, which happens when animals partly swallow solid pieces of food such as tubers of potatoes, carrots or maize cobs, results in severe bloat and death.

5 Ayoade, J.A., Makhambera, P.E. and Bodzalekani, M.Z. 1983. Evaluation of crop residues as feeds for goats. Part 1. Voluntary intakes, digestibility and nitrogen utilization of groundnut and bean haulms. South *African Journal of Animal Science* 13(1).

6 https://www.grainsa.co.za/use-of-sunflower-oilcake-in-dairy-cattle-rations

7 FAO. 2010. *Successes and failures with animal nutrition practices and technologies in developing countries*. FAO Electronic Conference 1–30 September 2010.

Steps to prevent problems

i. Always chop tubers of any crop (e.g. potatoes, carrots and radish) before feeding to prevent choking or blockage of the oesophagus.

ii. When you are not familiar with the feeding qualities of the crop residues, seek advice from your local agricultural extension officer or from literature.

iii. Make effort to find out if the crop residue was exposed to moisture and look out for signs of fungal growth or test for fungal toxins.

iv. Be aware of the potential danger of residues from crops that are usually sprayed with poisons for control of pests and diseases and follow the safe use of these products.

v. Always investigate poor animal performance to find out possible causes.

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The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research for development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative. Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation, and impact assessment.

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