



# Sustainability and Food Security through Judicial Use of Agricultural Wastes by Technological Intervention for Animal Feeding

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

India has approximately 600 million livestock, which requires almost 1000 million tons of hay or green fodder to sustain present level of productivity. Despite the fact that cereal crop residues are of low feeding value (i.e., poorly available nitrogen, low digestibility with lack of useful minerals) and have low voluntary intakes (around 1.5-2 kg/100 kg mature body weight), they constitute and continue to be an important feed resource for sustainable dairy production in the developing world. Annually >20 million tons of straw biomass is being burnt in the field due to various reasons which is causing serious environmental pollution. On this view feeding trial of urea treated maize straw and huller rice bran and silage of maize feeding in cow was conducted. Urea treated straw feeding was 5.9± 0.3 kg/ day/animal with concentrate and roughage ratio was 40: 60. Total feed intake was 13kg/day/animal. Urea treatment of straw (UTS) costing average 0.84 Rs/kg and feeding of UST decreased the concentrate requirement by 20% saving average 8503Rs/Inter calving period/cow. UTS also prevent the decrease in milk yield by 10% when green fodder was not available. Costing of Silage making was 0.72Rs/kg and feeding of silage increased the milk yield and net income by 10% and 10,516Rs/Animal/ year, respectively. From this study it can be concluded that the dairy farming could be a profitable entrepreneurship when farming with application of urea treatment and silage technology for agricultural wastes.

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*Keywords: Maize crop residue; urea treatment; banana; silage.*

## 1. INTRODUCTION

India has approximately 600 million livestock, which requires almost 1000 million tons of hay or green fodder to sustain present level of productivity. The prices of conventional feed ingredients as well as grains are constantly escalating globally. Crop residues, comprising mainly of straw (from fine grains such as wheat, oat, rice etc.) and Stover (from coarse grains such as maize, sorghum, millets etc.) obtained after harvesting the crops, form an abundantly available feedstock (~4 billion metric tons globally) for ruminant feeding [1]. In India, annual availability is >100 million metric tons each of rice straw, wheat straw and sugarcane bagasse, which are otherwise unfit for human consumption. Despite the fact that cereal crop residues are of low feeding value (i.e., poorly available nitrogen, low digestibility with lack of useful minerals) and have low voluntary intakes (around 1.5-2 kg/100 kg mature body weight), they constitute and continue to be an important feed resource for sustainable dairy production in the developing world [2,3]. Straws of legume crops have generally better nutritive value, forage quality and thus are nutritionally superior to cereal straws. Stovers have better nutritional quality than straws with respect to intake and organic matter digestibility (>50% vs. <50%) [4]. Straws and stovers are generally used to feed low producing animals or can be used as a source of bulk in the high producers' ration to fulfill their appetite, can help correct physically effective fibre shortage for milk fat synthesis in high concentrate feeding systems and may beneficially provide additional heat increment during cold stress conditions [4]. General ratio of straw: grain is 1:1 to 1:3.

Management of crop residues linked with burning of straws is a real 'burning issue in country like India, [3,5]. Annually >20 million tons of straw biomass is being burnt in the field due to various reasons which is causing serious environmental pollution. It is advisable to feed straw rather than burning it at least from the point of methane emission and as the land devoted for green forage production is not expected to expand beyond its present level (i.e., 4% in India), and the crop residues are produced without additional allocation of land and water [6], there is an urgent need for the efficient utilization of nutrients from crop residues.

If these are utilized judiciously this may provide enough energy and nutrients to the animals. Organic and low input dairy production relies on feeds, especially forages, produced on-farm. To sustain milk production, feed supplements are typically used either for cattle, sheep or goats to balance the rations in terms of e.g. energy and protein supply and intake of essential nutrients. By-products from agricultural, forestry, food processing and bioenergy sectors can be considered sustainable sources to fulfill the need of additional feeds for milk producing animals, and agro-forestry systems may provide additional roughage in the diet. Ruminants are particularly suited for converting fibrous by-products into valuable animal products. Innovative use of novel and underutilized feed resources has the potential to improve the efficiency of the "green economy" [7]. Objective of this study to introduce some neglected and underutilized crop waste for animal feeding through technological interventions.

## 2. MATERIALS AND METHODS

The study area had feeding of urea treated crop residue wastage and silage to dairy animals. Total 125 farmers from 13 villages of Banka district were randomly identified from which have trained from Krishi Vigyan Kendra, Banka and regularly fed Urea treated straw and silage and they were interviewed personally using standard procedure with pre-module questionnaires. The data generated were analysed by independent samples t-test using SPSS-24.

## 3. RESULTS AND DISCUSSION

Urea treated maize straw feeding was  $5.9 \pm 0.3$  kg/ day/animal with concentrate and roughage ratio was 40: 60. Total feed intake was 13 kg/day/animal. Urea treatment of straw (UTS) costing average 0.84 Rs/kg and feeding of UST decreased the concentrate requirement by 20% saving average 8503Rs/Inter calving period/cow. A milch cattle with 400 kg body weight producing 5 kg milk would have a cost benefit ratio of 1.45 while in case of treated straw the cost benefit ratio would increase to 1.67. The feeding of urea treated straw is comparatively more viable in economic term as farmer can save 12.9 rupees more from same animal with same production level [8]. UTS also prevent the decrease in milk

yield by 10% when green fodder was not available. Presently Bihar produces 19 lakh MT of maize. By the year 2020 the state will be producing 90 lakh MT (estimated 2020 data as per Agri Road Map). Grain to Stover ratio which measured was approximately 2:1. For example a farmer producing 10 tons from 5 acres of land of maize should expect about 5 tons of maize stover in the farm. The crude protein content of stovers and straws increases when treated with urea. There is also increased dry matter intake, live weight gain and milk production from urea treated stovers and straw compared to untreated material [9]. Estimates of 180 to 200 kg of maize cobs produced per ton of grains [10] translate to significant quantities of maize cobs being potentially available as feed resources. Costing of Silage making was 0.72Rs/kg and feeding of silage increased the milk yield and net income by 10% and 10,516Rs/Animal/ year, respectively. You can be able to estimate the amount of stover produced from a unit of land by using a grain to Stover ratio which measured at approximately 2:1. For example a farmer producing 10 tons from 5 acres of land of maize should expect about 5 tons of maize stover in the farm. Common practice among farmers is where the whole stalk and leaves is fed to livestock without chopping or any kind of treatment. This results in high wastage and very low intake because a cow for example will choose to eat the leafy part and part of the stalk leading to major losses. The nutritional content of crop residues is low in utilizable nutrients i.e energy, protein and trace elements. Here lignin makes material unavailable by binding with proteins and other compounds. This masks what is in the cell making them impossible to be reached by rumen microorganisms. The crude protein content of stovers and straws increases when treated with urea.

### 3.1 Maize Cob/Cob Cover

Estimates of 180 to 200 kg of maize cobs produced per ton of grains [10] translate to significant quantities of maize cobs being potentially available as feed resources. Corn cobs (CC) are a by-product of a major cereal grown worldwide. Since the ratio between corn grain and CC may reach 100:18, a large quantity of CC can be generated [11]. It was concluded that ground corn cobs used as the whole roughage source in TMR containing 60% concentrate significantly improve nutrient intake and milk yield in lactating dairy

crossbred cows [12]. Currently the cob is used in its intact form after removal of grain or ground into smaller particles. Farmers, therefore, burn the maize cobs for heating and cooking, plough them back in the fields or throw them away.

Powdered corn cobs can be a good ingredient in hog and poultry feeds. During the dry months when grass is not available, the crushed corn cob can be a substitute for forage grass Zbsarian [13]. Maize cobs are not very palatable to ruminants [14]. Adding 1% molasses may help to improve intake [15]. When fed with restricted grain rations, ground maize cobs have replaced up to 60% of the roughage (alfalfa hay) without affecting milk production or composition, although feed intake was reduced when maize cobs were the only source of roughage [16]. Ground maize cobs replacing 50% of alfalfa-grass hay resulted in a lower milk yield but in higher weight gain [17]. Ground maize cobs included at 20% of the ration were a better roughage than ground alfalfa hay, and equal to chopped alfalfa hay, for maintaining feed intake and milk production, but neither cobs nor alfalfa hay maintained the pretrial milk fat concentrations [18]. Inclusion of up to 30% maize cobs in the diets of West African Dwarf goats (supplemented with brewers grains, wheat offal and palm kernel cake) gave the best growth performance. There were no deleterious effects on the haematological and serum biochemical parameters and, therefore, they were considered safe to include in ruminant diets up to 30% [19]. In India, adult goats were maintained on a diet of 60% maize cobs and 40% commercial mixture [20]. Ground maize cobs (8-mm sieve) were fed *ad libitum*, either in a mash or pelleted, as roughage for adult goats (with 250 g/d of concentrate mixture) without any deleterious effect, but pelleting improved nutrient utilization [21].

**Table 1. Total mixed ration with Maize cob/stover**

Ingredients	Quantity (%)
Maize cob/straw	50
Mustard cake	16
Rice polish	10
Wheat bran	5
Molasses	15
Mineral	2
Salt	1
Urea	1
Total	100

### 3.2 Sugarcane Crop Residue

Sugarcane is the major cash crop in Bihar. In India Sugarcane is a major commercial crop for Sugar industries. In Bihar, it is grown in an area of 2.65 lakhs hectare with an average productivity of 69.72 ton per hectare and sugar recovery of 9.22% against the national average of 68.8 t/ha and 10.17% respectively. Presently Bihar produces 125 lakh MT of sugarcane. By the year 2022 the state will be producing 250 lakh MT.

#### i) Whole sugarcane

Whole sugarcane is not commonly fed to animals or cultivated as a fodder crop since it fetches a fairly high price for sugar production. However, under certain conditions, such as excessive production of cane and delay in harvesting, rejection of the cane by the factory, non-availability of irrigation and non-availability of fodder crops, whole sugarcane is sometimes fed to the animals. Feeding trials conducted on crossbred cattle producing 10 to 12 litres of milk indicate that whole sugarcane can easily replace conventional fodder crops like sorghum with an average intake of 20.5 kg per day and dry matter digestibility ranging between 56 to 57 percent [22].

#### ii) Sugar cane leaf

Sugarcane tops, as indicated earlier, are utilized in many areas as green fodder during the harvesting season. Trials conducted on ensiling of sugarcane tops with urea produced encouraging results and good quality silage could be obtained. Ensiling of tops for preservation is now being popularized. In most of the sugarcane producing areas the tops are the sole green material available to dairy animals

particularly between January to April when it is relatively dry. The average quantity of tops available is about one third of the cane harvested. These are mostly fed as green to the animals or sometimes dried and stored and fed like cereal straws (in Western Maharashtra). However, in some areas like South Gujarat tops are used as fuel and now attempts are being made, by organizations like ours, to convince the farmers on the use of tops for feeding animals and to ensile them for storage.

#### iii) Sugarcane Bagasse

Bagasse is available in sugar factories and crushers after extraction of juice. Average bagasse production is about 30 percent of the sugarcane crushed and about 90 percent of bagasse produced is used as fuel. A small quantity is also available with farmer during the process of jaggery preparation. Parity large proportion of bagasse is used as source of energy in the form of fuel for boilers. So, the thinking in terms of using bagasse for feeding cattle in view of increasing shortages of good roughages and increasing interest in milk production by farmers. The palatability and nutritional value of bagasse for the livestock (cattle and buffaloes) are much better than the rice hull available from the huller rice mills and the latter may be used as fuel saving the former for the feeding in need during scarcity period. The bagasse were found low in protein and also raw and steam treated bagasse were unpalatable despite supplementation with salt. But steam treated significantly improve the digestibility. Supplementation of 1 kg concentrate mixture is beneficial in improving the nutritional status of animal fed urea molasses supplemented bagasse and steam treated bagasse [23].

**Table 2.**

Total mixed ration with sugar cane bagasse		Total mixed ration for non lactating animal weighing 150-300 kg	
Ingredients	Quantity (%)	Ingredients	Quantity (Kg)
Sugarcane bagasse	50	Sugar cane bagasse	2
Maize	12	Sugar cane leaf	3
Mustard cake	17	Molasses	0.8
Wheat bran	4	Urea	0.035
Molasses	15	Salt	0.030
Urea	1	Mineral mixture	0.05
Mineral	1		

Table 3.

Chemical composition (% on dry matter basis)									
	CP	EE	CF	N.F.E	Ash	Silica	P	Ca	Source
Banana Stem	8.5	4.69	22.78	49.63	14.65	2.52	0.42	2.30	Research Highlights of ANRS (1973-2004), AAU, Anand. P 203.
Sugarcane bagasse (Raw)	1.4	1.44	40.51	54.11	2.52	1.34	0.07	0.24	Research Highlights of ANRS (1973-2004), AAU, Anand. P 216
Sugarcane bagasse (Steam treated)	1.4	1.78	39	55.43	2.34	1.35	0.08	0.29	ADF-(54-51) ADL-(13-12)
Sugar cane top	6.2	1.5	30.9		8.5				D.V. Rangnekar
Sugar cane (6 month)	3.4	1.4	21.7	68.1	5.4				D.V. Rangnekar
Maize straw	3.6	2.1	26	60	8	4	0.23	0.25	Research Highlights of ANRS (1973-2004), AAU, Anand. P 31.
Maize cob	1.7-3.8	1.86	30.54	62	2.68	0.81	0.06	0.19	Research Highlights of ANRS (1973-2004), AAU, Anand. P 48.
Maize cob cover	4	1.44	32	60	4	1.65	0.09	0.30	Research Highlights of ANRS (1973-2004), AAU, Anand. P 48.
Huller rice bran/Rice kuski	7.6	4.2	26	42	19	15.77	0.53	0.17	Research Highlights of ANRS (1973-2004), AAU, Anand. P 33.
Rice polish	12	17	5	56	10	4.8	1.21	0.19	Research Highlights of ANRS (1973-2004), AAU, Anand. P 44.
Pineapple waste	4.5	1.2	17.8		8.1		0.13	0.5	Simon et al., 2005

### 3.3 Technologies Developed for Utilization of Agricultural Wastes

**Total Mixed Rations for Dairy Cattle:** A total mixed ration (TMR) is composed of forages, commodities/byproducts (such as whole cottonseed), grains, protein supplement(s), minerals, and vitamins that have been mixed together to make a balanced ration in which the weight of each ingredient is known. This mixture is then offered to cows as their sole source of feed. By blending together all the forages, grains, commodities, and protein and mineral-vitamin supplements, cows are less able to selectively consume individual ingredients. Ideally, each bite of feed a cow consumes will contain the same proportion of forages and concentrates. TMR can be defined as, "the balancing and combining of all feeds into one complete ration". This complete ration provides all essential nutrients that are required to meet the needs of the animal.

Feed costs decrease because include feeds they previously could not feed easily. Decrease the cost of purchased concentrates when byproducts are purchased in bulk and included in the mixed ration. Increased the DMI as the peak DMI is achieved 4 to 8 weeks earlier than conventional systems. Optimal microbial protein synthesis: (maximised at pH of 6.3 to 7.4). Increased milk production by approximately 5 to 8%. Each additional kg DM consumed increases milk yield by 0.9 to 1.5l. Improved fat% because of improved rumen fermentation, and optimal pH (6.2 to 6.8) achieved, resulting in both maximal rumen fermentation and cellulose digestion leading to the formation of acetic acid, the precursor of butter fat production. Reduced digestive upsets due to each bite of feed having the same composition, minimising pH fluctuations in the rumen. No need to feed mineral/vitamin supplements as all the requirements included in the TMR. Eliminate concentrate feeding at milking. Variety of less palatable feeds can be utilized in the ration: as these are masked by the other ingredients by the elimination of selection. Better control of the cow's diet [24].

**Complete feed block (CFB):** Complete feed block is composed of forage, concentrate and other supplementary nutrients in desired proportions capable to fulfil nutrient requirement of an animal. This system is economical and efficient as it allows inclusions of low cost Agro industrial byproducts and low quality crop residues with their efficient utilization. Complete feed supplies readymade, balanced, low cost

ration for ruminants for the benefit of landless labourers and small farmers. The CFBs were found to be very nutritious, easily digestible and handy to transport. The blocks have dimension of 0.5 cubic feet containing about 13% proteins and 50 to 55% total digestible nutrients. The nutritive value is 33% higher than common feed [25].

**Urea molasses mineral block licks:** The urea molasses mineral block (UMMB) is a strategic feed supplement for ruminant animals. Molasses, urea and other ingredients are used in the manufacture of molasses/urea feeds that are prepared as blocks. Unpalatable ingredients also included and made palatable by making UMMB. It is well established that the benefit of using UMMBs is through enhancing the efficiency of rumen fermentation, which increases the digestibility and intake of forages, leading to greater supply of microbial protein for production purposes. There is another dimension to supplementing poor quality forage-based diets with the blocks, and that is lower emission of methane per unit of forage digested or per unit of meat or milk produced when supplementing with the blocks, because of better rumen fermentation.

#### Urea treatment of straw:

##### Process:

- i. Chaffing/thrashing of crop residue/stover by chaff cutter to 1-2" size.
- ii. Collect/store the chopped straw at a safe and dry place till further use.
- iii. Weigh 100kg straw for urea treatment
- iv. Make the urea solution by dissolving 4 kg urea into 40 liter water.
- v. Spread the straw layer on polythene or tarpaulin sheet.
- vi. Fill the urea solution in a container and spray over straw layer uniformly.
- vii. Fill the urea treated straw immediately in an airtight bag and close it properly.
- viii. Ensure the complete air tightness of bag and keep it for at least 2 weeks.
- ix. Open the bag; remove top 1-1 ½ inch layer and offer the straw to livestock.

**Solid state Fermentation:** The neglected and Underutilized agricultural by products have high lignin content and lower digestibility and protein content and poor palatability of crop residues and grasses discourage their use as the sole animal feed. Lignin, being a cementing material in plant cell wall restricts the fullest accessibility of carbohydrates, the energy reserve, to the

microorganisms inside the gut of ruminating animals. Among various microorganisms known for lignin degradation, white- rot fungi (majorly basidiomycetes) have been adjudged most promising lignin degraders and have been largely studied for bioconversion of plant residues into nutritionally digestible animal feed under solid-state fermentation (SSF) conditions [26,27]. Out of various selective lignin degrading fungi, only few have been studied in detail (*Lentinus edodes*, *Pycnoporus cinnabarinus*, *Cereporiopsis subvermispora* and *Phlebia brevispora*) at laboratory scale [28,29,30].

The fungus *Crinipellis* sp. RCK-1 has potential in degrading lignin and not affecting much of cellulose and can therefore improve the nutritional quality of crop residues like wheat straw. *Crinipellis* sp. RCK-1, owing to its fast growing and selective lignin degrading nature, proved to be a potential candidate for effective solid state bioconversion of wheat straw into digestible and nutrient rich animal feed (Biotech Feed). The production of Biotech Feed, capable of replacing 50% grains, needs further interventions to make it a commercially viable product [31].

#### 4. CONCLUSIONS

From this study it can be concluded that use of agricultural waste like maize straw, maize cob cover and maize cob also use of others like banana stem as animal feed after nutrient enrichment through urea treatment and silage making make dairy farming profitable and prevent burn of crop waste in field.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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