Usage of crop residue for making livestock feed

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ILRI PROJECT REPORT

Usage of crop residue for making livestock feed

Seshukumar Avadhanam, Anand Polumati and Saradhy Ellamraju

Process Engineering and Technology Transfer Department
Council of Scientific and Industrial Research–Indian Institute of Chemical Technology, Hyderabad

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Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock

ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

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Executive summary

The Council of Scientific and Industrial Research–Indian Institute of Chemical Technology (CSIR–IICT) and the International Livestock Research Institute (ILRI) are attempting to find alternate raw materials for preparing animal feed/concentrate. Rice straw has been identified as one of the key raw materials for preparing the concentrate. Since rice straw, as it comes from the farm, is not palatable for animals, it was decided to find a process to improve its composition and thereby its palatability. IICT has tried two processes namely, chemical pre-treatment (CT) and steam explosion. Feed prepared by the treated rice straw was used for animal trials by ILRI and showed encouraging results. This report presents the lab and bench scale results of IICT and the equipment requirements along with block flow diagrams to operate 500 kg/ batch CT process or 250 kg/batch steam explosion process. The cost of the project and power requirements are discussed as is the availability of market and raw materials for such rice straw–derived feeds. The report also highlights government policy for livestock development and its associated industry and presents a business plan for running a pilot plant for improving rice straw. Finally, the level at which the animal feed industry becomes viable is arrived and found to be one lakh tons per annum with an investment of INR180 crore.

1 Introduction

Rice and wheat straw is available in plenty in India, but most of it is burned on farm due to various reasons, mainly for clearing the farm for next sowing. These crop residues from rice and wheat crops are the basic starting materials for the preparation of feed for cattle, buffalo and sheep among others. These animals eat these crop residues along with green fodder and specially prepared concentrates or compound feeds. Unfortunately, burning of the crop residues in farms creates a serious pollution problem in the country.

Crop residues have for a long time been a major source of food for animals and will continue to be so for the foreseeable future. Though crop residues are the largest feed resource in the country, their use and development has not received proper recognition due to their bulkiness, poor nutrient density and high transport costs. Presently, these crop residues are mixed with nutrients to make compound feeds. These importance of crop residues will continue to grow due to a deficit in feed resources and a rising demand for livestock feed, which cannot be fulfilled by green fodder alone. The consumption of concentrate feeds is also increasing as more farmers are seeking increase the yield of milk or meat from their animals. Crop residues are the best bet for increasing the production of these compound feeds for animals. Therefore, reliance on crop residues for animal feed will continue.

1.1 Crop residues statistics and their consumption as fodder

In India, 501 million metric tons (MMT) of crop residues are generated annually out of which 70% or 362 MMT are from cereal crops (rice, wheat, maize and millet). Of this 34% (and 22% from wheat crop) is from rice crops working out to 123 MMT and for wheat crop about 80 MMT, most of which (about 92 MMT) is burned on–farm. This on–farm burning of rice straw causes not only severe pollution of land and water in local and regional levels but also an estimated nutrient loss to the soil of approximately 3.85 tons (t) of organic carbon, 59,000 t of N2, 20,000 t of phosphorus and 34,000 t of potassium. This information was given out by Niti Aayog in an article in *The Economic Times* in Feb 2019. Niti Aayog said that crop residues from rice and wheat crops can be used for various alternative purposes such as fodder for animals, for generation of electricity and as raw material to the paper/pulp industry.

It is estimated using data from various sources that Telangana and Andhra Pradesh together produce about 13.5 MMT (2014–15) of rice straw per annum.

Tables 1–3 give the total livestock in India as per 2019 census, the feed requirement of different animals per day and the estimated demand and availability of fodder in India as per the Compound Livestock Feed Manufacturers Association of India (CLFMA) data compiled in 2013–14.

Table 1: India livestock census 2019

Department of Animal Husbandry and Dairying, 20th census	
Cattle	192.49
Buffalo	109.85
Sheep	74.26
Goats	148.88
Pigs	9.06
Mithun	0.38
Yaks	0.06
Horses and ponies	0.34
Mules	0.08
Donkeys	0.12
Camels	0.25
Total livestock (millions)	**535.78**

Table 2: Typical quantities consumed by animals (kg/animal/day)

	Dry fodder	Green fodder	Concentrates
Cattle	5.50–6.00	4.00–4.75	0.3–0.6
Buffalo	6.00–7.50	4.00–6.00	0.4–1.0
Goats and sheep	0.20	1.00	0.06

Source: Dikshita and Birthal (2010).

Table 3: Total consumption of feeds and fodders in India (in MMT): 2003

Animal category	Population (million)	Green fodder	Dry fodder	Concentrates
Cattle	185.2	366.8	289.8	23.6
Buffalo	97.9	277.7	159.8	19.8
Goat	124.4	68.1	9.1	2.7
Sheep	61.5	37.0	4.3	0.9
Others	1.2	6.9	2.9	0.2
Grand total	**470.2**	**756.6**	**465.9**	**47.3**

By 2020 India would require 825 MMT of green fodder, 494 MMT of dry fodder and 54 MMT of concentrate feed.

Table 4: Projected demand and availability of fodder in India (by 2020)

Fodder	Demand projections (2020) MMT	Availability projections	Shortfall (2020) %
Dry fodder	468	417	11
Green fodder	213	138	35
Concentrate feed	81	44	45
Total	**762**	**599**	**91**

Source: CLFMA annual survey 2013–14, NDRI

Table 4 also projects the big gap in the availability of concentrate feed compared to dry and green fodder. By 2020, India would require 825 MMT of green fodder, 494 MMT of dry fodder and 54 MMT of concentrated feed. It is clear from the data in the tables above that both the demand and shortfall are high and there is a need to bridge the gap by looking in to all the available sources of feed in India. It is imperative to look for alternate resources for preparing the concentrate feed.

A typical feed composition as used by ILRI in their trials to find alternate resources for preparation of concentrate feed is given in Table 5. As identified by Niti Aayog and successfully tried by ILRI, use of crop residue for preparation of compound feed is a good alternative.

It is clear from the data in the Tables 1–4 that both the demand and shortfall are high and there is a need to bridge the gap by looking in to all the available sources in India. A typical feed composition as used by ILRI in their trials to find alternate resources for preparation of concentrate feed is given in Table 5. As identified by Niti Aayog and successfully tried by ILRI, the use of crop residue for preparation of compound feed is a good alternative. The processed used to do this are examined in this report.

Table 5: Likely formulation of the compound feed that will be marketed after using pre-treated rice straw with either the chemical pre-treatment process or the steam explosion process

Ingredient	**Quantity (%)**
Pre-treated rice straw	71
Soya meal	19
Molasses	8
Min mix	1
Salt	1
Total	**100**

1.2 Hay/straw analysis

Rice straw is fed to livestock in most areas where green fodder is scarce. Stubble that is left in fields after harvesting of rice is also grazed. Rice and wheat straw is readily available in India, hence in this report, preparation of compound feed using rice straw is considered. The chemical analysis taken from two different sources on a dry matter basis are given in Tables 6 and 7. Rice straw is a poor–quality feed in terms of protein and mineral content. It is high in lignocelluloses, silica and insoluble ash. Rice straw is also poorly palatable and its intake by animals is low. However, the intake of straw depends on straw type (coarse, fine, long, dwarf, leafy, steamy, fresh, stored, hard, and soft), animal species and breed, body weight of animals, other feeds in the ration, physiological state of the animal etc. In general, fine (slender), soft, long, leafy and stored rice straw is preferred by animals.

Looking at the composition of rice straw and its limited preference by animals because of its poor palatability, ILRI and IICT assessed whether it can be improved by identifying a suitable process that would enhance its palatability and improve its chemical composition.

Table 6: Laboratory analysis of rice straw samples

	CP	**ADF**	**TDN**	**Calcium**	**Phosphorus**
Sample	**Per cent by weight, Dry Matter basis**				
1	2.9	56.7	43	0.49	0.09
2	3.4	56.1	43	0.42	0.07
3	3.4	55.2	44	0.43	0.07
4	4.0	42.1	54	0.28	0.12
5	4.1	41.4	54	0.24	0.12
6	4.1	43.0	53	0.24	0.11

Source: Daniel et al. (2021)

Note: CP = crude protein; ADF = acid detergent fibre; TDN = total digestible nutrients. Samples are sorted from lowest to highest, CP. TDN is estimated from ADF for all samples as: TDN = 85.7–(0.756×ADF)

Table 7: Chemical composition of rice straw (% on dry matter basis)

Organic matter	**82**
Crude protein	4
Crude fibre	37
Non–fatty esters	43
Total ash	18
Calcium	0.14
Phosphorus	0.05
Neutral detergent fibre	75
Acid detergent fibre	54
Cellulose	37
Lignin	8
Silica	8

Source: Singh and Schiere (1995).

This report discusses in detail the alternate processes tried by CSIR–IICT at laboratory level and the encouraging results obtained by ILRI in its animal trials using the concentrate feed prepared from the pre-treated rice straw provided by CSIR–IICT and finally, it identifies the gaps in the data obtained in lab experiments for scaling up. It also discusses the cost of the project to establish a pilot plant to collect this data and take it to a commercially–viable size (Singh and Schiere 1995).

2 Process

ILRI approached CSIR–IICT for pre-treatment of biomass to be used as fodder for animals after the addition of nutrients. CSIR–IICT conducted biomass pre-treatment experiments using the biomass supplied by ILRI using chemical pre-treatment and steam explosion. The pre-treatment of lignocellulosic biomass is the key step, which is essential and challenging for facile conversion of biomass to valuable products. After the initial evaluation of different pre-treatment methodologies available in literature and based on the generated data, CSIR–IICT, Hyderabad, developed a chemical–based pre-treatment method and steam explosion method and evaluated the process at length for its effectiveness at both laboratory and bench scale. The pre-treatment processes available in literature were evaluated and modified to delignify the biomass and to prepare feed stock from raw rice straw supplied by ILRI.

2.1 A lab and bench scale process for preparing rice straw to make fodder mixture for animal trials

The biomass supplied by ILRI was preprocessed by milling to the required size and was achieved with minimum power consumption. It was then pre-treated using a chemical process and a steam explosion process. The pre-treatment process developed by CSIR–IICT was simple, with very low dosage of chemical input and high solid loading, coupled with simple operating conditions with recycling and reusing of the water used in the process. Between 20 and 30 experiments were conducted by recycling and reusing the chemicals and water by steam explosion and chemical pre-treatment processes which are described below. The experimental results are given in Tables 8 and 10.

Steam explosion

Steam explosion experiments were conducted in the 50 L SS steam explosion unit using 1–6 kg dried rice straw at 140–170°C with a residence time of 10 minutes with and without alkali addition as given in Table 8. The pre-treated mother liquors were processed through membrane filtration and 70–80% of water was recycled in the process. The analysis of the different pre-treated biomass samples revealed that alkaline peroxide addition was efficient in the removal of 80–85% lignin and improving the overall cellulose and hemicellulose content. The experimental results were tabulated in Table 9.

Table 8: Stepwise procedure of steam explosion

Step	Procedure
Step 1	Coarse sizing of biomass from 300–100 mm using circular straw/suitable cutting unit to size of 25–50 mm
Step 2	Pulverizing the biomass from 25–50 mm to 2–5 mm in two stages. Stage 1: 10–15 mm Stage 2: 2–5 mm
Step 3	Collection and storage
Step 4	Material handling –transportation to the reactors
Step 5	Prewash – for removal of sand/mud
Step 6	Charging of biomass and addition of chemicals Quantities of chemicals for 1 kg batch of biomass: water =1.5 kg; no chemicals: pressure = 10 bar, temperature = 170^0 Sequence: (i) Charge water and biomass, (ii) maintain the pressure for fixed residence time, (iii) record the corresponding temperature, (iv) blow down the biomass to the expansion chamber, (v) wait until the temperature cools down, and (vi) discharge the material.
Step 7	Process monitoring and control. pH monitoring at 30 min intervals and adjusting pH as required.
Step 8	Discharge the liquid, solid–liquid separation, centrifugation to remove excess water
Step 9	Drying using Rotocone dryer
Step 10	Delumping of dried pre-treated biomass using suitable pulveriser

Table 9: Experimental results data

S. No	Biomass (kg)	Water (kg)	Chemicals (kg)		Temp (°C)	Time (mins)	Pressure (bar)	M.L. weight (kg)			Cake weight (kg)
			NaOCl	NaOH				Before wash	After wash	Total	
1	1	1.5	NA	0.440	171	10	10	5.16	NA	5.16	6.23
2	1	1.5	NA	NA	172	30	10	8.38	NA	8.38	5.21
3	2	3	NA	NA	150	60	4	15.4	NA	15.4	2.40
4	1	Nil,	0.2	NA	170	15	10	12.6	NA	12.6	3.70
5	1	Nil,	0.18	NA	150	60	6	21.6	NA	21.6	10.60
6	6	30	NA	NA	170	30	10	300	NA	300	38.04
7	6	30	NA	NA	172	30	10	187.4	NA	51.5	28.88
8	6	60	NA	NA	171	30	10	218	NA	218	22.98
9	6	60	NA	NA	172	30	10	300	NA	300	14.85
10	6	60	NA	0.03	172	30	10	72	80	152	33.70
11	6	60	NA	0.06	172	30	10	80	NA	80	28.30
12	6	60	NA	0.075	170	30	10	85	NA	85	37.37
13	6	60	NA	0.120	171	30	10	32	NA	32	20.89
14	6	60	NA	0.120	170	30	10	110	NA	110	34.40
15	6	60	NA	0.180	170	30	10	36	NA	36	41.75
16	6	60	NA	0.180	170	30	10	72	NA	72	25.60
17	6	60	NA	0.180	170	60	10	80	NA	80	31.60
18	6	60	NA	0.180	170	30	10	80	NA	80	28.20
19	2	20	NA	0.060	140	60	4	18	NA	18	4.23

The equipment and utilities used in the operation of a steam explosion are: electrode boiler: Heater: 66 kW, air compressor of power load: 4 kW, compressed refrigerated air dryer of power load: 0.4 kW, vacuum pump of power load: 1 kW.

Chemical pre-treatment

In this process, alkaline treatment was carried out using oxidizing agents such as H_2O_2 alone or in combination with alkali as given in Table 10. The required chemicals included acids, alkali, oxidizing agents, surfactants and ionic liquids for pre-treatment. The role of H_2O_2 is essentially to promote removal of lignin and break the lignin-carbohydrate bonds. The optimized process includes low temperature operation in atmospheric pressure for minimum chemical consumption. The water from the pre-treated mother liquor was recovered and recycled through membrane filtration and 70–80% of the water was recycled in the process. The alkali treatment experiments were conducted using NaOH with different concentrations ranging from (0.05 2.25w/w), temperature in the range of 40–50°C and a reaction time of 3–4 hours with a solid loading of 10–20% using 10-litre and 1,000-litre reactor vessels. The experimental results are tabulated in Table 11 below.

Table 10: Chemical pre-treatment process

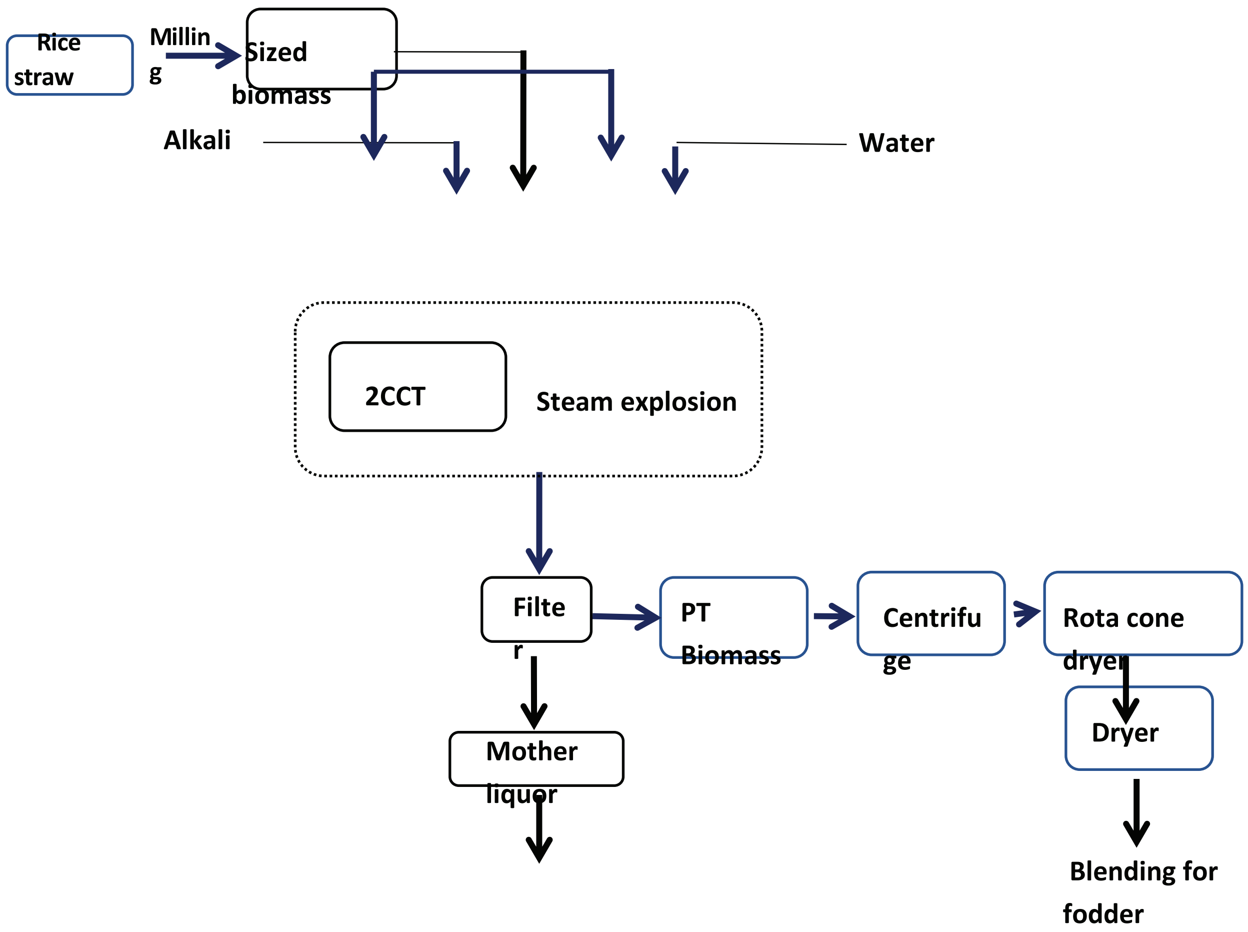
Step	Procedure
Step 1	Coarse sizing of biomass from 300–100 mm using circular straw/suitable cutting unit to size of 25–50 mm
Step 2	Pulverizing the biomass from 25–50 mm to 2–5 mm in two stages. Stage1: 10–15 mm Stage 2: 2–5 mm
Step 3	Collection and storage
Step 4	Material handling – transportation to the reactors
Step 5	Prewash (For removal of sand/mud)
Step 6	Charging of biomass and addition of chemicals Quantities of chemicals for 1 kg batch of biomass: water =12 kg ; NaOH=100 gm; H_2O_2=100 gm Sequence: (i) charge water, NaOH, (ii) check the pH of the solution, (iii) preheating of biomass to 45⁰C, (iv) slowly under stirring with 60 rpm for 30 mins. Ensure pH is between 11.5 and 12.0.
Step 7	Process monitoring and control. PH monitoring at 30 mins intervals and adjusting pH as required.
Step 8	Discharge the liquid, solid–liquid separation, centrifugation to remove excess water
Step 9	Drying using Rotocone dryer
Step 10	Delumping of dried pre-treated biomass using suitable pulveriser

Table 11: Experimental results data

S. No	Biomass (kg)	Water (kg)	Chemicals (kg)		Temp (°C)	Time (hrs)	Reactor (litres)	M.L. weight (kg)			Cake weight (kg)
			H_20_2	NaOH				Before wash	After wash	Total	
1	0.5	5	0.280	0.05	50	4	10	4.9	NA	4.9	2.0
2	4.5	60	1.7	0.250	46	4	100	55	NA	55	21.0
3	4.5	60	1.7	0.250	46	4	100	58	NA	58	23.0
4	4.5	60	1.7	0.250	46	4	100	59	NA	59	20.0
5	4.5	60	1.8	0.250	46	4	100	58	NA	58	24.0
6	4.5	60	1.7	0.250	46	4	100	58	NA	58	22.0
7	32.0	600	9.0	1.50	46	4	1,000	550	NA	550	188.0
8	35.0	700	10.0	2.25	47	4	1,000	680	NA	680	204.0
9	35.0	700	10.0	2.25	47	4	1,000	690	NA	690	158.5
10	35.0	700	10.0	2.25	44	4	1,000	670	NA	670	191
11	35.0	750	10.0	2.25	46	1,000	1,000	740	NA	740	169
12	0.325	5.32	0.0937	0.032	48	4	10	5.5	NA	5.5	1.5
13	35.0	750	10	2.6	48	4	1,000	740	NA	740	212
14	35.0	750	0.3	5.0	48	4	10	7	NA	7	3.2
15	35.0	750	10	5.0	48	4	1,000	720	NA	720	172.5
16	35.0	750	10	4.0	46	4	1,000	700	NA	700	184.5
17	35.0	750	10	4.0	47	4	1,000	750	NA	750	180
18	35.0	750	10	3.5	45	4	1,000	750	NA	750	171
19	35.0	750	10	4.0	46	4	1,000	750	NA	750	161
20	35.0	750	10	3.5	46	4	1,000	720	NA	750	195

The analysis of the different pre-treated biomass samples revealed that alkaline peroxide treatment was efficient in the removal of 80–85% lignin and improving the overall cellulose and hemicellulose content. The equipment and utilities used in the operation of a chemical Pre-treatment in 10L reactor: Fluid circulator of power loads 3 kW, vacuum pump of power load of 1 kW, agitator motor of power load of 0.5 kW. The equipment and utilities used in the operation of a chemical pre-treatment in 1 KL reactor: electrode boiler of power load of 36 kW, vacuum pump of power load 0.5 kW, dosing pump of power load: 12 W, water charging pump of power load of 1.5 kW, agitator motor of power load: 3.7 kW.

Figure 1: Flow diagram for lab or bench scale process used by IICT



3 Pilot plant

The pre-treated biomass (rice straw) was analysed for its composition and compared with the raw straw. Tables 12 and 13 give the chemical compositions of raw straw and chemically treated straw, respectively. It can be noticed that the treated straw has improved in many ways, essentially in reduction in lignin content and increase in protein and other nutrients. The results of tests performed by ILRI on animals (goats and sheep), which are given in Table 14, were very encouraging. Based on this experience, a decision was made to start the next level of the process, experimentation at pilot-plant level, to test whether it can become the basis for commercialization of the process and process designs.

The lab or bench scale operations normally used in a research and development (R&D) laboratory involve only a few steps as most of the unit operations are done manually. However, at pilot scale, each step involves significant material handling, measurements and estimations. When one designs a pilot plant to give an input of 500 kg/batch by CT process and 250 kg/batch by steam explosion process, the equipment requirement changes, though the process conditions are maintained. The bench scale process is analysed for its unit operations and appropriate equipment are identified and sizes are estimated to give the final results, namely the chemical composition same as at lab/bench scale. Selection of the equipment and size are such that the process followed at the pilot plant level will be identical to the bench scale process. Since bulk density of rice straw is very low, a continuous process is envisaged at pilot plant level to the pre-processing stage. However, the main process for pre-treatment remains batch mode only. In this report, the pilot plant described is designed as per the following:

1. Pre-processing equipment is common to both CT and steam explosion processes and is continuous to give 300 kg/hr production
2. Chemical pre-treatment process is for 500 kg/batch production.
3. Steam explosion process has a capacity 250 kg/batch.

The process is illustrated in the block flow diagrams in Figure 2–Figure 4. Equipment sizing shown in the block flow diagrams is done on the following assumptions.

a. Bulk density of 2–2.5 mm raw straw is 0.15 t/m^3.

b. Foreign matter in raw straw is 10%.

c. Bulk density of wet straw is 0.5 t/m3 or 0.5 kg/l.

d. Bulk density of soaked straw is 0.6 kg/l or 0.6 t/m^3.

These are to be measured and recorded while performing experiments on pilot plant.

Figure 2: Block diagram for processing of straw to fodder-processing of equipment

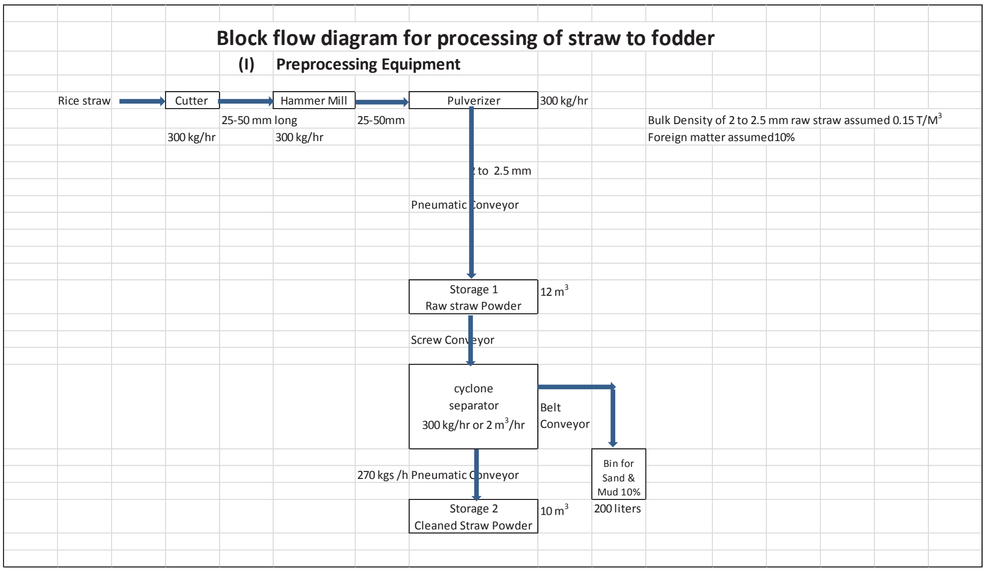


Figure 3. Block diagram for processing of straw to fodder–chemical pre-treatment

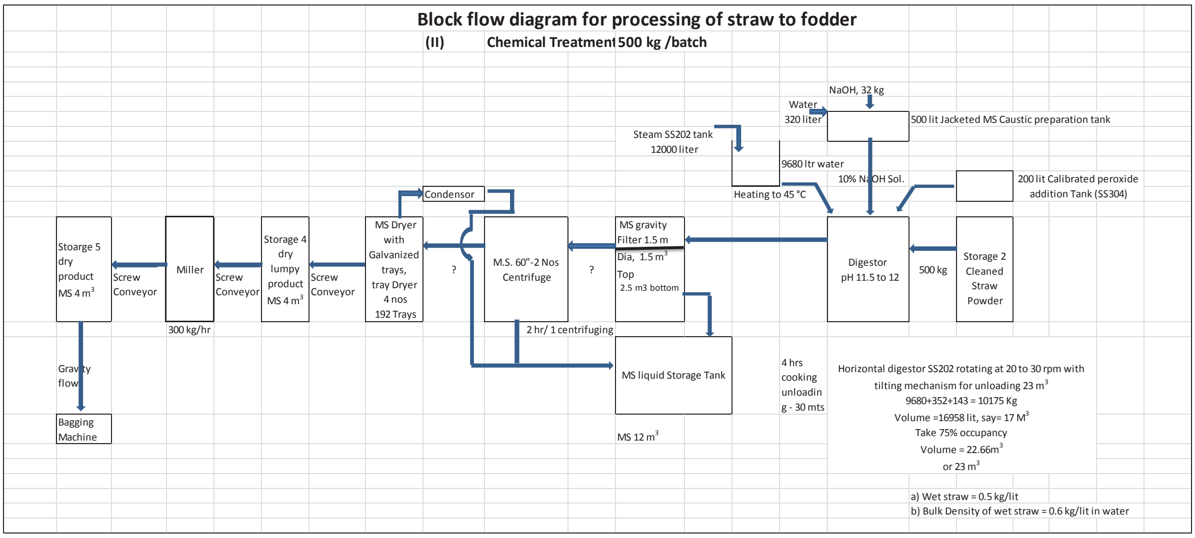
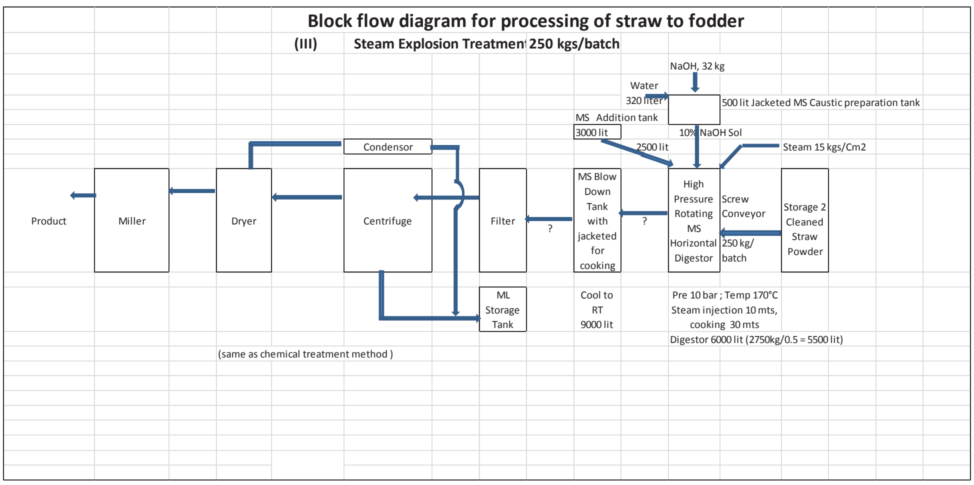


Figure 4: Block diagram for processing of straw to fodder-steam explosion



The equipment required for the pilot plant is listed in Tables 12–14. The tables also give the approximate cost and power requirement for each of the equipment. In the absence of measured or reliable engineering data, the equipment sizing may not be accurate and only when the pilot plant is run and all the engineering data collected can the adequacy and accuracy of each the equipment be established. This data will help to give a basic design process with reasonable accuracy for designing a commercial plant.

Table 12: Preprocessing equipment – 300 kg/hr

S. no	Equipment	Description size/capacity	No.	Power (HP)	Cost (INR lakhs)
1	Rice straw	Bundling and storing in shed			
2	Cutter	300 kg, mild steel (MS)	1	3	0.60
3	Hammer mill	300 kg, MS	1	5	1.00
4	Pulveriser	300 kg, MS	1	7.5	1.20
5	Pneumatic conveyor		1	2	0.50
6	Storage 1– raw straw powder	12 m^3, MS	1	–	3.60
7	Screw conveyor		1	1	0.50
8	Cyclone separator	300 kg/hr or 2 m^3/hr, MS	1	3	6.00
9	Pneumatic conveyor			2	0.50
10	Belt conveyor			1	0.50
11	Storage 2– cleaned straw powder	10 m^3 MS	1	–	3.00
12	Storage 3 – bins for storage of sand and mud	200 l MS	4	–	0.60
	Total			24.5	18.00

Table 13: Chemical pre-treatment process – 500kg/batch

S. no	Equipment	Description size/capacity	Numbers	Power (HP)	Cost (INR lakhs)
1	Storage 2 – cleaned straw powder	10 m3			
2	Screw conveyor		1	1	0.50
3	Digester	Horizontal digester SS202 rotating at 20 to 30 rpm with tilting mechanism for unloading 23 m^3	1	40	20.00
4	Hot water tank	12,000 l –SS202 with stirrer	1	4	5.80
5	Caustic preparation tank	500 l jacketed MS tank with sitter	1	1	1.50
6	Peroxide addition tank with pump	SS–304–200 l	1	1	1.00
7	Gravity filter	1.5 m diameter 1.5 m^3 top 2.5 m^3 bottom MS	1	–	1.80
8	Liquid storage tank with pump	MS 12 m^3	1	3	4.40
9	Conveyor		1	1	0.50
10	Centrifuges	60 inches basket type MS	2 x 15	30	7.00
11	Conveyor		1	1	0.50
12	Tray dryers	MS 192 trays dryer, galvanized trays electrical	4 x3 HP 8 kW (14 X 4)	56	8.80
13	Condenser		1	–	0.60
14	Screw conveyor		1	1	0.50
15	Storage 4	MS 4 m^3	1	–	1.50
16	Screw conveyor		1	1	0.50
17	Miller	300 kg/hr	1	5	1.00
18	Screw conveyor		1	1	0.50
19	Storage 5	MS 4 m^3	1	–	1.50
20	Bagging machine		1	5	6.00
				151	63.90

Table 14: Steam explosion process – 250 kgs/ batch

Sl. no	Equipment	Description size/ capacity	Numbers	Power (HP)	Cost (INR lakhs)
1	Storage 2 – cleaned straw powder	10 m3			
2	Screw conveyor		1	1	0.50
3	High pressure digester	Boiler steel horizontal rotating digester – 6,000 l 10 bar	1	20	15.00
4	Caustic preparation tank	500 l jacketed MS tank	1	1	–
5	Water addition tank with pump	MS 3,000 l	1	3	1.40
6	Blow down tank	MS jacketed tank/ 9,000 l	1	–	3.00
7	MS gravity filter	1.5 m diameter, 1.5 m^3 top 2.5 m^3 bottom	1		(*)
8	Liquid storage tank	MS 12 m^3	1		(*)
9	Conveyor		1		(*)
10	Centrifuges	60 inches basket type MS	2		(*)
11	Conveyor		1		(*)
12	Tray dryers	MS 192 trays dryer, galvanized trays	4		(*)
13	Condenser		1		(*)
14	Screw conveyor		1		(*)
15	Miller	300 kg/hr	1		(*)
16	Screw conveyor		1		(*)
17	Storage	MS 4 m^3	1		(*)
18	Bagging machine		1		(*)
				25	**19.90**
	Grand total			**200.50**	**101.80**

(*) This equipment is already accounted for in CT and pre-equipment sections.

4 Finances

To establish and run a facility having a pilot plant with all the equipment listed in Table 12–14 requires other supporting facilities such as land and buildings and other infrastructure. It also requires estimates and provision for all expenditure that will be incurred while putting up the facility. All these costs need to be planned for and to arrive at the final cost of the project. Many of the estimates are based on the experience and the norms generally followed by financial institutions and banks. Once the cost of the plant and machinery is arrived at, other capital expenses are based on the percentage of capital expenditure depending on the complexity of unit operations. More accurate numbers can be obtained when actual designs are frozen based on the engineering data collected in the pilot plant and the costs obtained from the vendors/equipment manufacturers.

The cost of the scheme comes to INR 574.00 lakhs, which covers most of the administrative and financial expenses during the establishment of the facility. The facility itself is versatile and by the time all the pilot plant runs are completed it gives a good idea on which of the two processes is a better option technically and financially (viability). It also helps in freezing the equipment and sizes for pre-treatment of raw straw for a plant of any capacity.

Tables 15 give the details of the cost of the scheme for setting up of pilot plant and Tables 16–21 give the details for all the figures that have been taken for arriving at the cost of the scheme.

Table 15: Cost of the scheme

	Cost of the scheme	
S. no	**Details of the scheme**	**INR lakhs Proposed**
1	a) Land, factory site (2 acres @ INR 30 lakhs/acre)	60.00
	b) Site development costs (@ INR 8 lakhs/acre)	16.00
2	Civil and structural (see details in Table 18)	115.05
3	Plant and machinery (see details in Table 16)	289.19
	Utilities (see Table 17)	49.00
4	Fee for consultants Table 21	30.00
5	Commissioning (6% on P&M)	12.82
6	Licence fee (PCB, SEB deposits, GST and miscellaneous)	10.00
7	Preliminary expenses Table 22	5.00
8	Preoperative expenses Table 19	25.10
9	Margin for working capital	10.00
	Total	**573.16**

Table 16: Cost of the plant and machinery

S No	Description	INR lakhs
1	Process equipment	101.80
2	Cost of utilities	49.00
3	Generator	8.50
4	Laboratory equipment	7.35
5	Firefighting equipment and safety systems	11.76
6	Electrical systems/equipment	17.64
7	Valves, pipes, pipe fittings, insulation, flexible hoses, studs, bolts and gaskets	17.64
8	Erection	21.37
9	Packing and forwarding and transportation @ 5% (of S. No 1–7)	10.68
10	Taxes and duties @18% (of S. No 1–9)	43.45
Total		**289.19**

Table 17: Utilities

S No.	**Utilities**	**INR lakhs**
1	Boiler	5.00
2	Bore wells	2.50
3	Water storage wells with pumps	10.00
4	Boiler softener	1.50
5	Equipment for water recovery	15.00
6	ETP	15.00
	Total	**49.00**

Table 18: Civil and structural details

S. No	**Description**	**Total area in m^2**	**Rate in INR per m^2**	**Total INR in lakhs**
1	Production building	600	14,000	84.00
2	Compost area	81	800	0.65
3	ETP	200	2,000	4.00
4	Admin, QC, WS etc	100	14,000	14.00
5	Roads	620	2,000	12.40
6	Total area	2	Acres	
Total prices in INR lakhs				**115.05**

Table 19: Preoperative expenses

Preoperative expenses for six months

S. No.	**Details of expenses**	**INR lakhs**
1	Salaries and wages (see Table 20 for the breakdown)	8.10
2	Office expenses	6.00
3	Travel expenses	4.00
4	Conveyance	3.00
5	Legal expenses and auditors fee (ad hoc)	2.00
6	Miscellaneous	2.00
	Total preoperative expenses	**25.10**

Table 20: Cost breakdown for salaries and wages in Table 19

Description		INR lakhs
Manager, per month, INR	60,000	3.60
Operator, per month, INR	25,000	1.50
Accountant, per month, INR	20,000	1.20
Security, per month, INR	10,000	0.60
Stores, per month, INR	20,000	1.20
Total, lakhs		**8.10**

Table 21: Consultancy charges

Description	INR lakhs
Civil engineers and architects	2.25
Technical consultancy	18.00
Consultants for financial, pollution control board (PCB), licenses etc	9.75
Total	**30.00**

Table 22: Preliminary expenses

Description	Cost	Total INR lakhs
Accountant	20,000 x 6	120,000
Security	10,000 x 6	60,000
Office expenses	30,000 x 6	18,0000
Travel and conveyance	20,000 x 6	12,0000
Miscellaneous	3,000 x 6	18,000
Total		**4.98 lakhs (say 5.0 lakhs)**

5 Raw materials

It is estimated that the present concentrate feed requirement is 81 MMT and the shortfall is 45 MMT (see Table 4). It is important to know the quantity of available rice straw in the country and across different states because of its importance in the manufacturing of concentrate feed. Currently the required volumes of rice straw in India is between 55 and 60 MMT annually. The production volumes of various crops in India are presented in Table 23 based on data from the Ministry of Agriculture for the year 2012–13.

Table 23: Production of different crops in India (2012–13)

Crop	Amount
Rice	105.24 MMT
Wheat	93.51 MMT
Maize	22.26 MMT
Millet	16.03 MMT
Sugar cane	341.20 MMT
Fibre crops	7.79 MMT
Pulses	18.34 MMT
Oil seeds	30.94 MMT

Harvesting of these crops generates large volume of crop residues. The Ministry of New and Renewable energy estimated that about 500 MMT of crop residues are generated annually in India. The amount of crop residues generated states across India is given in Table 24. Table 25 gives the availability of crop residues as per Anandan and Gowda (unknown year) who note that the availability of rice straw is 135.61 MMT (34%) and that of wheat straw is 97.9 MMT (27%) of all straw available in the country.

The data in the tables indicates that lack of raw materials would not be a hindrance in the manufacturing of concentrate feeds.

Table 24: State-wise crop residue generated, residue surplus and burned

State-wise crop residue generated, residue surplus and burned

(Crop residue in Million Tonne)

S.N.	States	Residue generation*	Residue surplus*	Residue burned$
1.	Andhra Pradesh	43.89	6.96	2.73
2.	Arunachal Pradesh	0.40	0.07	0.04
3.	Assam	11.43	2.34	0.73
4.	Bihar	25.29	5.08	3.19
5.	Chhattisgarh	11.25	2.12	0.83
6.	Goa	0.57	0.14	0.04
7.	Gujarat	28.73	8.90	3.81
8.	Haryana	27.83	11.22	9.08
9.	Himachal Pradesh	2.85	1.03	0.41
10.	Jammu &Kashmir	1.59	0.28	0.89
11.	Jharkhand	3.61	0.89	1.10
12.	Karnataka	33.94	8.98	5.66
13.	Kerala	9.74	5.07	0.22
14.	Madhya Pradesh	33.18	10.22	1.91
15.	Maharashtra	46.45	14.67	7.42
16.	Manipur	0.90	0.11	0.07
17.	Meghalaya	0.51	0.09	0.05
18.	Mizoram	0.06	0.01	0.01
19.	Nagaland	0.49	0.09	0.08
20.	Orissa	20.07	3.68	1.34
21.	Punjab	50.75	24.83	19.65
22.	Rajasthan	29.32	8.52	1.78
23.	Sikkim	0.15	0.02	0.01
24.	Tamil Nadu	19.93	7.05	4.08
25.	Tripura	0.04	0.02	0.02
26.	Uttarakhand	2.86	0.63	0.78
27.	Uttar Pradesh	59.97	13.53	21.92
28.	West Bengal	35.93	4.29	4.96
	Total	**501.73**	**140.84**	**92.81**

Table 25:Availability of crop residues in India by state (2015)

States	Crop residues(000 tons)
Andhra Pradesh	18,047
Assam	7,070
Bihar	19,960
Chhattisgarh	9,533
Gujarat	14,137
Haryana	18,756
Himachal Pradesh	2,618
Jammu andKashmir	2,297
Jharkhand	5,949
Karnataka	20,713
Kerala	730
Madhya Pradesh	41,094
Maharashtra	15,177
Orissa	9,074
Punjab	32,636
Rajasthan	29,569
Tamil Nadu	21,446
Telangana	9,220
Uttar Pradesh	53,538
Uttarakhand	2,281
West Bengal	24,228
Others	4,706
AllIndia	362,793

Anandan and Gowda (unknown year)

6 Market scenario

Cattle and buffalo in India are fed on straws/residues of various crops such as rice, wheat, millet and sugarcane. These feeds are supplemented with green fodder from grazing. In some cases compound feed, which are a mixture of dry fodder and concentrates containing vitamins and other nutrients, are used by livestock keepers in the country.

This report describes the process of making livestock feeds using rice straw (a crop residue) as the main raw material. Rice straw is readily available throughout India, particularly in the northern states such as Punjab, Haryana and Uttar Pradesh, where most of it is burned in the fields after harvesting.

According National Dairy Development Board (NDDB) the livestock feed systems are categorized as follows:

1. Dry fodder + concentrate feed
2. Dry fodder + green fodder + concentrates
3. Dry fodder + green fodder + homemade concentrates
4. Silage + concentrates

The projected demand and availability of fodder in India was presented in Table 4.

India is the largest milk producer in the world with 133 MMT of it produced in 2012–13. The need to produce milk for its growing population is driving the feed industry at 7.5 MMT (2012–13) for dairy animals. However, the supply of compound feed for dairy industry is still low. If for one litre of milk produced, 0.5 kg of compound feed is required, then the approximate total demand for cattle industry is 67 MMT in India. However, the feed sector is currently unable to meet this demand.

6.1 Compound cattle feed

Compound feed plays an important role in improvement in milk yields of cattle and buffalo by offering a balanced feed. Driven by the strong growth in the dairy industry, compound feed volumes increased at an average rate of 6% between 2007 and 2013. At 10% consumption volumes in 2007, 7.5 MMT of concentrate feed was required. But this quantity would feed only about 7% of the total animals in India. Assuming 0.5 kg of compound feed requirement (industry standards), cattle feed requirement would be around 67–70 MMT and is depicted in Table 26.

Table 26: Cattle feed production in India by region in 2013

Region	States	Private sector (mm MT/year)	Cooperative sector (mm MT/year)	Total (mm MT/ year)	% share
Western	Gujarat, Maharashtra, Goa, Madhya Pradesh	1.80	1.70	3.50	48%
Northern	Punjab, Haryana, Uttar Pradesh, Uttarakhand, Rajasthan	0.80	0.42	1.22	17%
Southern	Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry	1.20	1.11	2.31	31%
Eastern	Bihar, Jharkhand, Odisha, West Bengal, Assam	0.20	0.10	0.30	4%

As depicted in the Table 26, out of total compound cattle feed produced in the India in 2013, 3.33MMT (45%) were by cooperative sector and the balance 55% (4 MMT) by the private sector.

With increased participation of the private sector in the dairy industry, the scenario is expected to change resulting in increased consumption of concentrate feed. The low penetration of compound feed in the cattle feed industry is one of the major bottlenecks affecting dairy development in India. Currently only 11% of total livestock feed requirement is met through compound feed. One of the main reasons for this low penetration of compound feed is the small number of large organized dairy farms, which currently account for only 24% of total dairy production in India. Lack of large-scale dairy farms remains a key constraint in the cattle feed industry as small-scale farms do not use modern feeding practices continuously, organized marketing structures are necessary to improve the use of compound feed in the industry.

6.2 Animal feed industry to grow at 13.9% between 2017 and 2020

In an April 2019 report on animal feed in India, Motilal Oswal Financial (2019) predicted that the overall “animal feed industry would grow at ~14% compound annual growth rate (CAGR) over financial years (FY) 2017–2020 to INR1,065 billon by FY 2020 (as per CRISIL).” They also reported that low compound feed penetration, declining availability of fodder and increased cross breeding of cows and buffalo offers huge opportunities for the cattle feed manufacturing industry. After analysis of the growth and opportunities in compound feed manufacturing, they estimated the figures given in the Table 27.

Table 27: Growth in compound feed manufacturing in India

Feed segment	Volume, MMT FY17	Volume, MMT FY20	Value(2020), INR billion
Cattle feed	7.5–8.5	9–10	197–199

(Indian feed industry 2015)

Table 28: Requirement of compounded feed in India 2015–2016

Type	Requirement
Compound feed requirement	80 million tons/year (total)
Requirement for dairy animals	30 million tons (only for dairy animal)
Present market for compound dairy feed	5.5 million tons/year
- Private feed sector	- 1.2 million tons
- Dairy cooperatives	- 2.5 million tons
- Unorganized sector	-1.8 million tons

(Indian feed industry 2015)

Table 29: Feed and fodder gap in India (2015)

SN	Type of fodder	Demand (million ton)	Availability(million ton)	Gap (million ton)
1	Dry fodder	416	253	163 (40%)
2	Green fodder	222	143	79 (36%)
3	Concentrates	53	23	30 (57%)

6.3 Market potential

India has witnessed a 10% increase in feed production to 29.4 million tons (Government of Gujarat 2017) essentially due to good weather conditions and improving farming methods and technology. However, the current feed requirement in the country stands at nearly 80 MT per year and there is a severe shortage. The demand for animal protein and dairy products in expected to increase the consumption of compound feed consumption to 28 million tons by FY18 and 80 MT by year 2020 as reported in Table 28.

All the data available in the public domain indicates there a wide gap between the availability of compound feed and the demand. In fact, the gap is increasing with time. There is opportunity to close this gap by through the use of technology and marketing innovations.

7 Government policy

As per the National Livestock Mission (NLM), which was formulated in the year 2014–15, the government of India has taken upon itself to support and encourage those who wish to develop newer fodder materials for livestock. Full details of the NLM are given in Annex 1. From the NLM it can be seen from mission objectives 2 and 10 that the government is, however, not yet adequately promoting the use of new fodder options (as noted in point 10).

Some of the objectives of the NLM include:

1. Increasing availability of fodder and feed to substantially reduce the demand-supply gap through measures, which include more area coverage under quality fodder seeds, technology promotion, extension, post-harvest management and processing in consonance with diverse agro-climatic condition.

2. Promoting innovative pilot projects and mainstreaming of successful pilots relating to livestock sector

7.1 NLM design

The mission is designed to cover all the activities required to ensure quantitative and qualitative improvement in livestock production systems and capacity development of all stakeholders. The mission will cover everything germane to improvement of livestock productivity and support projects and initiatives required for that purpose.

NLM sub-mission on feed and fodder development

The sub-mission is designed to address the problems of scarcity of animal feed and fodder resources, to give a push to the livestock sector making it a competitive enterprise for India, and also to harness its export potential. The sub-mission will especially focus on increasing both production and productivity of fodder and feed through adoption of improved and appropriate technologies best suited to specific agro-climatic regions in both arable and non–arable areas.

8 Business plan

Plan for conversion of rice straw to fodder

1. Design, fabricate, assemble/erect and commission a batch mode pilot plant to process five tons dry rice straw per day and obtain 3–3.5 tons dry product fodder.
2. The equipment should be such that it will facilitate processing by either one of the methods described in this report: chemical pre-treatment or steam explosion.
3. Validate the data collected at lab and bench scale at pilot plant level using these processes.
4. Determine the physical and chemical characteristics of the product obtained and compare with bench scale results.
5. Use the product for conducting trials on animals with and without additives.
6. Based on the results obtained in steps 3 and 4, change the process and process conditions and freeze the processed straw characteristics and formulation to give the best results in animal trials.
7. Collect all engineering data required for scale up:
    i. Batch process to continuous
    ii. From five tons per day capacity to 250–300 tons per day capacity.
8. Collect all data for reuse of water, and suspended and dissolved solids
9. Convert all waste materials including reject from the reverse osmosis (RO) plant to compost with or without additional inputs to make the whole plant have zero discharge.

Because of low bulk density and low cost of final product, a pilot plant producing less than 0.1 MMT of fodder per annum will not be viable. An approximate cost of the scheme for establishing 0.1 MMT plant will be about INR 180 crores.

9 Conclusions

Based on the results obtained from the pilot plant study, the final process should be halted and an appropriate digester designed before the commercial plant is set up. Before putting up a commercial plant, the following considerations also are to be noted and implemented. During pilot plant studies the required data to implement these points should be collected.

a. The location of the pilot plant should be determined by access to raw material (i.e. crop residues from rice fields). Raw material (rice straw) transportation should be minimized if not altogether avoided. For example, in Telangana and Andhra Pradesh more than 10 MMT of residue is available from rice crops (Government of India 2014) and it can support 10–12 industries of 0.1 MMT easily.

b. Optimization and recycling of water should be done to reduce energy consumption and to reduce wastage of water, as well as to ensures the plans have zero discharge.

c. Lignin that is removed from the crop residues should be used to generate steam for the boiler.

d. Solid wastes coming from the process or plant and also RO rejects should be used for making compost.

e. All recyclable materials will be safely stored and given to recycling plants.

f. Air pollution will be minimized to the extent of burning lignin in the boiler.

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11 Annex I

National Livestock Mission (2014–15)

The National Livestock Mission (NLM) was launched in financial year 2014–15 to ensure quantitative and qualitative improvement in livestock production systems and capacity development of all stakeholders.

The scheme is being implemented as a sub scheme of White Revolution-Rashtriya Pashudhan Vikas Yojna since April 2019.

The objectives of the NLM include:

1. Sustainable growth and development of livestock sector, including poultry.
2. Increasing availability of fodder and feed to substantially reduce the demand-supply gap through measures which include more area coverage under quality fodder seeds, technology promotion, extension, post-harvest management and processing in consonance with diverse agro-climatic condition.
3. Accelerating production of quality fodder and fodder seeds through effective seed production chain (nucleus-breeder-foundation-certified-truthfully labelled, etc.) with active involvement of farmers and in collaboration with the dairy/farmers cooperatives, seed corporations and private sector enterprises.
4. Establishing convergence and synergy among ongoing plan programs and stakeholders for sustainable livestock development.
5. Promoting applied research in prioritized areas of concern in animal nutrition and livestock production.
6. Capacity development of state functionaries and livestock owners through strengthened extension machinery to provide quality extension service to farmers.
7. Promoting skills-based training and dissemination of technologies for reducing cost of production, and improving production of the livestock sector.
8. Promoting initiatives for conservation and genetic upgradation of indigenous breeds of livestock (except bovines, which are covered under another scheme) in collaboration with farmers/farmers' groups/cooperatives, etc.
9. Encouraging formation of groups of farmers and cooperatives / producers' companies of small-scale and marginal farmers/livestock owners.
10. Promoting innovative pilot projects and mainstreaming of successful pilots relating to the livestock sector.
11. Providing infrastructure and linkage for marketing, processing and value addition for the farmers' enterprises.
12. Promoting risk management measures including livestock insurance for farmers.
13. Promoting activities to control and prevent animal diseases, environmental pollution; promoting efforts towards food safety and quality, and supply of quality hides and skins through timely recovery of carcasses.

14. Encouraging community participation on sustainable practices related to animal husbandry, involvement of communities in breed conservation and creation of resource map for the states.

Mission design

The mission is designed to cover all the activities required to ensure quantitative and qualitative improvement in livestock production systems and capacity building of all stakeholders. The mission will cover everything germane to improvement of livestock productivity and support projects and initiatives required for that purpose subject to condition that such initiatives which cannot be funded under other centrally sponsored schemes under the department.

The mission is organized into the following four sub-missions:

1. **Sub-mission on livestock development:** the sub-mission on livestock development includes activities to address the concerns for overall development of livestock species including poultry, other than cattle and buffalo, with a holistic approach. The risk management component of the sub-mission will, however, also cover cattle and buffalo along with other major and minor livestock.

2. **Sub-mission on pig development in northeastern region**: the sub-mission will strive to forge synergies of research and development organizations through appropriate interventions, as may be required for holistic development of pigs in the northeastern region including genetic improvement, health cover and post-harvest operations.

3. **Sub-mission on feed and fodder development**: this sub-mission is designed to address the problems of scarcity of animal feed and fodder resources, to give a push to the livestock sector making it a competitive enterprise for India, and also to harness its export potential. The sub- mission will especially focus on increasing both production and productivity of fodder and feed through adoption of improved and appropriate technologies best suited to specific agro-climatic regions in both arable and non-arable areas.

4. **Sub-mission on skill development, technology transfer and extension**: this sub-mission will provide a platform to develop, adopt or adapt the technologies including frontline field demonstrations in collaboration with farmers, researchers and extension workers wherever it is not possible to achieve this through existing arrangements.

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