NMBA
National
Mission on
Bamboo
Applications

INFO-SHEET

IS 03 09/05

Bamboo-based Charcoal Production

Charcoal made from bamboo finds ready uses and markets. It has been made for thousands of years in pits and even shallow depressions. Specially designed brick kilns, developed and tested by the National Mission on Bamboo Applications (NMBA), provide an opportunity to make high-quality charcoal from bamboo in an efficient, safe and reliable manner.

Charcoal is a product with many uses, in industry and in the domestic sector. It is utilised:

- at the village level, by blacksmiths and to meet household energy requirements;
- in the domestic sector, as fuel for cooking and heating;
- in the service sector, by dhobis and in *dhabas*;
- in the industrial sector, at different scales of activity, in furnaces, for forging and metal-working;
- as raw material for further processing into activated carbon and other industrial products.

The price of charcoal, depending on its quality and on local market conditions, ranges from Rs 5 to Rs 14 per kilogram.

Charcoal is a light, black, porous material resembling coal, with about 85 per cent carbon. It is produced by heating biomass under a system of controlled supply of air. This results in the removal of water and other volatile constituents. Wood, sugarcane waste, rice husk and bamboo are commonly used for making charcoal.

Charcoal made from bamboo has good properties, similar to wood and other ligno-cellulosic material in terms of high carbon content and calorific value.

Charcoal is produced by heating biomass with a controlled supply of air. This can be done by the conventional pit method, in brick or metal kilns, or in drums. Heating can be direct by igniting the biomass or it can be indirect.

Carbonisation in a brick kiln produces uniform-quality charcoal with good yield and low investment.

Bamboo is abundantly and commonly available in the country. It is fast-growing and a highly renewable resource; unlike timber, it can be harvested every year.

Bamboo makes excellent charcoal. It has excellent potential for charcoal production to meet rural energy needs for heating and cooking, as industrial fuel, and to make products such as activated carbon.

Quality of Bamboo Charcoal

Good-quality charcoal with the following characteristics can be produced from bamboo :

Carbon: 80–85 per cent
Ash: 4.5–6.5 per cent
Moisture: 6–9 per cent
Calorific value: 6,900–7,000 Kcal/kg

The Raw Material

- Any species of bamboo can be used for making charcoal.
- 4–5-year-old bamboo makes the best charcoal. It has by then attained its maximum bio-mass, and its moisture and starch levels have lowered.
- To get the best yield of charcoal, the moisture content of bamboo should be around 20 to 25 per cent. In the monsoon or other rainy periods, bamboo will have higher moisture content. At such times, the bamboo should be left to dry for some time before conversion to charcoal. (For large-scale operations, dryers can be used to bring down the moisture levels.)
- In many applications, the upper and lower portions of bamboo culms are not used, and are often thrown away. These can be used in charcoal-making. Lops and tops of bamboo culms and thicker branches can be used too. Processed waste from stick and sliver units consists of a large amount of particulate matter. Such particulate matter cannot be used in these kilns to make charcoal.

Location of the Kiln

Bamboo is typically a hollow cylinder. Transportation of bamboo therefore adds to costs. Kiln viability will increase if there are lower transportation and handling costs.

Charcoal kilns should be sited as close to the source of raw material as possible. Raw material can be sourced from plantations or forested areas, or collected from homestead plantations.

Since bamboo processing units generate waste, kilns can be sited in close proximity to such units as well.

Kiln Structure

The kiln is hemispherically shaped. It has a diameter of 3 metres.

It is made of clay bricks, mud and mortar.

The kiln has a rectangular opening at the bottom. Through this opening, raw bamboo is loaded into the kiln. After conversion, charcoal is taken out through the same opening.

There are several small (single-brick) openings for inflow/outflow of air.

There is a 2–3 brick-sized opening at the top of the kiln for firing of the feed.

Kiln capacity: 2.5–3.5 tons

Kiln volume: 14 cubic metres

Charcoal yield: 25 per cent

Diameter of kiln: 3 metres

Area required for each kiln: 5 square metres

Area required for a battery of 5 kilns: 25 square metres

Cycle time: 5–7 days

Batches per month: 4

Workers needed to manage 5 kilns: 2

Bill of Quantities for Construction of one kiln

Second-grade bricks: 6,000

Mud: 1 ton

Molasses/rice husk: 15 kg/50 kg

Operation

Charcoal-making is an age-old science. Using brick kilns of the type described allows charcoal production in a safe, efficient and simple manner.

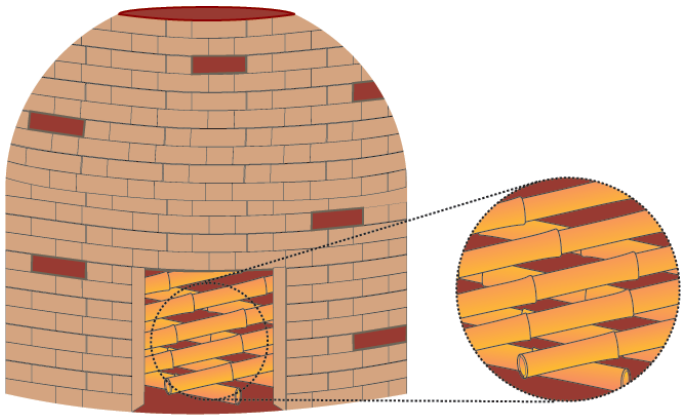
Slow carbonisation carried out with restricted air supply will provide good-quality charcoal with high calorific value and little ash.

Step 1: Sizing of Bamboo and Charging of Feed

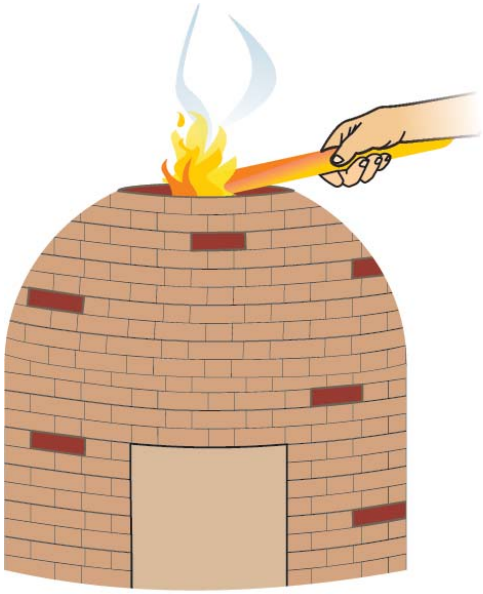
- Sizing of bamboo is the first step. The size of the end-product (charcoal) is related to the size of the bamboo placed in the kiln.
- Whole bamboo culms will need to be cut to the required size.
- If the bamboo section is too large, it will not fit into the kiln. The maximum length of any section should be 2.5 metres. The minimum acceptable size is 5 centimetres.
- Homogeneity of size in a batch will make stacking easier and produce better results.
- For every batch, a small quantity of bamboo will need to be sized between 10 and 12 centimetres; this will help in kindling the material.

Step 2: Charging of the Feed

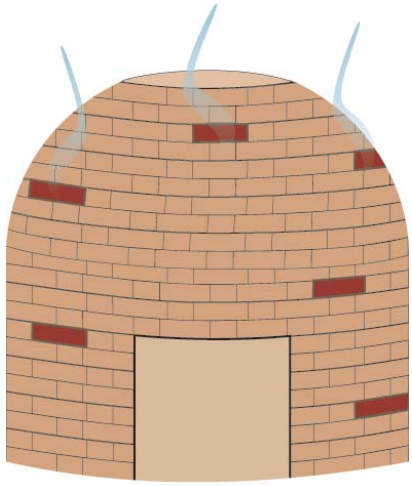
- Place the bamboo in the kiln through the door at the bottom. Stack the bamboo horizontally in the kiln.



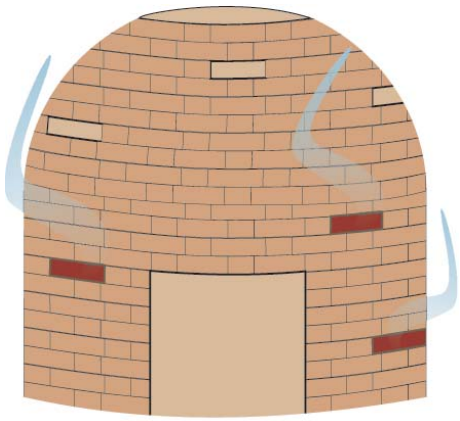
- Close the door with bricks, and plaster the outer face of the door with mud to provide better insulation and prevent leakage.
- Fire the feed from the opening at the top of the kiln.
- Close the opening at the top of the kiln after the feed has been ignited.



- The openings in the wall of the kiln should be kept open during the initial stages of firing to create the required draft.
- Initially, black smoke will be emitted from the openings in the wall at the upper end. The emission of smoke will gradually spread to the openings at the lower end of the kiln.



- Close the openings in the top rows once the black smoke changes to dense white fumes.
- Close all the openings one by one starting at the top row as the black smoke changes colour.

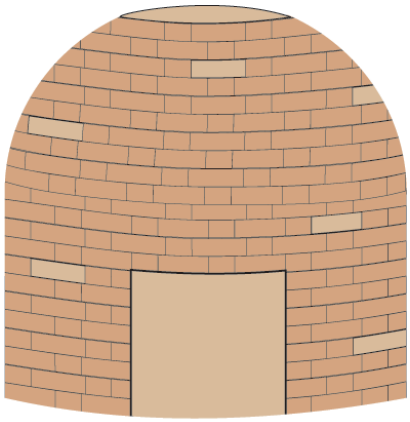


Step 3: Carbonisation

- Initially regulate a few openings (open/close) across the kiln in both horizontal and vertical directions, to create a draft and enable uniform carbonisation.
- In case a temperature sensor is available, maintain the temperature at 400–550° centigrade by regulating the openings. The temperature should not be allowed to drop below 350° centigrade as this will lead to incomplete carbonisation. The temperature should not rise above 500° centigrade as this will cause the biomass to burn and provide ash instead of charcoal.
- In case a sensor is not available, estimate the temperature. Over time, workers will acquire the necessary skills and experience to regulate the openings even without the use of sensors.

Step 4: Cooling

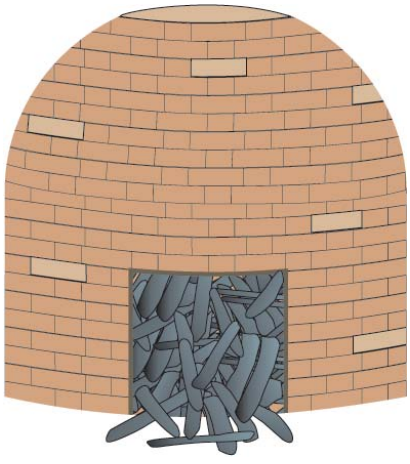
- Close all openings after 2 days.
- Do not allow air to enter the kiln at this juncture to prevent the charcoal from catching fire.



- Cooling will take a day. The objective is to reduce the kiln temperature to 100° centigrade to allow the charcoal to be safely extracted.

Step 5: Extraction of charcoal

- Break through the opening at the bottom of the kiln.
- In case the char is too hot to handle, sprinkle a small quantity of water. Excessive watering will lower the quality of the charcoal.
- Remove the charcoal carefully to a storage point for disposal.



Step 6: Cleaning

- Clean the kiln of charcoal and residues.

Production Cycle Time

The process of making charcoal, from initial loading through the different processes described above, will take 5 days, on average. It is not advisable to further reduce the cycle time, since this will tend to reduce the hardness of the charcoal.

In relatively warmer and drier conditions, charcoal-making will be faster, since the bamboo will have lower moisture content, and carbonisation will be speedier. The entire process may take 4 to 5 days.

In cold and wet conditions, charcoal-making will be slower. The process may take 6 to 7 days.

Kiln Batteries

A kiln can produce, on average and assuming 5 loadings in a month, 4.5 tons of charcoal.

A single kiln may not be commercially efficient or viable.

A battery of at least 5 kilns is commercially viable.

With a cycle time of 5–7 days, a battery of kilns can be operated in a manner where each kiln is in a different stage of production and a product batch can be extracted every day. This will ensure continuous production of charcoal.

Yield

The yield of charcoal from raw bamboo is typically around 25 per cent, if the moisture content of the raw bamboo is 15–20 per cent. With increased moisture content, the yield of charcoal reduces. It also increases the production cycle time as more energy is used up in the process of reducing the moisture content of the raw bamboo.

Period of Operation

Charcoal-making in kilns can be carried out throughout the year.

A shed to house the kilns will enable uninterrupted production even in very wet and rainy conditions. The height of the shed should be sufficient to prevent chances of conflagration or accidents.

Basic Economics

Kilns for charcoal production from bamboo should be located in an area where bamboo is available in plenty and at a cost of not more than 1000 kg to 1100 kg per ton.

The strength of the bamboo is not important; the determining properties are moisture content and bulk density.

Ideally, a battery of at least 4 to 5 kilns should be installed to maintain continuous production. A battery of 5 kilns can be operated by two workers.

(i) Investment cost

	Unit cost	*Total cost*
Construction cost of 5 kilns (including cost of material and installation)	Rs 15,000	Rs 75,000

(ii) Operational costs

	Unit cost	*Total cost*
Monthly raw material requirement (90 tons)	Rs 1,000	Rs 90,000
Monthly labour charges	Rs 4,500	Rs 4,500
Minor maintenance and miscellaneous expenses	LS	Rs 2,500
Total monthly expenditure		Rs 97,000
Monthly production of charcoal (22 tons)	Rs 6,000	Rs 1,32,000
Monthly net revenue	Rs 35,000	
Annual net revenue with an operation of 8 months per year		Rs 2,80,000

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