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Comparison of yield and quality of bamboo charcoal produced by traditional methods

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Abstract: A traditional pit method and a portable drum method were evaluated for the production of charcoal from the wastes of *Bambusa bambos*. An indigenous earthen pot method, traditionally used in Kerala, India for the production of teak wood distillate where charcoal is a byproduct, was also evaluated. The methods differed significantly in yield and quality of charcoal produced. The pit and drum methods gave higher yield of charcoal, but with low quality, whereas the earthen pot method gave a lower yield but with high quality. Charcoal with high volatile content (14-20%) and low fixed carbon (74-76%) suitable for domestic use was obtained from the pit and drum methods, while charcoal with low volatile content (9%) and high fixed carbon (84%) suitable for industrial use was obtained from the earthen pot method. In general, bamboo charcoal had high ash content (7.5%) and it was alkaline (pH 8.9-9.7) and brittle, with poor hardness.

Key words: Bambusa bambos, bamboo charcoal, volatile content, ash content, fixed carbon content.

INTRODUCTION

Charcoal, as a domestic fuel, has many advantages over firewood in terms of energy and economy. Further, it is the raw material for producing activated carbon, an important industrial product. While the pulp and paper industry and the traditional mat and handicrafts sectors utilize bamboo culms, the crooked basal portion as well as the low diameter top portion of bamboo culms are wasted as they cannot be utilized for any value-added product. Bamboo charcoal is reported to have an average calorific value of 7800 kcal/kg (Park *et al.*, 1998), greater density, ash, and volatile contents than the charcoal from *Eucalyptus urophylla* wood (Brito *et al.*, 1987). The activated carbon from bamboo charcoal is reported to be economically promising for the removal of dyes and phenol, in comparison to other commercial adsorbents (Wu *et al.*, 1999).

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In this context, a study was carried out to utilize the wastes of bamboo to produce charcoal and to evaluate the quality of the product using the traditional pit method and portable drum method, which are commonly used for charcoal production from coconut shell and wood in Kerala, India.

MATERIALS AND METHODS

The crooked basal portion of *Bambusa bambos* was collected from bamboo depots of Palakkad District of Kerala, air-dried and used for charcoal production. The basal portions of the culms were cross cut into 25 cm long pieces and then half-split and were used in drum and pot methods, while the whole pieces were used in pit method.

Pit method

The traditional pit method employed by the local communities in Kerala for the production of charcoal from coconut shell was tested for its suitability for bamboo charcoal production. A weighed quantity of bamboo of known moisture content was piled in a pit of 30 cm depth, 100 cm width and 100 cm length (Fig. 1). The bamboo heap interspersed with leaves, was slowly built up to the full, with a provision for air inlet and for lighting fire and over which mud plaster was applied leaving a hole at the top for venting the smoke. The bamboo was lighted and allowed to burn slowly. After three hours, the vent was closed to restrict air entry (to prevent further burning of charcoal) and the charge allowed to cool overnight. The heap was opened the following morning and charcoal collected and weighed after cooling. The moisture content of charcoal was determined by oven drying and yield was calculated on moisture free basis.

Drum method

An empty oil drum (cylindrical, 200 l capacity, top opened) of dimension 90 cm height and 55 cm diameter, was kept vertically and half-filled with weighed quantity of air-dried round bamboo billets of known moisture content; the billets were lighted and once the fire stabilized, the entire drum was gradually filled with bamboo billets. When the fire was distributed evenly, the drum was closed with a lid and the edges sealed with mud plaster to limit the air supply. The set-up was allowed to remain overnight (Fig. 2). The following morning the drum was opened and charcoal was collected and weighed after cooling.

Tongan Drum method

In this method, a drum of dimensions same as above, but with a lateral opening of 20 cm width and 80 cm length, was placed horizontally. The drum was loaded partially (one fourth) with weighed quantity of air-dried bamboo billets of known moisture content, and the material was ignited (Fig. 3). When the fire was distributed evenly,

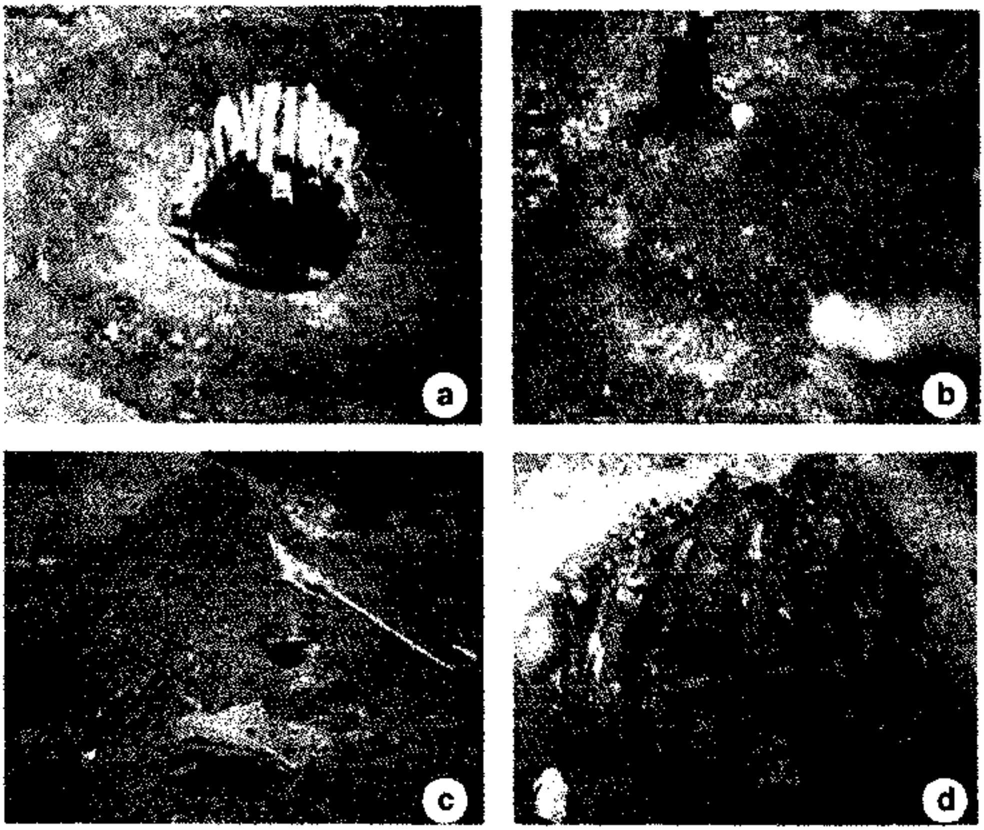

Figure1. Traditional pit method - various stages.

Figure 2. Portable drum method - various stages.

the drum was gradually filled with bamboo billets and finally the opening was closed and sealed with mud plaster and allowed to remain overnight. The charcoal was collected the next morning, weighed after cooling and the yield was determined.

Figure 3. Tongan drum method of charcoal production.

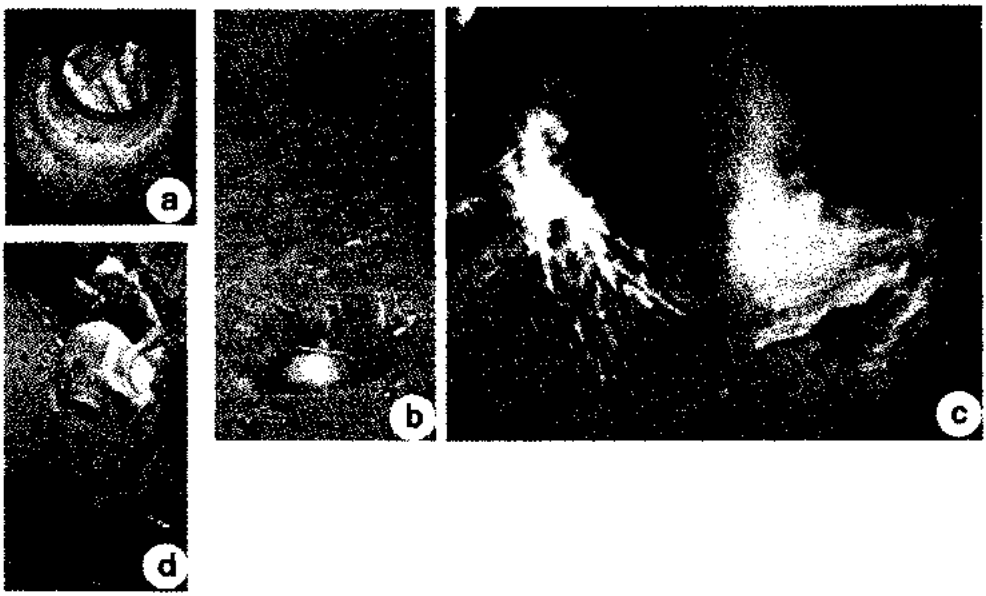

Figure 4. Indigenous earthen pot method of charcoal production yielding distillate – various stages.

Indigenous earthen pot method

This is an indigenous method to produce teak wood distillate in which charcoal is a by- product. In this method, an earthen pot of 100 l capacity is used. The bamboo was split, cross cut into 25 cm long pieces, stacked inside the vessel carefully. The filled-up pot was turned up side down and another small mud pot was connected at the mouth to collect the distillate, made air-tight by sealing with cloth soaked in clay and cow dung. The pot was kept in a small pit. An air-dried reed of about 1 m in length was connected to the small mud-pot and the joint was sealed airtight with mud plaster, cow dung and cloth. At the open end of the reed pipe, a small mud pot was placed for collecting the condensed distillate liquor. The pit was covered and made airtight by using clay and cow dung. Then firewood was placed over the earthen pot and ignited (Fig. 4). After some time, black liquor oozing as a result of destructive distillation was collected in the receiver pot. After about an hour, when the flow of black liquor ceased, heating was discontinued, and the assembly allowed to cool for an hour. The system was then carefully dismantled. Bamboo charcoal from the distillation vessel was allowed to cool, weighed and yield was determined. The distillate (bamboo tar) was collected from the receiver pot and volume of the liquor measured.

Analysis

Eight replicates of charcoal samples from each method of production were analyzed for moisture, fixed carbon, volatile and ash contents by ASTM methods (ASTM, 1981). Volatile and ash contents were corrected to moisture free basis and accordingly fixed carbon content was determined. The pH was determined from the extract of 10 g charcoal dust in 100 ml water.

RESULTS AND DISCUSSION

The details on yield and quality of charcoal produced by different methods are given in Table 1. Although yield was highest (36%) in the vertical drum method, there was no significant difference in yield among the pit method and the vertical and Tongan drum methods. The indigenous earthen pot method produced the lowest yield of 26.4 per cent along with 5.2 per cent (v/wt) distillate.

Table 1. Yield and quality of bamboo charcoal obtained by different methods (range of values within brackets; CV% values in italics)

Sl. No	Method of production	Yield (%) (on moisture free basis)	Quality			pH
			Mean volatile content (%)	Mean ash content (%)	Mean fixed carbon content (%)	
1	Pit method	33.7	18.7 (16.4-24.3) *14.2*	5.8 (4.5-10.1) *30.5*	75.5 (70.5-78.3) *40.9*	9.6
2	Vertical drum method	36.0	14.2 (12.3-15.6) *9.7*	10.8 (9.6-11.2) *5.5*	75.1 (73.5-77.1) *1.8*	9.2
3	Tongan drum method	33.0	19.8 (19.4-20.8) *3.3*	6.1 (5.6-6.9) *6.5*	74.2 (73.0-75.5) *1.1*	8.9
4	Earthen pot (Indigenous) method	26.4[1]	9.0 (7.7-10.6) *13.5*	7.1 (6.8-7.6) *4.8*	83.9 (82.5-85.4) *1.4*	9.7

[1] Yield of distillate – 5.2% (v/wt); n = 8.

The ash content of bamboo charcoal was found to differ significantly depending on the method of production and it varied widely from 4.5 to 11.2 per cent with an average of 7.5 per cent. Thus, the method of production is important in producing charcoal with less ash content. In general, the ash content of bamboo charcoal is comparatively higher than that of wood and coconut shell charcoal.

The fixed carbon content of charcoal from pit and drum (vertical and Tongan) methods was found to be comparable (75%), whereas the indigenous earthen pot method gave a product with high fixed carbon content (84%). The volatile content of charcoal from the pit and drum methods was high (14.2 – 19.8%), whereas it was significantly low for the indigenous method (9%). This indicates the superiority of product from the indigenous method. Further, it showed that indirect heating for carbonization yielded better quality charcoal, though the yield was slightly low. Good quality charcoal should contain at least 75 per cent fixed carbon. Charcoal with a volatile content of around 20 per cent is suitable for domestic use, especially for barbeque. Bamboo charcoal obtained from the pit and drum methods is suitable for domestic purpose as it falls under this category. Even though, volatile content and fixed carbon content are found to depend on the method of production, they are comparable with that of the charcoal from other sources.

Bamboo charcoal is found to be alkaline in nature; the pH values of water extract range from 8.9 to 9.7. In general, bamboo charcoal produced by all the different methods was very brittle.

CONCLUSION

The yield of charcoal from bamboo differs between the methods. A moisture free yield of 33 to 36 per cent was obtained from pit and drum methods. High ash content (5.8 – 10.8%) was recorded for the bamboo charcoal produced by the pit and drum methods. The volatile content and fixed carbon content were also found to vary depending on the method of production; high volatile (14.2 – 19.8%) and low fixed carbon content (74.2 – 75.5%) for the charcoal from pit and drum methods and low volatile (9%) and high fixed carbon content (83.9%) for the charcoal from the indigenous earthen pot method (indirect heating system). Since, charcoal with high quality (low ash and volatile contents, high fixed carbon) is required for industrial uses and the indirect heating system is found producing charcoal of better quality, indirect heating system may be more promising on product quality point of view for industrial use. The pit and drum methods can produce charcoal suitable for domestic purposes. As bamboo charcoal from all the different methods employed is found brittle, for industrial uses, it may be more suitable for powder charcoal applications. Bamboo charcoal is found to be alkaline in nature (pH 9-10), indicating the need for mild acid washing for making it neutral for chemical applications, where neutral charcoal is desired.

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