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Thermogravimetric behaviour and physical properties of *Bambusa vulgaris* in Ghana

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Abstract: In Ghana, the extent of utilization of bamboo is relatively low compared to Asian countries mainly due to lack of awareness of the potential of local bamboo species. In the present study the thermal behaviour and its relationship with moisture content and basic density of *Bambusa vulgaris* and *B. vulgaris* var. *vittata* from three sites in Ghana were examined. Results indicate step-wise disintegration at three to four different levels in the thermal process. The ash content of bamboo samples was below 1 per cent with no significant difference between the two varieties. Variation in physical properties existed among culms from three sites. Culm moisture content values ranged from 71.7 to 145.5 per cent with slight decline from the base to the top. Basic density values also varied between 466 and 761 kg/m^3 with significant difference among the three sites.

Key words: Thermogravimetric behaviour, carbonization, basic density, moisture content, *Bambusa vulgaris*

INTRODUCTION

Variation in technical properties significantly influences bamboo processing and utilization. Information on the physical properties of bamboo is necessary for assessing its suitability for various end products. The physical properties such as rate of drying, dimensional stability and strength influence bamboo behaviour in both processing and service (Janssen, 1985; Espiloy, 1987). Liese (1985; 1987; 1998) revealed that moisture content decreases and density increases along the height of the culm. In an earlier work on *Bambusa vulgaris* Schrad. Ex. Wendl from Ghana, basic density variation from base to top was reported. Anatomical investigations revealed the proportations of different tissues in bamboos of Ghana. Little information, however, exists on properties such as shrinkage, durability, moisture content and thermal behaviour of bamboo from different zones of Ghana. This paper investigates selected physical characteristics and thermal behaviour of *B. vulgaris* to ascertain its suitability for diverse uses in comparison with the known bamboo species.

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MATERIALS AND METHODS

Mature culms of *B. vulgaris* and *B. vulgaris* var. *vittata* were randomly selected and harvested from four different clumps in three predominant bamboo growing locations in Ghana Assin-Fosu in the Central Region, Akim Oda in the Eastern Region and Manso-Amenfi in the Western Region. Harvesting of culms was done between 20th January and 20th February 2006, during the dry season.

The samples were put into nylon sacks and transported to the Wood Science Laboratory and kept at 5 °C in the cold store room to ensure freshness. Internodes from the lower part of each culm were removed using a band saw. Two to three bamboo rings of 25 mm thickness were cut from the internodes. Test samples of dimension 25 mm x 25 mm by culm wall thickness were prepared for moisture content and basic density determination according to ISO 22157-1:2000E. For shrinkage measurement, 100 mm long segments were obtained from remaining portion of each internode. The samples were air-dried for about two weeks and the length, outer diameter and culm thickness were measured at regular intervals using a vernier caliper. For the thermal behaviour of the samples the Thermogravimetric Analyser (TGA) 500Q was used. About 5 mg of bamboo powder that was retained in the 60/80 mesh was loaded into the TGA and weight loss at different temperature levels was determined.

RESULTS AND DISCUSSION

Thermogravimetric behaviour

The loss of weight of the samples was recorded (Fig.1). The phase of disintegration of the powder occurred at less than 200 °C and less than 5 per cent of sample powder got ignited. The second phase of the carbonization was from 250 to 400 °C when most of the sample (66.54%) was burnt. Above this temperature, there was a gradual decline to about 750 °C, where an average of 12.75 per cent was lost. Thus the highest rate of decline was recorded between 200 °C and 400 °C.

Research in China and India on bamboo charcoal production reveals different carbonization stages: precarbonization, carbonization and high temperature refining stages. The stages conform to different stages in the production process.

Under the pre-carbonization phase of charcoal production, which conforms to the first phase in Figure 1, there is autoignition of bamboo pieces and in this case bamboo powder. At this stage, a large quantity of heat is needed to raise the temperature for thermolysis. In the second phase which is closely related to the carbonization stage, (between 280 and 450 °C) the thermolysis process is rapid. This is a stage of exothermic reaction releasing a large amount of heat. The last stage is referred to as the high temperature refining which is completed at temperature above 450 °C. This is a stage

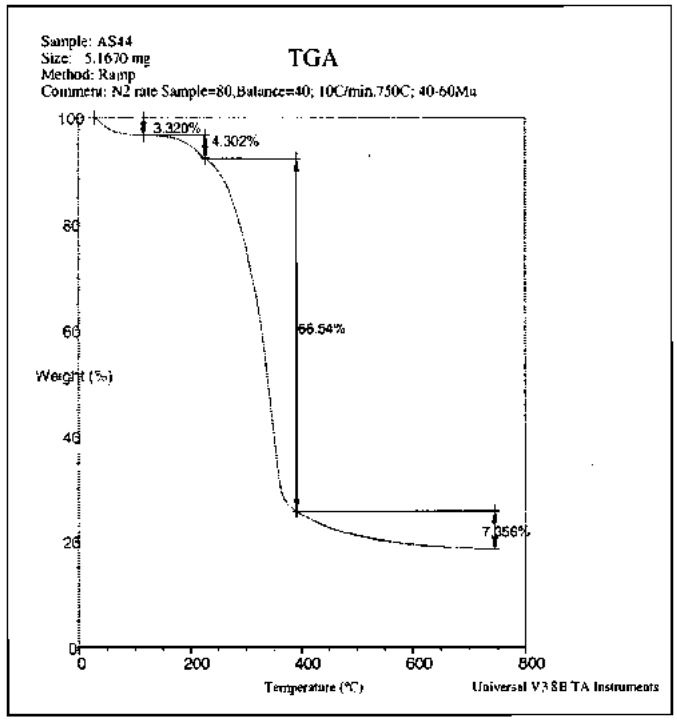

Figure 1. Weight loss of bamboo samples with temperature.

of high temperature thermolysis. The volatile matter is discharged in this process by the elevated temperature and consequently, the fixed carbon content in charcoal is increased. The initial and final phases of refining process must be controlled according to the temperature on the curve (Fig. 2).

The moisture content variation of bamboo samples from culm base to top pertaining to the three localities of collection is shown in Figure 3. The lower values were obtained from Assin-Fosu locality whilst the highest values were obtained from culms from Manso-Amenfi in the Western Region of Ghana. Since the season of harvesting and species type were the same in this experiment, the observed variations were mainly due to age differences among culms and the site characteristics. Rainfall in the western region is relatively higher than that in other regions of Ghana. Further, Manso-Amenfi is covered by moist evergreen forests whilst Akim Oda and Assin Fosu fall within the moist semi-deciduous forest zone. The moisture content variation observed in the present study is in accordance with several earlier studies. Liese (1985) reported values of average moisture content of 100-150 per cent. The moisture content has profound influence on bamboo processing. In developing drying schedules for bamboo splits the initial moisture content could serve as a guide for choice of suitable range for temperature and relative humidity.

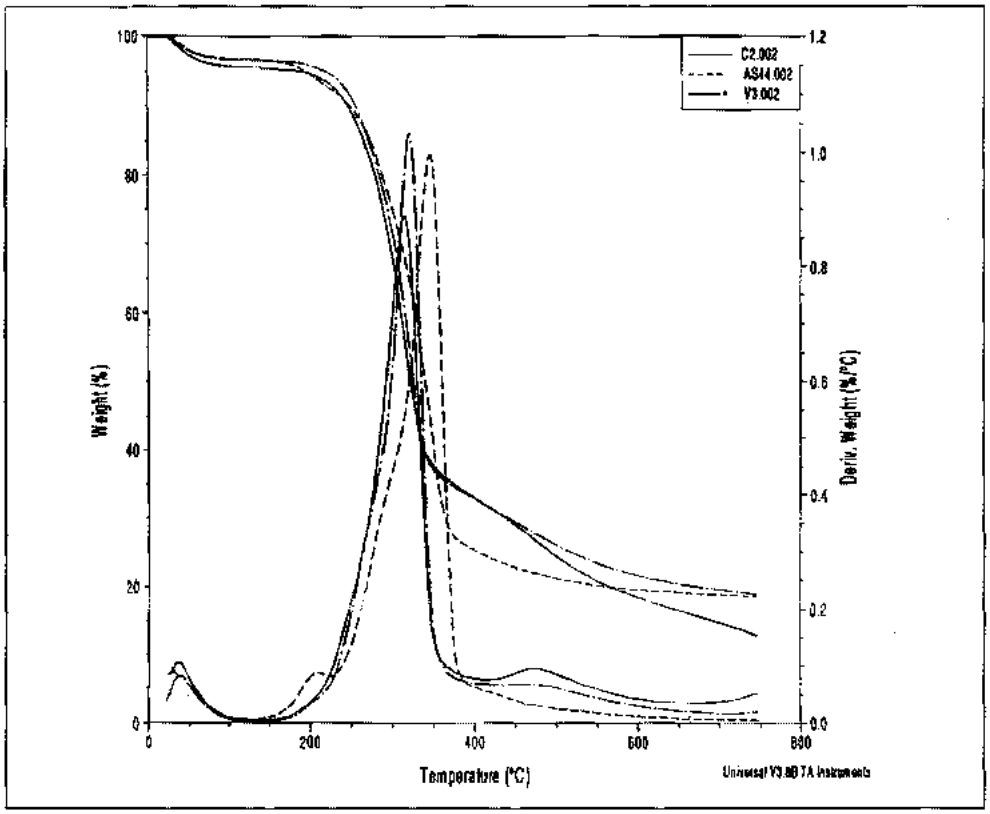

Figure 2. Weight loss and derived weight loss of bamboo samples from three different localities of Ghana.

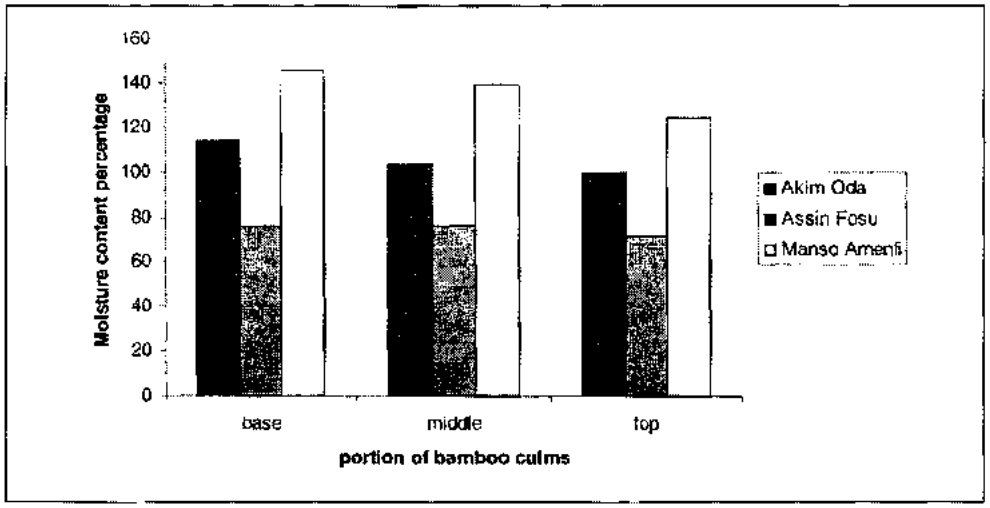

Figure 3. Variation in moisture content of *Bambusa vulgaris* culms from three locations in Ghana.

Basic density variation

Variation in basic density has been widely reported in different species of bamboo. Recent investigations have shown that the basal portion of bamboo culms has the lowest density and highest moisture content when compared with the middle and the upper portions (Anwar *et al.*, 2005). The variation is said to be mainly dependent on the type, density of vascular bundles and their composition. Table 1 depicts the trend of basic density obtained from the three sites. The values range from 466 to 762 kg/m^3 as reported by Ebanyenle and Oteng Amoako (2006).

Table 1. The variation in basic density of bamboo culms from three sites in Ghana

Sites/ Culm portion	Base	Middle	Top
Akim OdaMean	581.92	580.22	599.00
	456.40	544.10	639.70
	432.90	431.30	481.30
	587.52	606.90	572.20
	(514.69)	(540.63)	(573.05)
Assin-FosuMean	690.00	744.40	776.00
	696.50	688.20	743.00
	717.40	742.80	744.40
	757.70	730.00	782.40
	(715.40)	(726.35)	(761.45)
Manso-AmenfiMean	593.00	629.10	632.80
	371.30	555.60	623.00
	442.50	491.53	653.50
	457.60	427.50	507.50
	(466.10)	(525.93)	(604.20)

CONCLUSION

It is essential to have comprehensive and accurate information on the properties of bamboo and the extent of variation for deciding its utilization. The information obtained in this study reveals that slight difference in the disintegration of bamboo over varied temperature range in *B. vulgaris* from three sites in Ghana. The variation in physical properties also conforms to the results obtained around the world.

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