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Bamboo in Green Construction in Ghana: the Studies of Selected Anatomical Properties.

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Abstract

Most of the existing research on the anatomy of bamboo species in Ghana and most West African countries have centered almost entirely on the gross structure of bamboo species. Limited information exists on their microstructure structures and dimensions. This has rendered industrialists in the construction industry handicapped to fully understand and utilize native bamboo species. As the call for greener future intensifies, bamboo has been identified as an important non timber industrial material that will help achieve the green construction because it has over 1500 documented uses. In this present study, the microstructure characteristics of Bambusa *vulgaris var. vulgaris and B. var. vittata* from three major bamboo sites in Ghana were undertaken. Results revealed range in fibre bundle width from 311-506µm and the diameter of metaxylem vessels of 128-196 µm. The vascular were type iii and iv with fibre strands of the heart-blocked and arc-like type. The implications of the features in construction were highlighted. The paper conclude**s** with recommendation**s** for further studies in the structure of other bamboo species including those in trial test in plantations for wider acceptance and enhanced utilization for construction purposes.

Key words: *Bambusa vulgaris**, a***natomy, ultramicrostructure, bamboo internodes, phytochemical properties.

Introduction

The sustainable use of bamboo resources is an important part of forest management in the tropics. Bamboo has about 1500 documented uses worldwide (INBAR 2006). While its use in Southeast Asia is widespread, the extent of bamboo utilization in Ghana is relatively low. Lack of knowledge about the technical properties of native bamboo species and also poor processing techniques have been cited for this trend (UNIDO 2001). Nevertheless, the creation of a sound bamboo industry would help ease the pressure on Ghana's natural forests and help attain the green revolution. The sustainable use of bamboo will help balance product diversity with the environmental concern.

Among the different bamboo species in Ghana, *Bambusa vulgaris* is the predominant species (Ebanyenle and Oteng Amoako 2008, Tekpetey et al. 2008).*Bambusa vulgaris* which is a native sympodial bamboo species in Africa and Madagascar with multiple uses (Bystriakova et al. 2004) and is rated as a moderately resistant bamboo species (De Guzman 1978).In Ghana, *Bambusa vulgaris* is reported to be the predominant bamboo species. The knowledge of its properties and variation is known to significantly influence the level of acceptance, processing and utilization of bamboo resources.

The information on the ultra microstructure of bamboo, for instance, is necessary for assessing its suitability and quality for specific products. The fibro-vascular proportion, vascular bundle types and diameters of vessels influence bamboo behaviour (Liese 1987, 1998, 2000). Liese (1985) reports that anatomical properties of bamboo culm vary according to species, the condition of growth, age of the bamboo and part of the culm. The percentage, distribution and orientation of tissue and cells such as parenchyma, fibers, and vascular bundles vary considerably along and across the bamboo culm (Espiloy 1985, Liese 1985, Soeprayitno et al. 1985).The bamboo culm comprises about 50 per cent parenchyma, 40 per cent fibres and 10 per cent vessels and sieve tubes (Liese 1987).

In an earlier work on *Bambusa vulgaris* Schrad. Ex. Wendl from southern Ghana results revealed similar values proportions of different tissues as recorded in other countries (Assouan 2002). Ebanyenle and Oteng Amoako (2008) also reported significant variation in the morphological and physical properties from different ecological zones. Notwithstanding, the level of acceptance and utilization of bamboo is low. Little information, exist on the ultra microstructure of our native bamboo species and extent of variation in different ecological zones in Ghana for better understanding of their behaviour during processing and when in service.

The knowledge of these properties will enhance the mode of preservation treatment and the extent of natural durability of *Bambusa vulgaris*. This is what the paper seeks to elucidate in three bamboo growing areas in southern Ghana This paper investigates some selected anatomical features of bamboo to enhance understanding of its behaviour in service and suitability for diverse uses.

Material and Methods

Sound internodes of matured bamboo (above 3 years) were harvested from Kumasi (Ashanti Region), Akim Aduasa (Eastern Region) and Assin Fosu in the Central Region of Ghana. The samples were placed under shades at the Wood Science Workshop, Kwame Nkrumah university of Science and Technology and were transported to Open Key Laboratory at International Centre for Bamboo and Rattan (ICBR), Beijing, China for the anatomical studies. The 4th internodes from the ground level and the 12th internodes of *Bambusa vulgaris* were chosen for the anatomical studies. Three softened samples were sectioned from the middle part of selected internodes and the Leica Sliding Microtome – M2000R model was used to prepare transverse and longitudinal sections of the softened blocks. Sections were then observed using XL 30 ESEM ^{TM} FEG Environmental Scanning Electron Miscroscope. The vascular bundle types, the metaxylem vessels, parenchyma and its inclusions; and the arrangement of pitting were observed. The thickness of the fibre bundle at protoxylem side of the vascular bundle of Ghanaian Bamboo was also measured over the culm wall of base 4th internodes.

Results and Discussion.

In transverse sections, the observation of bamboo samples from the three sites revealed basically two main types of vascular bundles: the classical Types III and IV.These types of bundles is characteristic of sympodial bamboo like *Bambusa vulgaris.* The type III occurs mostly on the 12th internodes whilst the type IV were found both in the 4th and 12th internodes in the three sites studied. Though these types of vascular bundle in bamboo is a good condition for relatively higher pulp yield than in other monopodial bamboo species, it might be more difficult to process than the monopodial types. The implication therefore during processing is that in machining of *Bambusa Vulgaris* from natural stands in Ghana difficulty might be encountered in comparison to bamboo species of the monopodial type like *Phyllostachys pubescence* (Moso bamboo).The fiber strands were mainly the heart- blocked shaped and arc-like shaped.

Parenchyma Cells and Inclusion

It was observed that the parenchyma cells in *Bambusa* vulgaris were more circular in shape rather than the rectangular of some bamboo species. Figure 4 and 5 shows that the shape of the parenchyma cells of Moso bamboo seems more rectangular than those observed in the *Bambusa vulgaris* samples as evident. This might be due to genetic variation in monopodial and sympodial bamboo types. The micrographs as revealed in Figure 1, 2 and 3 shows that the parenchyma cells of *Bambusa vulgaris* were either partially filled or fully filled with starch granules. This is characteristic of older bamboo culms. In earlier works around the world no starch granules where found during the first year of growth but abundant granules were found in older culms. The parenchyma cells have been turned into storage cells. Liese (1997) reported that the abundance of starch granules is characteristic of older bamboo culms two years and above. The absence or presence of starch granules in raw bamboo culms influences its susceptibility to termites and insect attack because the starch is a source of food for the insects.

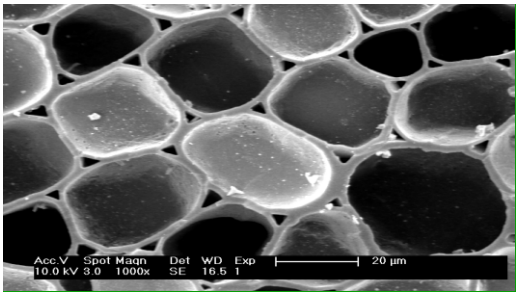


Figure 1- Parenchyma cells *of Phyllostachys pubescence* (Moso)

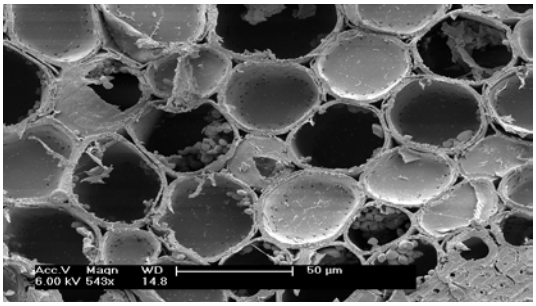


Figure 2 -Parenchyma cells of *Bambusa vulgaris* from Assin Fosu,Ghana

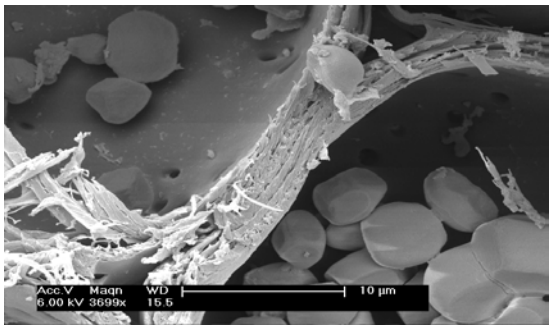


Figure 3- Starch granules in *Bambusa Vulgaris* from Akim Oda, Ghana.

The season of harvesting has also been reported to have a great impact on the abundance of starch in bamboo culms at different height, the need to plan for its harvesting is important to sustainable harvest and utilization. The generally accepted trend is that drier months register higher starch content for use in shoot growth during the raining season.

Metaxylem In ***Bambusa Vulgaris***

Results revealed that the vessels diameter from the three sites gave values ranging from 128 to 196µm.The minimum value was the outer culm of the 12th internode from Assin Fosu whilst the highest was from the base (4th internode) of culms from Assin Fosu. This is displayed in Figure

4.In all cases, the inner culm diameter were relatively higher than the outer vessel diameter and the variation was not significant among the sites of harvest at P<0.05. The variation in the appearance and diameter of the vessels could be responsible for differential conduction of fluid in culm wall. Vessels possess several large simple perforations on their side walls for the contact between vessels in addition to the normal simple perforation of the end walls (personal observation).

On an average, the conducting system, including the phloem, account for about 8% of the total culm. This appears rather small when compared with the lumen area of softwood tracheids (60-70%), diffuse porous hardwood vessels (20-30%), ring porous hardwoods (15- 30%) and rattan metaxylem (15-20%) (Liese,1994).

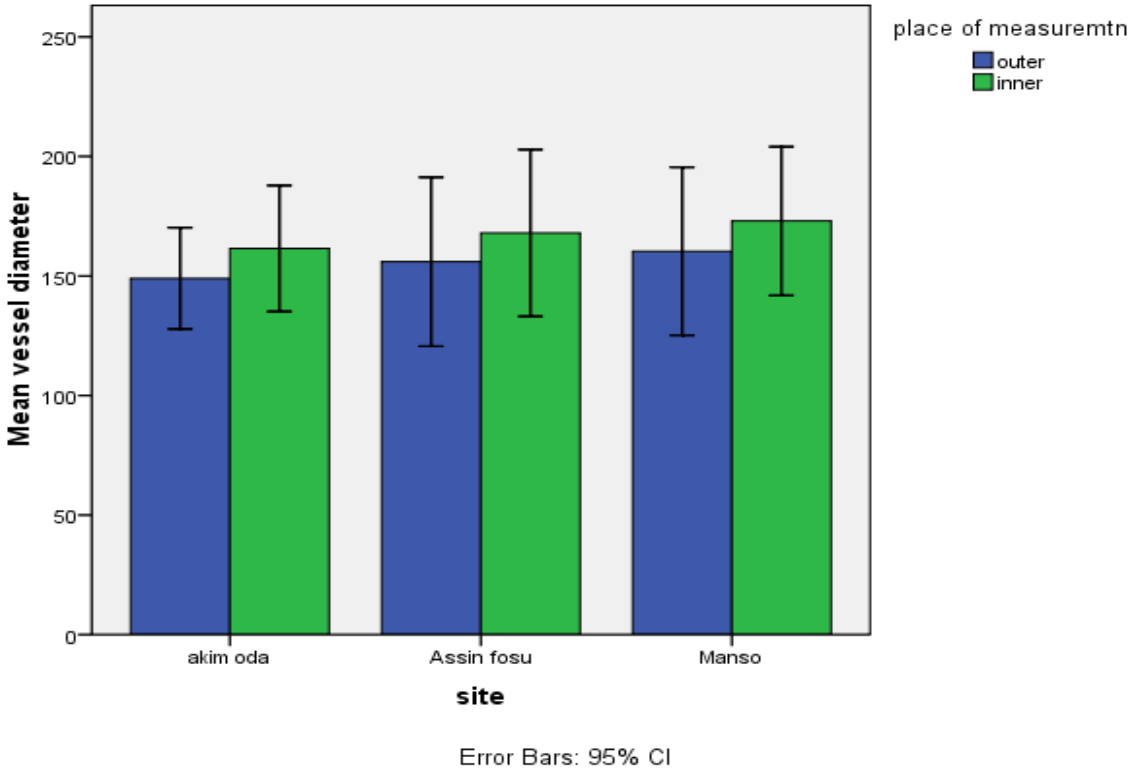


Figure 4- Mean vessel diameter of *Bambusa vulgaris* from three sites in Ghana

Varied results for vessel diameter have been reported by various researches. Espiloy (1987) obtained an average vessel diameter of 165 µm for *Bambusa blumeana* and 220µm for *Gigantochloa levis* (values at the base were slightly higher than the top). Wu and Hsieh (1991) also reported a diameter decrease for *Dendrocalamus latiflorus* from the 6th internode towards the top, but a slight increase in the case of *Phyllostachys edulis*. Kumar and Dobriyal (1992)

measured for *Dendrocalamus strictus* a vessel size of 60 µm at the outer part, 85 µm at the middle and 100 µm at the inner part. Abd. Latif (1995) registered mean values of 147-187 µm for *B. vulgaris* and 114-137 µm for *G. scortechinii*, both with smaller diameters at the top. These information are required for understanding the behaviour of bamboo during seasoning and preservative treatment.

The inclusion in parenchyma cells from Assin Fosu might be a peculiar inclusion of parenchyma cells near the vascular bundles of Bambusa *vulgaris* in Ghana (Fig 5). It could be a form of starch granules apart from the round or ellipsoidal type encountered in earlier research work. The structure was observed at the 4th internode from Assin Fosu,Ghana.

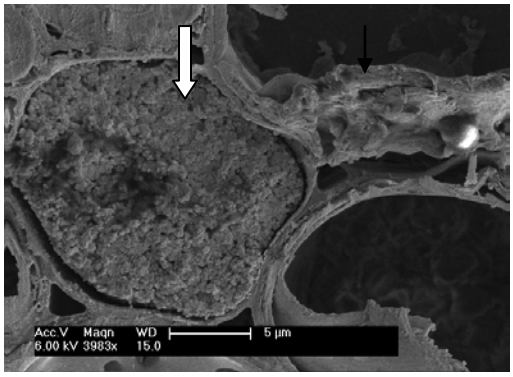


Figure 5- Inclusion in the parenchyma cell of *Bambusa vulgaris* from Assin Fosu,Ghana.

Conclusion and Recommendation

This work has established that there is important structural variation in the anatomical structure of Bambusa *vulgaris* from the three different zones in Ghana. The research has enhanced the knowledge on how Bambusa vulgaris might behave during processing and utilization bamboo in Ghana. Further collaboration is needed to identify 'new structures' and also to understand the nature of bamboo species in most developing countries and it niche for diversified utilization.

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References

Abd. Latif, M. 1995. Some selected properties of two Malaysian bamboo species in Relation to age, height, site and seasonal variation. Ph.D. Thesis, Faculty Forestry, UPM.

Assouan, J.T. 2002. Some anatomical and selected physical properties of two bamboo species grown in Ghana. MPhil (Wood Technology) Dissertation:Department of Wood Science and Technology,KNUST,Ghana.

Bystriakova, N. Kapos,V. and Lysenko, I.2004.Bamboo Biodiversity. UNEP-WCMC/INBAR

Ebanyenle, E. and Oteng-Amoako, A.A.2008.Site differences in morphological and physical properties of *Bambusa vulgaris* grown in Ghana. Discovery and Innovation.19 (3) 222-225.

Espiloy, Z.B. 1987. Physico-mechanical properties and anatomical relationships of some Philippine bamboos. In: Proceedings, International Bamboo Workshop, Hangzhou, China, 1985, Chinese Acad. For. and IDRC, Canada.

Espiloy, Z.B. 1994. Effect of age on the physico-mechanical properties o f some Philippine bamboos. In: Proceedings,Fourth International Bamboo Workshop. IDRC/FAO/UNDP, FAO Bangkok: 180-182.

Liese, W. 1998. The Anatomy of Bamboo Culms. Technical Report 18, INBAR,Beijing, China.

Liese, W. 1985. Anatomy and Properties of bamboo. In : A.N Rao, G. Dhanarajan and C.B Sastry (Eds.). Recent Research on Bamboo. Proceedings. International Bamboo Workshop, China, 1985. Hangzhou, China. Chinese Acad. For. Beijing, China and IDRC, Canada: 196-208.

Liese, W.1987. Anatomy and properties of bamboo. In: Proceedings, International Bamboo Workshop, Hangzhou, China 1985. Chinese Acad. For., Beijing, China and IDRC, Canada: 196-208.

Liese, W. and D. Grosser 2000. An Expand Topology for Vascular Bundle of Bamboo Culms.Processings of Bamboo 2000 International Symposium.Changmai Thailand. 121-134.

Liese, W, Weiner, G. 1996. Ageing of bamboo culms. Wood Science and Technology,

30. 77-89.

Liese, W, Weiner, G. 1997. Modifications of bamboo culm structures due to ageing and Wounding. In The bamboos. Linnaean Society, London, UK.313-322

Wu, S.C, Hsieh, J.S.1991. Anatomical characteristics of Taiwan giant bamboo and moso bamboo. In: Proceedings of the 4th International Bamboo Workshop, Chiangmai, Thailand. IDRC, Ottawa, Forestry Research Support Programme for Asia and the Pacific, Bangkok, Thailand..