J. Bamboo and Rattan, Vol.7, Nos. 3&4, pp. 243-249 (2008)

Bambusa vulgaris in Ghana: Chemical composition and phytochemical properties for enhanced utilization

S.L. Tekpetey *, N. A. Darkwa and **K. Frimpong –Mensah**
Department of Wood Science and Technology, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract: The search for suitable substitute for dwindling timber species has led to the study of technical properties of important non-timber forest products, especially bamboo. In Ghana, *Bambusa vulgaris* is the predominant bamboo species. There is limited knowledge about its chemical composition to enhance its use in paper making and also preservation treatment. The chemical and phytochemical properties of *B. vulgaris* from three major bamboo growing sites in Ghana were studied. Results revealed that the range of acetone extractives was between 1.00 and 2.4 per cent, whilst ethanol extractives range between 2.47 and 6.50 per cent. The klason lignin content ranged between 20.9 and 30.13 per cent, whilst the holocellulose values were between 69.01 and 72.34. Alpha cellulose ranged from 58.971 to 61.54 per cent. Analysis of results at $P<0.05$ revealed the components were not significant with site and height, except for the extractives (0.02-0.03). Post hoc test using Tukey Honestly Difference was significant for mean values between the bamboo sites: Akim Oda and Assin Fosu. Further, preliminary phytochemical screening also shows the absence of alkaloids, an important decay resistant indicator and the presence of anthraquinone.

Key words: *Bambusa vulgaris*, chemical composition, phytochemical properties.

INTRODUCTION

Bambusa vulgaris, an important sympodial bamboo is widely distributed in Southwest China and elsewhere in the tropics (INBAR, 2006). In Ghana, it is widely distributed in the High Forest Zone in Southern part and Africa (Bystriakova *et al.*, 2004). Currently, about 70 per cent of the local communities in Ghana use bamboo in one form or other and majority of them are annual users of bamboo products. Bamboos are not utilized adequately in Ghana considering their numerous uses elsewhere in Asia. Using sympodial bamboo for paper making or as architecture material is a good way for increasing bamboo utilization. Investigations on the chemical composition and phytochemicals in bamboo will offer significant basic data and information on the properties which have been cited as impeding wider acceptance in Ghana. The

* To whom correspondence should be addressed; E-mail: lartekp@yahoo.com

knowledge of these properties will enhance the mode of preservation treatment and the extent of natural durability of *B. vulgaris*.

MATERIALS AND METHODS

Field and laboratory procedures

Matured *B. vulgaris* var. *vulgaris* culms were harvested from three sampling areas around the moist-evergreen, moist-semi-deciduous forests, South East and North West of the High Forest Zone in Ghana. Bamboo culms were collected from Manso-Amenfi in the Western Region, Akim Oda in Eastern Region, and Assin Fosu in Central Region. These sites according to the survey conducted in 2001 by bamboo consultants are the major bamboo growing areas in the regions selected in Ghana and feasibility studies to these areas confirmed the abundance of natural bamboo stands especially *B. vulgaris* var. *vulgaris* with a few of other species like *B. vulgaris* var. *vittata* and *B. bambos* in botanical gardens around the southern part of Ghana.

Bamboo clumps with marked signs of fire, evidence of disease and animal attack were excluded and the bamboo clumps near rivers and streams (about 50 m) were also excluded from the sampling because of environmental significance to the protection of water bodies.

Chemical composition and phytochemicals of bamboo samples

This aspect of the work was carried out in two laboratories in Ghana- KNUST Chemistry Department Laboratory and the Forest Research Institute, Ghana (FORIG) Chemical Laboratory during February 2007 to August 2007.

The internodes of each height location for chemical analysis were cut into small strips. The strips were milled in a Wiley Mill at Forest Research Institute, Ghana. The material was then sieved manually to pass through a No. 40 mesh sieve (425 μm), but retained on a No. 60 mesh sieve (250 μm). The resulting material was placed in glass jars labeled with appropriate code for chemical analysis. All tests were conducted under the Technical Association for Pulp and Paper Industry (TAPPI) except for acetone extraction. Instead of alcohol-benzene, acetone and then alcohol were used for the extraction. Each test was conducted in duplicate.

Acetone and alcohol extraction

The extraction apparatus consisted of a Soxhlet extraction apparatus. A ten gram air dried sample was placed into cellulose extraction thimble. The thimble was plugged with a small amount of cotton and placed in a Soxhlet extraction tube. The boiling flasks containing acetone were placed on a heating mantle. The extraction was conducted for about five hours. When the extraction was completed, the remaining

solution was transferred to the boiling flask, which was heated on a heating mantle until the solution was evaporated. The flasks were oven-dried at 103±2°C, cooled in a desiccator and weighed until a constant weight was obtained.

Alcohol solubility

After the acetone solubility test, the alcohol solubility test was carried out on the same sample using the same procedure.

Klason lignin in bamboo

A one-gram, oven-dried sample of extractive-free bamboo was placed in a 150 ml beaker. Fifteen ml of cold sulfuric acid (72 %) was added slowly while stirring and mixed well. The reaction proceeded for two hours with frequent stirring in a water bath maintained at 20°C and the specimen was transferred by washing it with 560 ml distilled water into a 1,000 ml flask, diluting the concentration of the sulfuric acid to three per cent. An allihn condenser was attached to the flask. The apparatus was placed in a boiling water bath for four hours. The flasks were then removed from the water bath and the insoluble material was allowed to settle. The contents of the flasks were filtered by vacuum suction into a fritted-glass crucible of known weight. The residue was washed free of acid with 500 ml of hot distilled water and then oven-dried at 103±2°C. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained.

The per cent weight of hot water solubles = x/y x 100 %
x- Oven-dry weight of extracted sample
y- weight of moisture free sample

Holocellulose in bamboo

About two grams of extractive-free sample in 180 ml of distilled water and 8.6 g of sodium acetate, 6.0 g of ethanoic acid and 6.6 g sodium chlorite were mixed and digested in 250 ml conical flasks with a cover. The sample was placed in a water bath of temperature 70°C in a fume chamber. After three hours, the sample was filtered, washed with distilled water and dried in an oven.

The per cent weight of holocellulose = x/y x 100 %
x- Oven-dry weight of holocellulose
y- weight of moisture free sample

Alpha cellulose in bamboo

After the holocellulose extraction, 1.5 g of holocellulose was used for this analysis. A 1.5 g oven-sample was placed in 250 ml Erlenmeyer flask with a small watch glass

cover. About 100 ml of 17.5 per cent NaOH solution was added and stirred. After 30 min. 100 ml distilled water was added at 25°C and was left for 30 min. The beaker was removed and filtered in a filtering crucible. It was then transferred into a crucible, washed with 25 ml of 9.45 per cent NaOH solution and distilled water at 25°C. It was then washed with water and 40 ml of 10 per cent acetic acid and again with plenty of distilled water.

The percentage of cellulose was calculated using the formula
% weight of alpha cellulose = x/y x 100%
x- Oven-dry weight of alpha cellulose.
y- weight of moisture free sample.

RESULTS AND DISCUSSION

The chemical composition of *B. vulgaris* from three sites in Ghana is summarized in Tables 1 and 2. The acetone extractives range between 1.0 per cent and 2.4 per cent, whilst ethanol extractives range from 2.47 to 6.50 per cent among the three sites. The lignin content ranges between 20.90 and 30.13 per cent, whilst holocelluloses range between 69.01 and 72.34 per cent. Alpha cellulose ranges from 58.97 to 61.54 per cent. The cold water solubility of bamboo samples from the sites ranges from 7.89 to as high as 16.70 per cent. The highest value of extractives was from Assin Fosu sampling site.

In this study, the extractives content (acetone and alcohol) decreased from base to top in two of the sites sampled. The reverse was the case with Manso Amenfi, where there was slight increase from base to top of bamboo culms. The descending order is Assin fosu> Akim Oda> Manso Amenfi. Of the three different sites -Manso Amenfi, Assin Fosu, Akim Oda, there was no distinct variation within sites in the values especially, that of acetone extractives.

Table 1. Chemical composition of bamboo powder from three zones in Ghana

Culm label/sites		Acetone (%)	Ethanol extraction (%)	Cold water solubility (%)	Lignin (%)	Holo cellulos (%)	Alpha cellulose (%)
Akim Oda	A	1.43	5.80	16.70	21.33	69.01	61.02
	B	1.11	4.12	12.60	22.11	69.09	61.44
	C	1.00	2.80	7.89	26.51	69.95	59.21
Assin Fosu	A	2.40	5.20	15.20	29.63	71.25	58.97
	B	1.95	6.40	10.31	29.78	69.91	59.26
	C	1.62	6.50	10.30	30.13	69.25	59.23
Manso	A	1.14	2.47	10.30	23.30	72.34	60.20
	B	1.25	2.90	10.52	22.41	71.11	60.12
	C	1.40	3.75	12.30	20.90	69.54	61.54

*A: base; B: middle; C: top

Table 2. Range of chemical composition of *B. vulgaris* from three sites in Southern Ghana

Chemical composition	N	Minimum	Maximum	Mean	Std. deviation
Percent lignin	9	20.90	30.13	25.8944	3.97139
Alpha cellulose	9	58.97	61.54	60.1100	1.01591
Extractives contents	9	1.00	2.40	1.4778	.45160
Holocellulose	9	69.01	72.34	70.1611	1.15269
Extracts2 (alcohol)	9	2.47	6.50	4.4378	1.58244

Alpha cellulose

Alpha cellulose ranges from 58.97 to 61.54 per cent (Table 2). Within each site, slight variation in the alpha cellulose values was recorded among the three height levels, but there was no significant difference in these values at 5 per cent level of significance.

Klason lignin

The variations in the percentage of klason lignin obtained from the study are summarized in Table 1. Culms from Akim Oda recorded values ranging from 20.90 to 26.50 per cent with rise from base to top. The values for Assin Fosu were slightly higher, ranging from 29.63 to 30.13, whilst Manso Amenfi recorded relatively lower value of 20.90 per cent at the base and 23.30 per cent at the top. The value at the base was the same as that of Akim Oda, but the difference was observed at the top.

Increase in lignin in bamboo from the base to the top among *B. vulgaris* from Assin Fosu, Manso Amenfi and Akim Oda was recorded. The lignin values of about 20-30 per cent place *B. vulgaris* at the high end of the normal range of 11-27 per cent reported for non-woody biomass (Bagby *et al.*, 1971) and closely resemble the ranges reported for softwoods (24-37%) and hardwoods (17-30%) (Fengel and Wegener, 1984; Dence, 1992). The high lignin content of bamboo will contribute to its relatively high heating value, and its structural rigidity which makes it a valuable building material. Figure 1 shows the chemical components of bamboo analysed in this study. Klason lignin indicated widest range compared to the other component at different height levels, whilst acetone extractive was minimum.

Phytochemical analysis

The absence of alkaloids in the sample is a probable reason for the rapid decay of bamboo species in service in Ghana, especially when used in the raw state. Alkaloids are generally formed as metabolic by-products; however, their characteristic bitter taste and accompanying toxicity generally help to repel insects and herbivores. The absence of alkaloids coupled with large amount of starch granules in the parenchyma cells may be the main factor for rapid deterioration of bamboo culms when used in service in an untreated state. Earlier work on the low level of durability of bamboo culms has reported the abundance of starch and low extractive content as contributing

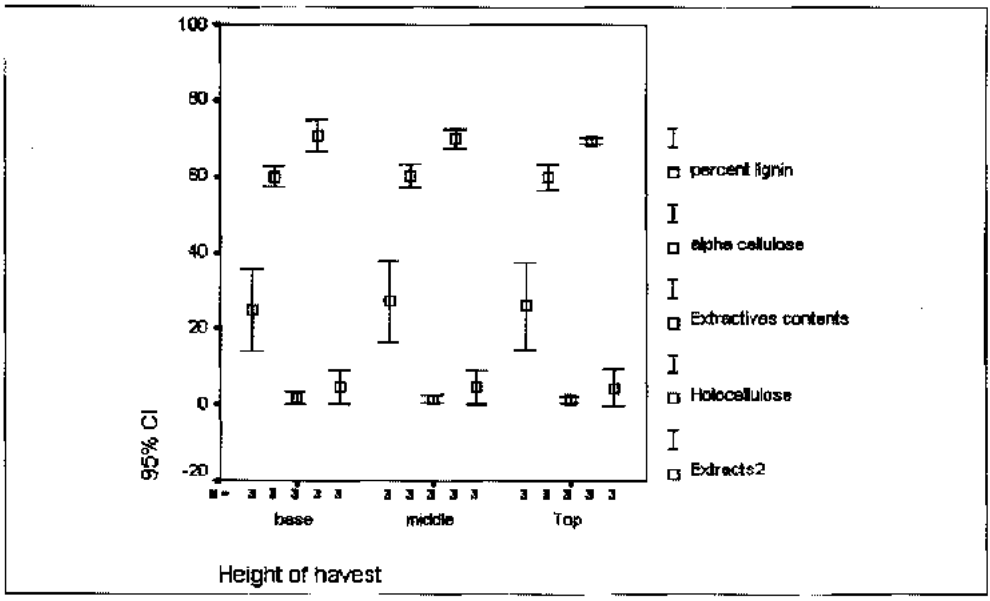

Figure 1. Multiple error bars for the chemical composition of *B. vulgaris.*

factors. The absence of alkaloids in the sample extracts explains the low durability of bamboo. Relatively, low density, high moisture content species with low extractive content are susceptible to insect attack and hence rapid deterioration especially in rainy season. The chemical preservation of bamboo culms may be preferable option to mitigating the low durability rather than a method of reducing the starch content of bamboo culms before their use in service of matured culms.The purgative action of some bamboo species could be attributed to the presence of anthraquinone in the extracts.

CONCLUSION

Chemical and phytochemical analysis of bamboo from three sites revealed that there is significant variation in the extractive content, but not in the other chemical components of *B. vulgaris* with sites and non-significant with height and the interaction of height and site. The phytochemical screening indicated the absence of anthroquinone glycosides, alkaloids, but the presence of flavonoids. It is recommended that further quantitative analysis of phytochemicals and their influence on bamboo utilization should be undertaken for both indigenous and exotic species.

ACKNOWLEDGMENTS

The authors would like to thank the International Tropical Timber Organization (ITTO) for their generous financial support under the Freezeliah Fellowship 2005.The KNUST Staff development scholarship has also been helpful in starting this work.

REFERENCES

Bagby, M.O., Nelson, G.H., Helman, E.G. and Clark, T.F. 1971. Determination of lignin in non-wood plant fiber sources. *Tappi* 54:1876-1878.

Bystriakova, N., Kapos, V., Lysenko and Stapelton, C.M.A. 2004. Distribution and conservation status of forest bamboo biodiversity in the Asia-Pacific region. *Biodiversity and Conservation* 12: 1833-1841.

Dence, C.W. 1992. The determination of lignin. In: S.Y. Lin and C.W. Dence, (Eds.). Methods in Lignin Chemistry. Springer-Verlag: Heidelberg: 33-61.

Fengel, D. and Wegener, G. 1984. Wood: Chemistry, Ultrastructure, Reactions. Berlin: Walter de Gruyter Publishers: 613p.

INBAR 2006. Bamboo for the Environment, Development and Trade. International Bamboo Workshop, Wuyinshan , Fujian China.