CHARACTERISTICS OF THREE BRAZILIAN GIANT BAMBOO SPECIES

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SUMMARY

Pachymorph bamboo species were introduced in Brazil during the period of the Portuguese colonization. Today there is a very large occurrence of several bamboo species in this country. Among several species the giant bamboos there are very interesting for construction purposes and handicrafts. In this work, three culm regions (basal, middle and apical) of giant bamboo species (*D. giganteus, G. verticillata* and *G. angustifolia*), were studied. The samples were cut and measured along their axis, and then were weighted for three moisture culm conditions (wet, air-dry and over-dry). Three replications were realized for each treatment. The results show that bamboo sample weight changes quickly with moisture conditions. Radial shrinkage of the samples was sometimes greater than tangential shrinkage. Longitudinal shrinkage was negligible. Analysis with imaging technique proved very useful to evaluate the distribution of the anatomic components of bamboo culms. The chips of bamboo species were also shredded to extract starch and separate the fibrous and residual fractions. The chips shredding was conducted in a common mixer with inverted cup. The composition ranged from 2 to 6% for starch and from 50.2 to 61.5% for cellulosic fiber.

INTRODUCTION

Several bamboo species were introduced in Brazil during the Portuguese colonization. Among these species the most important is *Dendrocalamus giganteus*, known as Giant bamboo. Nevertheless, other giant bamboo species, as *Gigantochloa verticillata*, can be found in Brazil, but in small quantities. During the 70's, radar scanning performed in the Western part of Amazonia revealed a very important concentration of the Guadua specie. Another occurrence of this other giant bamboo is in the "Pantanal" region (Center-West), where this bamboo is known as the "taquarucu" (giant bamboo in Indian language).

Despite bamboo presenting multiple possibilities of use, it faced a lot of restrictions in Brazil while it is largely used in Asia and some parts of Latin America. In this regions bamboo can compete against others more sophisticated materials. Among the reasons that prevent a more important utilization of bamboo in Brazil, we can cite a very poor technical knowledge about this renewable, easily-processed and widely-distributed material.

Several parameters must be considered in the determination of the physical-mechanical properties of the bamboo. Research on *G. angustifolia*, developed by Lopez (Ref.1) proved that the sample region affects the compression strength of the culms. Others important parameters are culm age, season and ecological conditions.

The starch content in the bamboo culm varies with the specie. For the *Bambusa vulgaris* specie, which is the most utilized in Brazil to produce fibers for paper-making, the extraction content of granular starch varies from 4.6 to 9.6% according Azzini & Gondim-Tomaz (Ref.2).

The average anatomical distribution in bamboo culms indicate 40% for bundle fibers, 50% for parenchyma cells and 10% for vessel (Liese, Ref.3). Nevertheless, anatomical bamboo distribution changes beyond radial orientation of the culm. Ghavami & Hombeck (Ref.4) reported, for *D. giganteus* specie, average values for bundle fibers that ranged from 15% to 30% for outer layers and from 40% to 70% for internal layers. Beraldo (Ref.5) evaluated the anatomical distribution of *Phyllostachys viridis* using imaging analysis techniques. Average bundle fibers values were respectively 63%, 37% and 25% for peripherical, middle and internal layers. Parenchyma cells distribution were, respectively, equal to 27%, 50% and 63% for the same regions. Vessel diameters, which were larger in the internal layers, became smaller in the outerlayers. But surface vessel occurrence was almost the same for all regions of the culm (8% to 12%).

The aim of this work is to contribute to the determination of some physical-mechanical, chemical and

anatomical properties of three Brazilian giant bamboo species, mainly for rural building purposes.

DEVELOPMENT

In November 1997, in the Agronomic Institute of Campinas-SP-Brazil, three seasoned culms were collected for three giant bamboo species: *Dendrocalamus giganteus, Gigantochloa verticillata* and *Guadua angustifolia*. For each culm, two internodes were selected from three regions: basal (bottom) middle and apical (top).

Anatomical analysis: samples collected in the three culm regions and having a length of 40 mm were polished with the mechanical Struers polisher utilizing Norton abrasives (number 200 to 1000). After this preliminary preparation, a digital image of the sample was obtained with the HP Scanjet scanner. The quality of image scanned was enhanced with the Khoros software.

Physical analysis: green bamboo samples were stamped with a waterproof ink in three directions (longitudinal, radial and tangential). Samples measurements were realized for three moisture conditions: green, natural air dried and over-dry. Samples shrinkage was calculated utilizing Brazilian wood recommendation test.

Mechanical analysis: the objective of this analysis was to develop a correlation between the compression strength of the samples and the speed of ultrasonic waves. The propagation time was determined with a Steinkamp BP-5 apparatus. The sensibility was 0.1 us. Compression strength was realized with Solotest equipment.

Chemical analysis: the contents of extracted starch and cellulosic fiber were determined in laminated chips (0.5 mm thickness) obtained from the basal, middle and apical regions of the bamboo culm. The chips shredding for the starch extraction and fibrous fraction separation were conducted in a domestic mixer with inverted cup. The shredding time and the ratio between the chips quantity and water were respectively, 30 seconds and 1:33. The fibrous fractions were converted into cellulosic fibers with a oxidizing solution composed of concentrated acetic acid (50%), peroxide (40%) and distillate water (10%).

RESULTS

Internode dimensions: Figure 1 shows the average dimensions of the three giant bamboo species (9 replications). Results show the predominance in height of the intermediate internodes (M) for the bamboos *G. verticillata* (GM) and *D. giganteus* (DM). This characteristic, combined with a larger diameter suggests their utilization for irrigation purpose as the head loss is smaller. *G.angustifolia* seems more indicated for structural utilization because their culms are very homogeneous and they have a small height and, hence, a greater stiffness.

Dry-air culm: Figures 2,3 and 4 show the drying curves of the dry-air culms for three positions of the giant bamboo species. Taller is the collected culm region, smaller is the moisture content. The drying rate of culms obeys to an exponential law. After 20 days of natural drying conditions all of samples had 12% average moisture content. For the basal (bottom) region of *G. angustifolia*) we obtained the following equation:

$$h = 11.20 + 111.76 (\exp (-0.18211 \ t \ 1.1027)) \qquad (1)$$

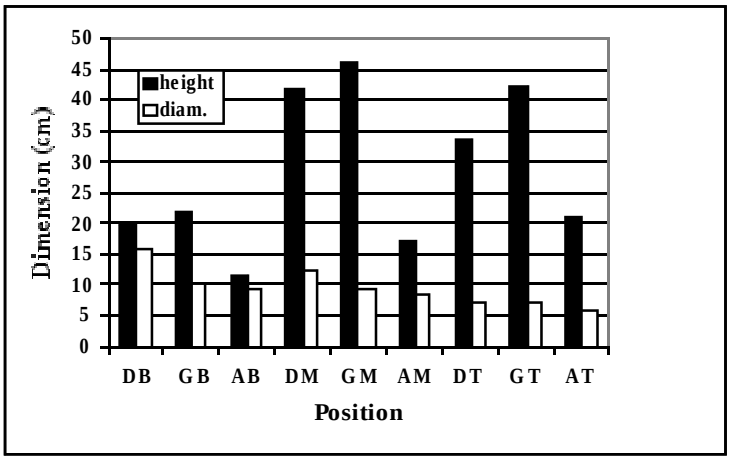

Fig. 1 - Bamboos samples dimensions

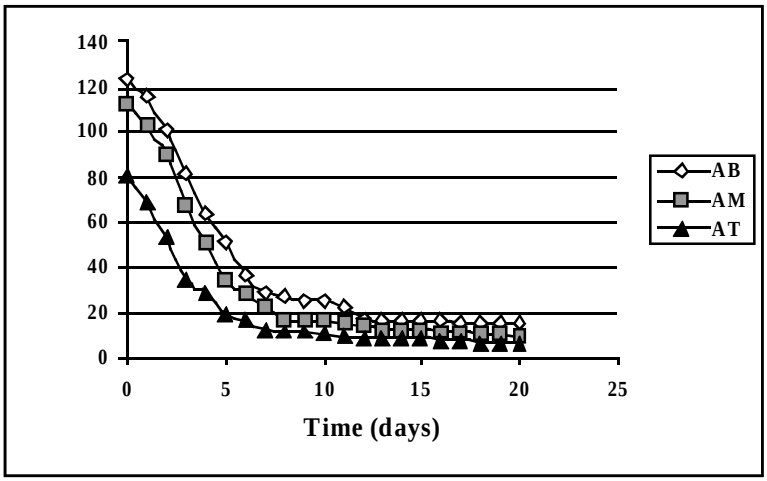

Fig. 2 - Drying curves for *G. angustifolia*

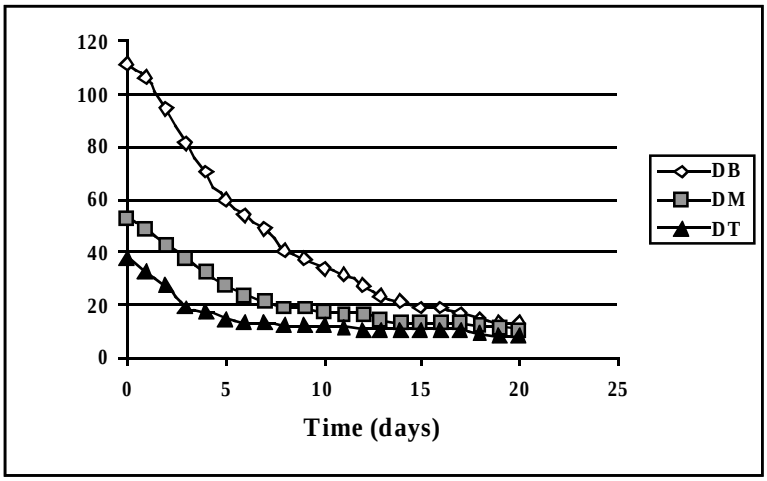

Fig. 3 - Drying curves for *D. giganteus*

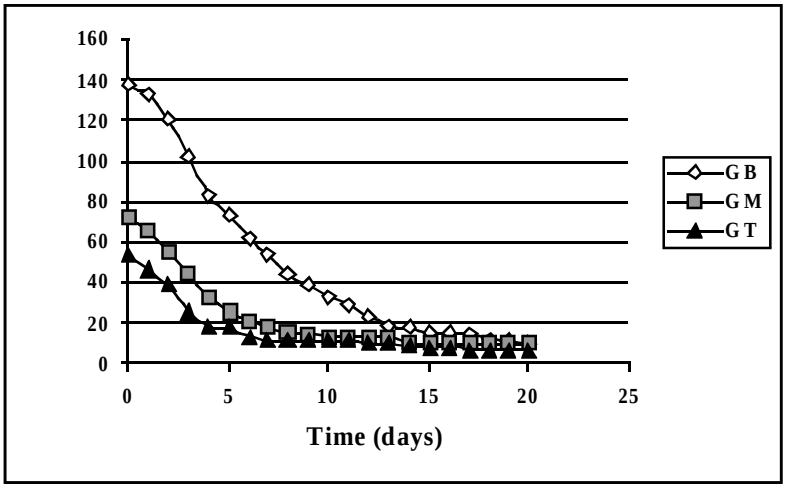

Fig. 4 - Drying curves for *G. verticillata*

Anatomical analysis: Images from polished bamboo samples were separated in three portions of the same height. Figures 5 and 6 show, respectively, the digitalized images from *D. giganteus* and *G.angustifolia* species. Dark regions (bundle fibers occurrence) are more concentrated at the bottom of figures (outer culm regions). Automatic image classification was not possible because vessels occurrence was confounded with bundle fibers. Table 1 present the distribution of bundle fibers across the culm (height and diameter position) for *D. giganteus* and *G. angustifolia* species. For the anatomical constituents of *G. verticillata* it was more difficult to obtain image with a good quality. There exists no significant statistical difference among position samples. So, the results suggest that it is easier to choose the samples from basal regions when a finished surface is needed.

Table 1 - Bundle fibers distribution (%)

Bamboo specie	Position	External	Middle	Internal
D. giganteus	**Bottom**	**54**	**40**	**26**
	Middle	**59**	**37**	**28**
	Top	**57**	**38**	**23**
G. angustifolia	**Bottom**	**44**	**30**	**17**
	Middle	**46**	**37**	**14**
	Top	**38**	**36**	**12**

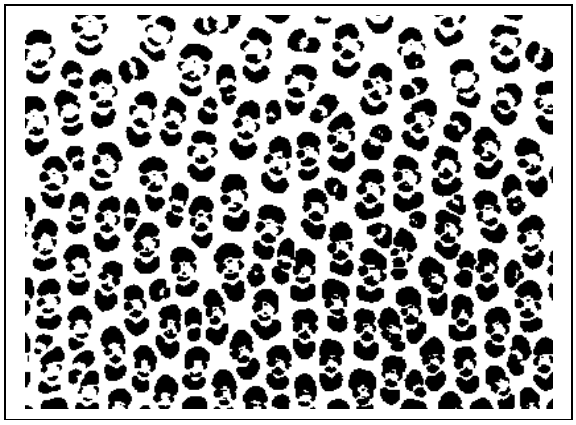

Fig. 5 - Digitalized image from *D. giganteus*

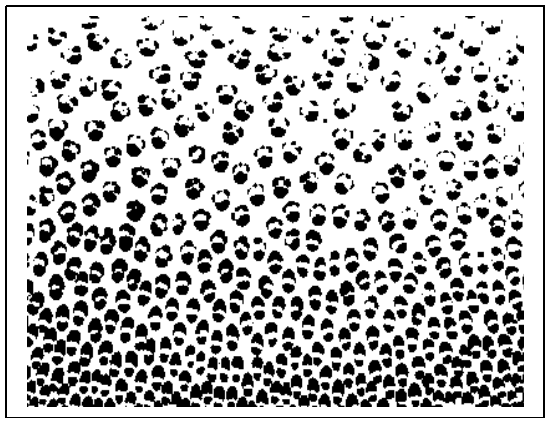

Fig. 6 - Digitalized image from *G. angustifolia*

Physical analysis: the results of the shrinkage of bamboo culms are presented in fig. 7 and 8. Natural culms shrinkage is greater than shrinkage of re-hydrated-dry culms. Dimensional sample variations are most important when the green culms are cut without nodes. For bamboo culms, shrinkage analysis or for utilization of bamboo is more interesting attempt weight stabilization of the samples. Axial shrinkage of the bamboo culms was negligible (according wood species), but radial (R) and tangential (T) shrinkage did not present the same trend as observed in wood species (tangential greater than radial).

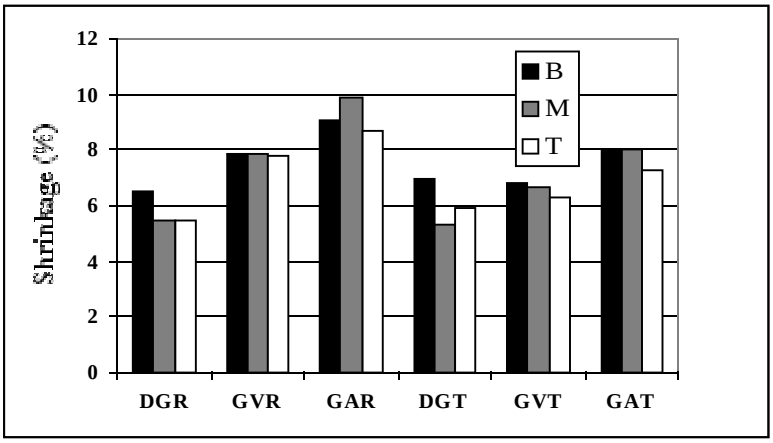

Fig. 7 - Shrinkage after rehydratation

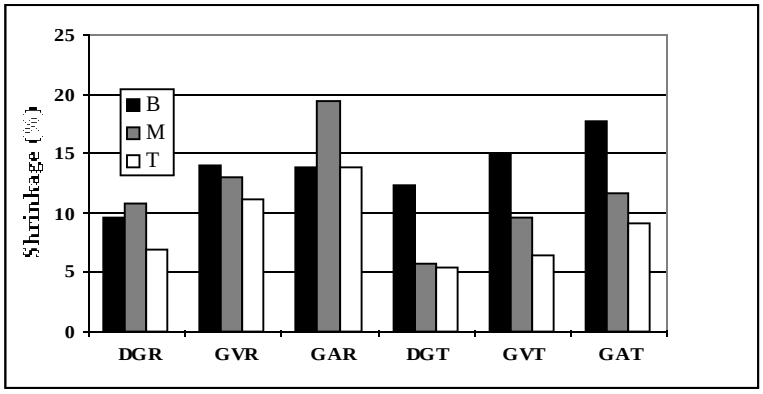

Fig. 8 - Natural shrinkage of bamboo samples

Mechanical analysis: strength compression results of the bamboo samples are presented in fig.9 and 10. For most cases, the sample region does not influence the compression test. However, like a woody material, natural air dried bamboos were more stronger than green culms. Density for natural air dried samples ranged from 0.66 (GB) to 0.97 (DP); density for green samples ranged from 0.83 (GB) to 1.15 (DP). The density presented only small variations. Samples from the top region (P) had a greater density when compared with the bottom region (B). A significant correlation between density and compression strength was not observed.

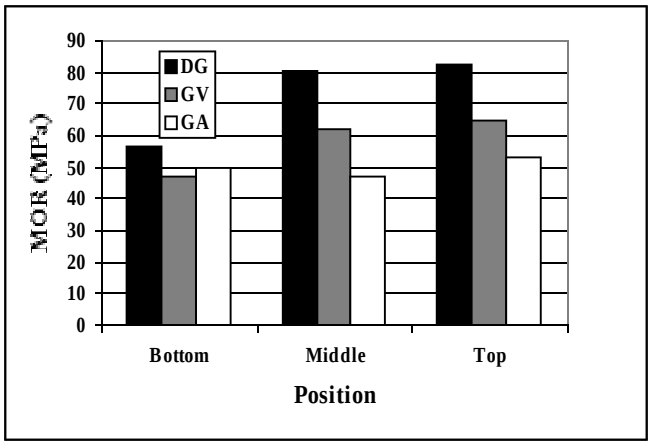

Fig. 9 - Compression strength of air dried culms

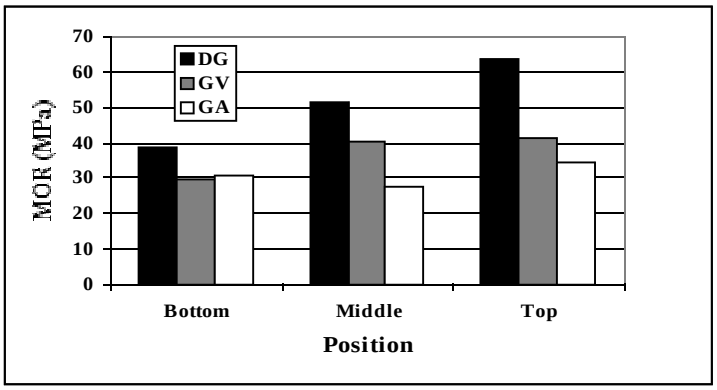

Fig. 10 - Compression strength of green culms

Non-destructive evaluation tests by ultrasonic speed wave did not show a good correlation with density. It seems that this is caused by small speed wave variations, which ranged from 4 (AP) and 5.6 km/s (GM), for green samples, and from 5 (AP) and 6.1 km/s (GM), for natural air dried samples.

Chemical analysis: The contents of extracted starch (1.7% to 3.8%) and cellulosic fiber (50.2% to 61.5%) did not change with species, but were a function of the culm regions in the *D. giganteus* and *G.verticillata* species. For these species, the highest starch contents were observed in the culm middle regions (fig. 11 and 12). The starch quantity obtained from these species is smaller than that of the *B. vulgaris* (4.7% to 9.6%). The contents of cellulose fiber are similar among the analyzed species.

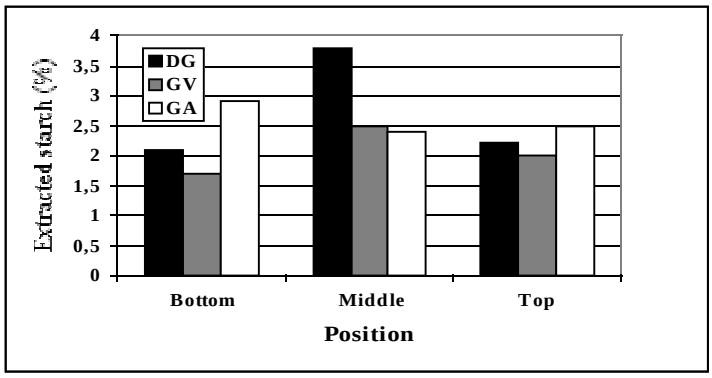

Fig. 11 - Extracted starch contents

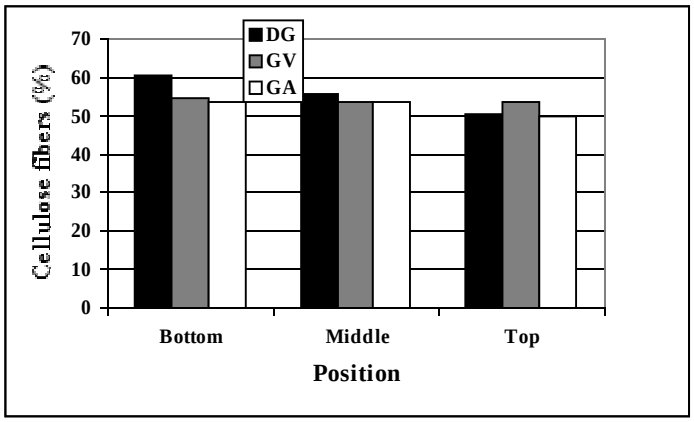

Fig. 12 - Cellulose fibers content

CONCLUSIONS

Brazilian giant bamboo species did not show a great variation in their properties. However, samples collected from three culm positions (basal, intermediate and apical) present differences. Fiber bundles are more concentrated in the 1/3 external layers. Starch contents ranged from 1.7 to 3.8% while cellulosic fibers ranged from 50.2 to 61.5%. There was not correlation between density and compression strength of the samples or ultrasonic speed wave.

REFERENCES

1 - Bambu-su cultivo y aplicaciones en: Fabricacion de papel, Construccion, Arquitectura, Ingenieria, Artesania, Lopez O.H. 1974. Estudios Tecnicos Colombianos, Cali, Colombia, 318 p.
2 - Extracao de amido em cavacos de bambu (B. vulgaris) tratados com solucao diluida de hidroxido de sodio. Azzini A., Gondim - Tomaz. 1996. Bragantia, Caminas, Brasil, 55 (1), 137-140.
3 - Reserch on bamboo, Liese W. 1987. Wood and Science Technology, 2(3), 189-209.
4 - Application of bamboo as an construction material. Ghavami K., Hombeck R.V. 1981. Proceedings of the latin America Symposium Applied to Low Cost Housing, IPT, Brasil, 49-66.
5 - Généralisation et optimisation de la fabrication d'un composite biomasse végétale-ciment a variations dimensionelles limitées vis-a-vis des variations de I'humidité, Beraldo A.L. 1994. These do Doctorat. Universite Henri Poincaré, Nancy 1, Nancy, France, 222p.