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An Investigation on Morphology, Anatomy and Chemical Properties of Some Myanmar Bamboos

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မြန်မာ့ဝါးအချို့၏ရုပ်သွင်ဗေဒ၊ အင်္ဂါဗေဒ နှင့် ဓာတုဂုဏ်သတ္တိများကို စူးစမ်းလေ့လာခြင်း

ဒေါ်ခင်မေလွင်၊ B.Sc. (I.C), Dip. Pulp & Paper Technology (India)
လက်ထောက်သုတေသနအရာရှိ
ဒေါ်ရီရီဟန်၊ M.Sc. (Bot.) (Rgn.) ၊ လက်ထောက်သုတေသနအရာရှိ
ဦးကျော်ဝင်းမောင်၊ B.Sc. (Bot.) Q (Rgn.) ၊ သုတေသနလက်ထောက်
ဦးအောင်ဇော်မိုး၊ B.Sc. (Bot.) Q (Mdy.) ၊ သုတေသနလက်ထောက်
ဒေါ်စုမြင့်သန်း၊ B.Sc. (Chem.) Q (Mdy.) ၊ သုတေသနလက်ထောက်
သစ်တောသုတေသနဌာန၊ ရေဆင်း

စာတမ်းအကျဉ်းချုပ်

များပြားလှစွာသော ဝါး၏အသုံးကျမှုများသည်၊ ဝါး၏ဂုဏ်သတ္တိများ ပေါ်တွင် မူတည်ပါသည်။ ဤစာတမ်းတွင် ဝါး၏ ဓာတုဂုဏ်သတ္တိများနှင့် ဝါး၏ပြင်ပလက္ခဏာ၊အင်္ဂါဗေဒများကို နားလည်အောင် လေ့လာခဲ့ပါသည်။ လေ့လာခဲ့သော ဝါးမျိုးများမှာ တင်းဝါး (*Cephalostachyum pergracile*), ဝါးဘိုးဝါး (*Derdrocalamus giganteus*) နှင့် မျှင်ဝါး (*Dendrocalamus strictus*) တို့ ဖြစ်ပါသည်။ အထက်ပါ ဝါးများကို ပျဉ်းမနားမြို့နယ်၊ ဆင်သော့မှ စုဆောင်းယူခဲ့ပါသည်။ လေ့လာတွေ့ရှိချက်များအရ ဝါးဘိုးဝါးသည် ဓာတုပါဝင်မှုအများဆုံးဖြစ်ကြောင်းနှင့် ဝါး၏အင်္ဂါဗေဒလေ့လာချက်အရ ဝါး၏ Vascular strand များသည်မျိုးခွဲရာတွင် အသုံးဝင်သော လက္ခဏာများရှိကြောင်း တွေ့ရပါသည်။

An Investigation on Morphology, Anatomy and Chemical Properties of Some Myanmar Bamboos

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Abstract

The various uses of bamboo depends on the unique properties of its culm. The investigation is an attempt to understand the anatomical characters and chemical properties of bamboo. The species selected for investigation are Tin Wa (*Cephalostachyum pergracile*), Wa bo (*Derdrocalamus giganteus*) and Hmyin Wa (*Dendrocalamus strictus*). The materials were collected from Sinthawt, Pyinmana Township. It was found that the Wabo had the highest chemical contents among the three tested species. And the distribution of vascular strands are useful in identifying the bamboos anatomically.

Contents

1. Introduction

Bamboos are perennial grasses with woody stems or culms which occur mostly in natural vegetation of tropical, sub tropical and temperate regions and are abundant in tropical Asia. Bamboo is the most important forest product for rural people. It is used as a construction material and for making mats, baskets, fish traps, fishing poles, tool handles, ropes, umbrellas, toys, musical instrument, furniture, rayon etc. Edible bamboo shoots are sold in the market in raw, boiled or fermented forms. The most important industrial use of bamboo is in making pulp and paper.

The number of species of bamboo as recorded in the revised check list of Myanmar is 15 genera, 97 species. The most common bamboo species in Myanmar are Kyathaung Wa (*Bambusa polymorpha* Munro.), Wanet (*Dendrocalamus longsnathus* Kurz. Munro.), Hmyin (*Dendrocalamus strictus* Nees.), Tin Wa (*Cephalostachyum pergracile* Munro.) and Wabo (*Dendrocalamus giganteus* Munro.)

The main constituents of the bamboo culms are cellulose, hemicellulose and lignin and, minor constituents consist of resins, tannins, waxes and inorganic salts. The composition varies according to species, the conditions of growth, the age of the bamboo and the part of the culm. The bamboo culm tissue matures within a year when the soft and fragile sprout becomes hard and strong. The proportion of lignin and carbohydrates is changed during this period. However, after the full maturation of the culm, the chemical composition tends to remain rather constant.

Knowledge of Bamboo anatomical components and their behavior is more important now than ever. There is a need for effective protection against external influences, careful isolation of Bamboo components, and a search for new products based on them. For a better understanding of known technologies and further development of new process, basic research into the isolation, characterization and reaction of bamboo components is require.

Anatomy of the vascular bundles of bamboo culm is a useful guide for bamboo taxonomy. The details can be used when some bamboos cannot be identified with their flowers. It is also used in identifying some bamboos from ancient cultural relics. In addition, the splitting property, strength and the ratio of fibre strands of bamboo culm used by modern paper making industry, handicraft industry and other bamboo processing industries. Bamboos can be identified on the basic of characteristics and features, arrangements and types of the vascular bundles. If the cross-sectional area of vascular bundle sheaths and the fibre strands are larger, then the bamboo wood is strong and contain a high percentage of fibre. If the vascular bundles are evenly distributed the bamboo wood has a good splitting property.

In Bamboo the fibre content is about 60 to 70 percent by weight. The fibres constitute the sclerenchymatous tissue and occur in the internodes as caps of vascular bundles and in some species additionally as isolated strands. They contribute to 40-50% of the total culm tissue.W. Liese (1985) The distribution of fibre varies in different portion of the plant. The fibre content is greater in the periphery than inside, parenchyma predominates here. Fibre distribution is highest in the internodes situated at one quarter to one half the height of the culm. Bamboos fibres show considerable variation in shape, size and wall thickness. They are usually long and straight with tappering end. The length of fibres varies among species and even within the species. The fibers in the same plant also varies in length in the culm. Across the wall the fibre length often increases from the pheriphery, reaches its maximum at about the middle and decreases towards the inner part (Lessardet. al. 1980.) The fibres near the node is smaller than the internodal portion.

In this research, an investigation on the anatomy and chemical of three species of two genera belonging to the family Gramineae has been undertaken. The species are *Cephalostachyum pergracile*, Munro (Tin-wa), *Dendrocalamus strictus,* Nees (Hmyin-wa) and *Dendrocalamus giganteus* Munro (Wa-bo).

2. Literature Review

The bamboo culm is consisted of many kind of chemical compounds, in addition to cellulose, semi- cellulose and lignin are also dominated. There are still other nutrient substances, such as protein (1.5% - 6%), glucose (2%), starch (2.02% - 5.18%), as well as fat and wax (2.18%- 3.55%). So they are very susceptible to mould and rotting during their transportation and storage, which factors make their span of use much shorter. (Tang Yongyu, 1984)

The approximate chemical compositions of bamboo culms are generally similar to those of hardwoods, except that alkaline extract, ash and silica contents which are higher than in hardwoods. High silica content causes scaling during evaporation of spent liquor for recovery of the chemical in pulping. (Takayoshi Higuchi, 1985)

The cellulose in bamboo amount is more than 50 % of the chemical constituents. The degree of polymerization (D-P) for bamboo is considerably higher than for dicotyledoneous woods. Cellulose is difficult to isolate in pure form because it is closely associated with the hemi-cellulose and lignin. More than 90% of bamboo hemicellulose consist of a xylan which seems to be a 1,4 linked linear polimer forming a 4-0-methyl-D- glucuronic acid, L- arabinose, and D- xylose in a molar ratio of 1.0: 1.3: 25 respectively.

Lignin represents the second most abundant constituent in the bamboo and much interest has been focused on its chemical nature and structure. Bamboo lignin is a typical grass lignin, which is built up from the 3-phenyl-propane units p- coumaryl, coniferryl, and sinapyl alcohols interconnected through biosynthetic pathways. (W. liese,1985)

The Bamboos, belonging to the gramineae, possess a primary shoot without secondary growth. The culm consists of internodes and nodes. In the internodes the cells are axillary oriented, whereas the nodes provide the transversal inter connections. No radial cell elements such as rays, exist in the internodes. The outermost part of the culm is formed by a single layer of epidermal cells and the inner side is covered by a layer of sclerenchyma cells. (W.Liese, 1980)

The gross anatomical structure of a transverse section of internode is determined by the vascular bundles, their shape, size, arrangement and number. The vascular bundles contrast the parenchymatous ground tissue, which is much lighter in colour. At the peripheral zone of the culm, the vascular bundles are small and numerous at the inner part, larger and fewer. Within the culm, the total number of vascular bundles decreases from bottom to top, and their densenes increases correspondingly.

The culm consists of parenchyma cells forming the ground tissue and the vascular bundles composed of vessels, sieve tubes with companion cells, and fibers. The total culm consists of about 50% parenchyma, 40% fibres and 10% conducting cells (vessels and sieve tubes). W.Liese (1980). The distribution of cell types within the culm is influenced by the type of vascular bundle present.

The ground tissue consists of parenchyma cells, which are mostly vertically elongated with short, cube like ones interspersed in between them. The elongated cells possess thicker walls, which become lignified in the early stages of shoot growth. The shorter cells are characterized by a denser cytoplasm and thin walls. The parenchyma cells are connected with each other by small, simple pits located walls.

The vascular bundle in the bamboo culm consists of xylem with two large metaxylem vessels with one or two protoxylem elements and the phloem with thin-walled, unlignified sieve tubes connected with companion cells. The vessels are larger at the inner part of the culm and become small toward the outer part. Both the vessels and the phloem are surrounded by sclerenchyma sheaths. They differ considerably in size shape and location, according to their position in the culm and the bamboo species. (W.Liese, 1980)

Most of the species have separate fibre strands on the inner or the inner and outside of the vascular bundle. (Grosser and Liese, 1971, 1973, and WU and Wang 1976, Jiang and Li, 1982).

Four to five major types of vascular bundles can be differentiated. The vascular bundle types and their distribution within the culm correlate with the taxonomic classification system of Holttum (1956) based on the ovary structure.

As a matter of fact, specific features and characteristics should be closely examined in attempt to identify bamboos by means of their anatomical structure.

Fibre morphology and chemical properties of lignocellulosis materials are of considerable importance especially in determining their enduse. Fibre dimensions, as well as fibre length, influence the physical and mechanical properties which in turn affect the workability (Parameswaran and Liese, 1976). In reality, between different kinds of plant species is due to the differences in their peculiar anatomical and chemical properties.

3. Materials and Methods

The three bamboo species, Tinwa (*Cephalostachyum pergracile* Munro.), Wabo (*Dendrocalamus giganteus* Munro.) and Hmyin wa (*Dendrocalamus strictus* Nees.) of three years old were collected from Sinthawt, Pyinmana Township Forest Area during the year 2000.

For chemical study, all the culms of three bamboos species were divided into three equal portions basal (B), middle (M) and top (T).

The method used for the approximate chemical analysis of bamboos were based on TAPPI methods using three replicates which were randomly cut from each portion. All cuts were ground to 60 – 80 mesh size.

Chemical analysis for determining the percentage of some chemical constituents was conducted on oven dry mild bamboo samples according to the following standard method.

a.	Hot water solubles	TAPPI T 207 (1978)
b.	1% NaOH solubles	TAPPI T 212 (1978)
c.	Alcohol – benzene solubles	TAPPI T 204 (1978)
d.	Lignin	TAPPI T 222 (1978)
e.	Ash	TAPPI T 15 (1978)
f.	Silica	

Three portions of bamboo culms were first crosscut into one feet length and the cuts were then splits open into two or three pieces for the carbonization analysis.

The initial stage of the study was concerned the carbonization of bamboo under the laboratory conditions. Pyrolysis was carried out in a 100 liter iron retort without air at 800 C.

The charcoals produced were analysed to determine moisture content, specific gravity, ash contents and fix carbon content according to the analytical methods JISM 8812 (1963). Activated power of Bamboo charcoal was tested by potassium permanganate solution.

Morphological and taxonomical study of bamboos were done at the Herbarium, F.R.I.

For anatomical study, samples were obtained by taking the middle part of the internode. Samples measuring 4-10 mm x 20mm were taken from the central internode in the portion. The specimens were boiled with water for 20 hours for softening and microtomed to obtain 20-25 um thickness of cross section for observation. The sections were stained in safranin, dehydrated and mounted on slides for microscopic examination. The variations of structure and shape of vascular bundle were observed under light microscope.

The fibres in bamboo vary in length for different species as well as in the same species and even in the same plant. Stereological counting was done to measure the length of the fibres. Among these samples one was from the internode with the epidermal layer, second was also from the internode but without epidermal layer, third sample was from the nodal portion and the fourth from the epidermal layer.

All the samples were marked and were processed separately. To study the fibre length, the schulze method (1980) of immersing samples for 26 hours in a mixture of equal volumes of hydrogenperoxide and glacial acetic acid was used. The tests were done at the Wood Anatomy Laboratory. Macerated materials for each dimension 25 cells elements were measured microscopically at random. The photomicrographs were taken by using the Olympus Universal Research Microscope, Vanox model.

4. Chemical study of selected bamboos

Approximate chemical analysis for some Myanmar bamboos species and their results are summarized in Table I.

Table I. Chemical composition of the three bamboo species compared to others in China, India and Japan.

Species	Local name	Ash (%)	Hot water soluble (%)	1% NaOH soluble (%)	Alcohol benzene soluble (%)	Holo-cellulose %	Lignin (%)	Silica (%)
Cephalostachyum pergracile	Tin wa	2.2	8.0	23.5	6.3	60.2	18.1	1.11
Dendrocalamus giganteus	Wabo	1.9	16.6	28.4	7.4	63.6	17.8	0.73
Dendrocalamus strictus	Hmyin wa	1.6	13.0	24.6	7.7	59.8	22.8	1.47
Range of values for 10 Indian bamboo species*		1.7-3.2	3.4-6.9	15.0-21.8	0.2-3.2	-	22.0-32.2	0.44-2.11
Range of values for 10 Japanese bamboo species*		0.8-3.8	5.3-11.3	22.3-29.8	0.9-10.8	61.9-70.4	19.8-26.6	0.1-1.78
Range of values for 10 China bamboo species*		0.67 - 2.65	5.41 - 15.94	26.91-35.32	3.88-9.11	71.98-79.39	22.02-26.75	-

(* Asian Bamboos)
Moisture free basis
Source. J.A.J.O Escolano and Mon salud 1967. The Kraft pulping quality of some philippine bamboos.TAPPI 416-419.

As shown in table I the chemical composites of Hmyin Wa, ash content, hot water solubility, 1% NaOH solubility, alcohol-benzene solubility and lignin content are similar to those Asian bamboos. The ash content, 1% NaOH solubility hot water solubility and alcohol benzene solubility of Tin wa are similar to the other Asian bamboos, but lignin content is a little bit lower than other.

The ash content, alcohol-benzene, 1% NaOH solubility, and holocellulose content of Wabo is very similar to the other bamboos, but hot water solubility is higher than other bamboos. It is found that the silica content of Wabo (0.73%) is the lowest. The lignin content of wabo is also lowest among others.

Some properties of bamboo charcoal are shown in table II. With regard to ash contents, those of experimentally obtained , Tinwa charcoal was a little bit high in 5.4%, those for the commercial charcoals were 2-6 %. Ash content of Hmyin wa charcoal was highest among tested species. The highest volatile matter and lowerest fix carbon were also found in Hmyin wa.

When activated power of Bamboo charcoal was tested by potassium permanganate solution, Wabo charcoal was absorbed completely the colour from potassium parmagenate solution. (Plate I) Its showed that activated power of bamboo charcoal was highest in Wabo charcoal between three tested species.

Table II. Properties of Bamboo Charcoal

Species	Local name	Moisture %	Ash %	Volatile matter %	Fix carbon %
Cephalostachyum pergracile	Tin wa	3.0	5.4	11.1	83.5
Dendrocalamus giganteus	Wabo	2.0	4.8	12.7	82.5
Dendrocalamus strictus	Hmiyn wa	2.5	11.0	23.1	65.6

5. Morphological and taxonomical study of the selected Bamboos.

5.1 *Cephalostachyum pergracile* Munro.

A deciduous, arborescent, tufted bamboo.

Culms 10-30 m tall erect, glaucous-green, somewhat whitish-puberulous below the nodes; nodes scarcely thickened; internodes 30-45 x 5-7.5 cm, wall very thin.

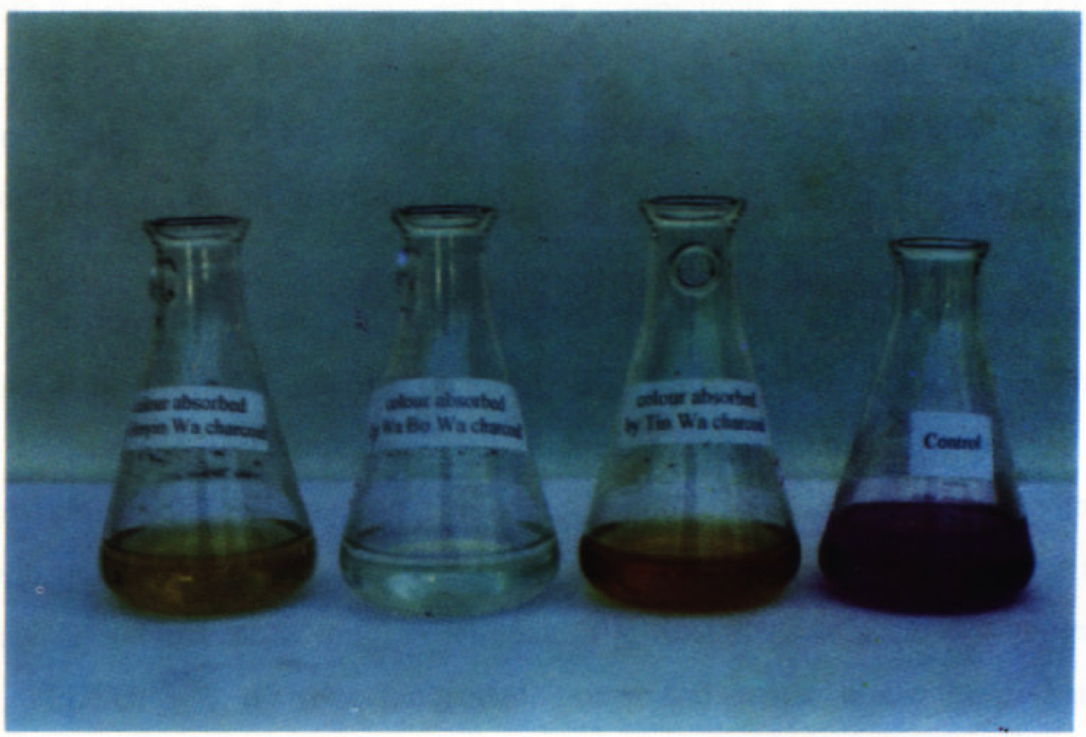
Culm-sheaths chesnut-brown, broader than long, 10-15 x 15-20 cm, covered with black, stiff deciduous hairs, afterwards polished; imperfect blade 5 cm long, ovate, cordate, cuspidate, densely hairy within, decurrent into a wavy fringe bordering the top of the sheath and ending on either side in a rounded auricle; both fringes and auricles edges with long, stiff curved, white bristles; ligule very narrow, entire.

Leaves variable, 15-35 x 2.5 -3.25 cm or sometimes even 6.25 on broad, linear-lanceolate, thin rounded or cuneate at the base into a short petiole, terminating above in subulate, scabrous, acuminate point, glaucescent beneath, rough on both the surfaces and margins; main vein conspicuous, secondary veins 7-13 pairs, intermediate usually 5, transverse veinlets few, oblique; sheaths glabrous, faintly striate, ending in a small, ciliate callus, auricles at the mouth with a few, early caduous cilia; ligule very narrow, entire.

Inflorescence a large panicle with long drooping, filiform spikes bearing distand broad heads of spikelets, chaffy, sheathing bracts; rachis very slender, wiry. Spikelets in bacteate cluster, 1-2 cm long, without glumes, but bearing 1-2 cm sterile florests, followed by a fertile floret, ending in a terminal sterile florest or flilform, produced rachilla; lemmas, 1-1.5 cm long, ovate-lanceolate, many nerved, densely harily; peleas as long as lemmas, 2 keeled, the keels close together, apex bifid. Lodicules 2,n arrow, lanceolate, obtuse and ciliate at the tip, 3-5 nerved, persistent. Stamens with narrow filaments; another purple, obtuse. Ovary smooth, sub-globular; style one; stigmas 2-3, stout, recurved. Caryopsis 1 cm long.

PLATE I

Colour absorbing with bamboos charcoal



Colour absorbed by bamboos charcoal

5.2 *Dendrocalamus giganteus* Munro.

The tallest of bamboos with close culms and slender branches.

Culms 24-30 m tall, 20-30 cm diameter, usually 2-2.5 cm thick-walled, dull green, covered with white waxy crust when young; internodes 35-40 cm long, lower nodes with root scars.

Culm-sheaths 30-50 cm long and broad, falling early, hard, smooth, shining within, dull yellow and covered with dark-brown hairs on the back; ligule 8-13 mm high, stiff, dark, serrate; auricle prominent, brown, cripsed; blade 13-38 cm long and upto 5 cm broad, spreading at right angles, stiff, acuminate,edges inflexed.

Leaves variable in size, in much culm upto 50 cm long and 10 cm broad, oblique, oblong, acuminate, smoot above, hairy beneath; petiole 3-5 mm long; ligule 2-3 mm high, serrulate; auricle small, glabrous.

Inflorescence a huge panicle with long slender curved branchlets, bearing lax heads of few spikelets; heads up to 2.5 cm diameter; rachis joints 1.2-2.5 cm or morre slender, hairy below, white-scurfy above often curved, furrowed on one side.

Spikelets 1.2-1.5 x 7.8 mm, minutely pubescent, somewhat flattened, ovate, acute, spiny, many-flowered; empty glumes 1 to 2, ovate, mucronate, elongate; flowering glumes thin, papery, striate, many-nerved, mucronate, minutely hairy; palea of lower flowers 2-keeled and ciliate on the keels, of upper flowers usually not keeled and glabrous. Stamens with long filaments; anthers 7.5 –10 mm long, acuminate at the tip. Ovary ovoid, hairy; style long, hairy, ending in a feathery purple stigma.

Caryopsis oblong, about 7-8 mm long, obtuse, hairy above.

5.3 *Dendrocalamus strictus* (Roxb.) Nees.

A deciduous densely tufted bamboo.

Culm 8-16 m high, 2.5 –8 cm in diameter, pale blue-green when young, dull green or yellowish when old, much curved above half of its height; node somewhat swollen, basal note often rooting, lower nodes often with branches; internodes 30-45 cm long, thick-walled.

Culm-sheaths variable, lower ones shorter, 8-30 cm long with golden-brown stiff hairs on the back, sometimes glabrous in dry localities, striate, rounded at the top, margin hairy; ligule 2-3 mm high, toothed; auricle small; blade triangular, awl-shaped, hairy on both sides.

Leaves linear-lanceolate, small in dry localities, upto 25 x 3 cm, in moist areas, rounded at the base into a short petiole, tip sharply acuminate with twisted point, rough and often hairy above, softly hairy beneath; ligule very short.

Inflorescence a large panicle of large dense globular heads 4-5.0 cm apart; rachis rounded, smooth.

Spikelets spinescent, usually hairy; the fertile intermixed with sterile smaller ones, 7.5-12 x 2.5-5.0 mm, with 2 to 3 fertile flowers; empty glumes 2 or more, ovate, spinescent, many-nerved; flowering glumes ovate, ending in a sharp spine surrounded by ciliate fufts of hair; pelea ovate or obovate, emarginate, lower ones 2-keeled, ciliate on the keels and 2-nerved between them, uppermost not keeled, often nearly glabrous, 6 to 8 nerved.

Stamens long-exserted; filaments fine; anthers yellow, shortly apiculate. Ovary turbinate, stalked, hairy above and surrounded by a long style ending in a purple feathery stigma.

Caryopsis brown, shining, ovoid to sub-globose, ca 7.5 mm long, hairy above beaked with the persistent base of the style, pericarp coriaceous.

6. Anatomical study of the selected Bamboos.

It was found that, *Cephalostachyum pergracile* consists of one central vascular strand; supporting tissue only as sclerenchyma sheaths; and sheath at the intercellular space (protoxylem) strikingly larger than the others. *Dendrocalamus strictus* consists of two parts, the central vascular strand with sclerenchyma sheaths and one isolated fibre bundles. But *Dendrocalamus giganteus* varied from above mentioned species for it consists of three parts, the central vascular strand with small sclerenchyma sheaths and two isolated fibre bundles outside and inside the central strand.

Therefore the findings are in agreement with Holttum (1956) as he indicated that

Cephalostachyum pergracile	- type II
Dendrocalamus strictus	- type III
Dendrocalamus giganteus	- type IV

As shown in plate II, it can be seen that the woody stem consists of a number of vascular bundles composed in part of fibrous elements. Besides, these bundles are distributed irregularly throughout the culms.

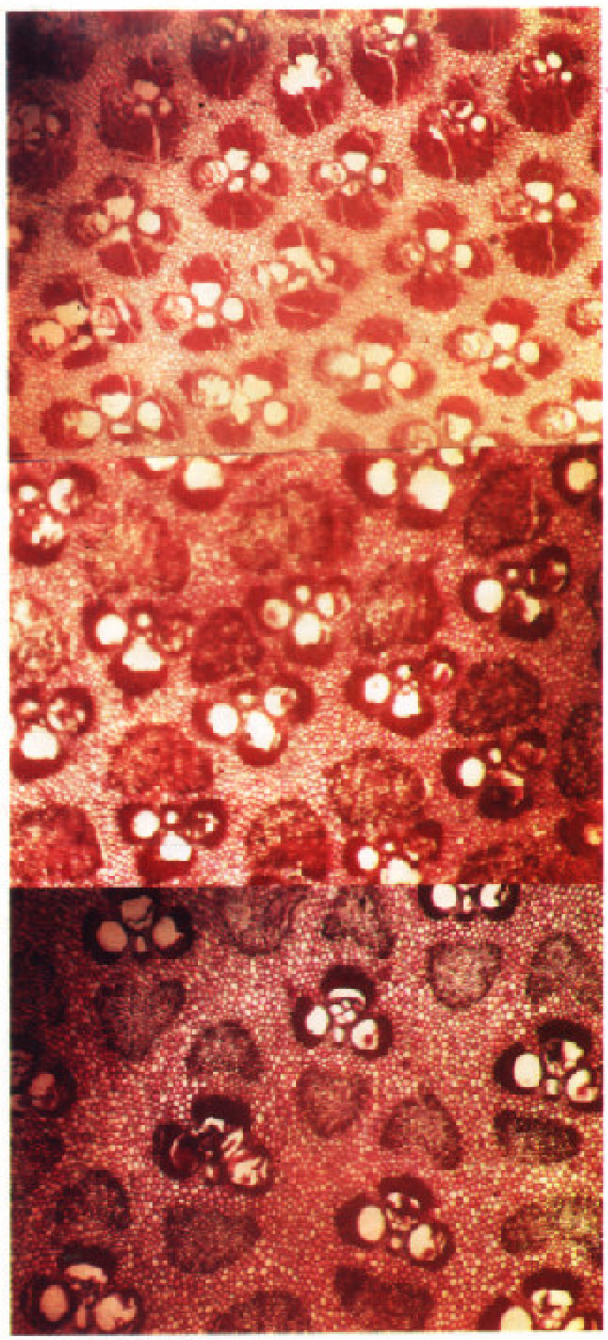
The anatomy of the individual vascular bundle is shown at high magnification in plates III A, III B and III C in which it can be seen that they are composed in part of large vessels which serve for the conduction of water; sieve tubes, which convey albuminous matter; and strong fibres, which furnish mechanical strength to the plant and which also provide the fibres used in paper- making.

Each vessel is surrounded by soft tissue (parenchyma), the sieve tubes are accompanied by companion cells (small cells among the sieve tubes) and generally one or more inter-cellular openings can be found in the bundle. The whole vascular is surrounded by fundamental tissue composed of thin –walled weak cells which do not form a constituent part of paper and which, together with the soft tissue surrounding the vessels, have to be got rid of as much as possible in the preparation of the fibre for manufacturing paper pulp.

The data of different sterelogical counts are tabulated in Table III and IV respectively. According to the obtained results, the fibre lengths showed variation between different samples. The average length, width and thickness of fibres in three species are given in Table III.

In Table IV it is shown in Column 1, the first sample which was taken from internode with epidermal layers are 2099.71 µm, 1825.52 µm and 2415.41µm. The second sample pointed out in column 2 are 2722.4 µm 3490.63 µm and 2933.03 µm. The third sample (nodal portion) in column 3 are 1340.18 µm, 1572.86µm and 1595.92 µm. The fourth sample in column 4 are 1390.93 µm, 1592.33 µm and 2280.62 µm.

PLATE II



A

B

C

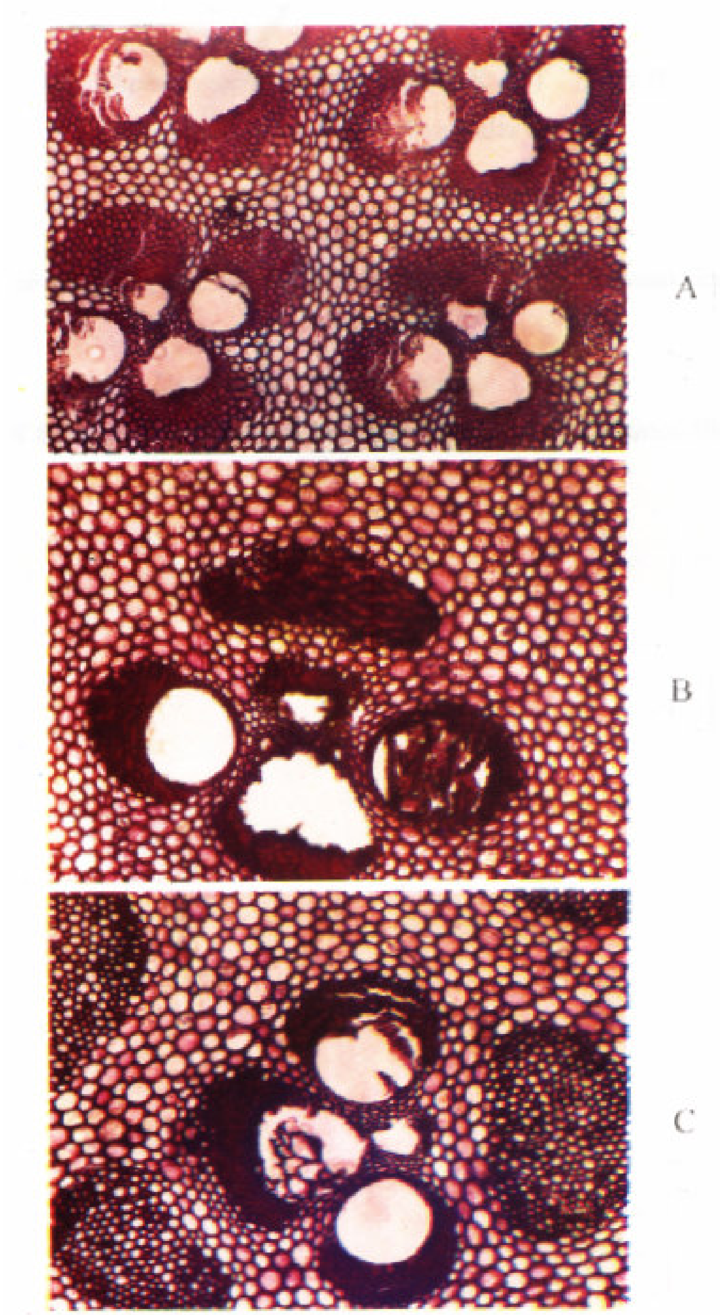
Cross Section showing vascular bundles surrounded by fundamental tissues

A. *Cephalostachyum pergracile* (X 80)

B. *Dendrocalamus strictus* (X 80)

C. *Dendrocalamus giganteus* (X 80)

PLATE III



Different types of vascularbundles

A. *Cephalostachyum pergracile* (X 80)

B. *Dendrocalamus strictus* (X 80)

C. *Dendrocalamus giganteus* (X 80)

Different types of vascular bundles

A. *Cephalostachyum pergracile* (X 80) Type II
(consisting of one central vascular strand)

B. *Dendrocalamus strictus* (X 80)
(consisting of two parts, the central vascular strand and one isolated fibre bundles)

C. *Dendrocalamus giganteus* (X 80)
(consisting of three parts, the central vascular strand and two isolated fibre bundles)

Table III. Showing the average length, width and wall thickness of the fibres of the three species of Bamboos

Sr. No.	Species	fibre length (mean) (micron)	fibre width (mean) (micron)	fibre wall thickness (micron)
1	*Cephalostachyum pergracile*	2722.4	20.37	2.5 - 7.5
2	*Dendrocalamus giganteus*	3490.63	17.68	2.5 - 7.5
3	*Dendrocalamus strictus*	2933.03	15.25	2.5 - 10

Table IV. Fibre length measurement at internodal and nodal portion

Sr. No.	Species	Internode		Node	
		with epidermis mean (micron)	without epidermis mean (micron)	with epidermis mean (micron)	without epidermis mean (micron)
1	*Cephalostachyum pergracile*	2099.71	2722.4	1340.18	1390.93
2	*Dendrocalamus giganteus*	1825.52	3490.63	1572.86	1592.33
3	*Dendrocalamus strictus*	2415.41	2933.03	1595.92	2280.62

7. Discussions

The Wabo has the chemical properties with highest chemical composition. High hot water solubility showed that it has a high starch content. It is also concentrated with carbohydrate, mainly of the hemicellulose, which factor showed it's span of use were short and its should be pretreated with some kind of preservation before using. The approximate chemical composition of other two species, Tin wa and Hmyin wa are very similar to those of Asian bamboos.

The activated power of bamboo charcoal was highest in Wabo among three tested species. It showed that Wabo can produces as chemical such as activated carbon. The lower content of silica and lignin content of Wabo showed that it is also most suitable for the pulp and paper making.

Low fix carbon content, high volatile matter content and high ash content of Hmyin wa charcoal showed that it is no good in quality. The other two species, Tin wa charcoal and Wabo charcoal have high fix carbon content, low volatile matter content and low ash content. It showed that the two charcoals have good quality.

As indicated in Table IV, the fibre lengths were found to vary along the length of the same internode, the fibers near the nodal portion were shorter than the fibers found at the internodal portion. The largest fibre was found in the middle part of the internode. Towards the outer periphery of culm, the fibres are found gradually decreasing in size, smallest are found at the outermost layer of the internode.

8. Conclusions

Based on the results in this study, the following conclusions may be drawn. For the chemical properties points of view, Wabo has the valuable chemicals and highest quality. It should be produce as activated carbon for the improved utilization and economy. It is also most suitable for the pulp and paper making. But it will be required to some kind of pretreatment for the long time span.

Among three tested species, the other two species, Tin wa and Hmyin wa are very similar to the Asian bamboos in approximate chemical composition. They have intermediate quality for the pulp and paper making and other uses. Wabo and Tin wa can produce good quality charcoal. But Hmyin wa should not produce as charcoal.

Fibres in the middle portion of the internode are larger than the other portion.Towards the periphery the fibres become shorter. At the nodal portion fibres are shorter than the internodal portion. The easy cultivation of bamboo and its fibre characteristic is an important factor to think about its potential for pulping in most part of the world. More and more research on bamboo species should be carried out to develop or enhance its better utilization and to make more productive.

For the chemical industries, it is understood, that the future source of raw materials for the production of tar, turpentine, acetic acid, activated charcoal and a few other chemical can be gained directly from bamboos.

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