# Quantitative Microscopical analysis on cellular elements for the identification of Bamboo pulp

**J. Bhattacharya**
**Gita Guha (Miss)**
**B. Bhattacharyya**

*Twenty-five samples of Bamboo pulp have been studied microscopically for the six types of cellular elements. One hundred elements have been examined in each sample (total : 2500) for percentage incidence, dispersion and correlation. All the types of elements are found to occur in different proportions although two of them are not always present in every sample. Four out of six types are always found to occur which show a great magnitude of correlation between each other apart from significant difference between mean percentage. Hence, study of bamboo pulp greatly depends on only four out of six types of cellular elements.*

**Introduction :**

Pulping of bamboo is done by chemical means for the manufacture of paper & board. Morphological identification of various cellular elements of the bamhoo pulp is already known.[1,2] Quantitative microscopical studies on the diameter and length of fibres is also on record[1] but the information with regard to the incidence of each type of cellular element in a pulp sample as well as the knowledge of the extent to which one type is related to the other is still inadequate. With this end in view, quantitative studies have been attempted on the cellular elements present in bamboo pulp.

**Material and method :**

Fresh bamboo pulp received from M/S Orient Paper Mills, Brajraj Nagar, Orissa, has been taken for study and a suspension is made in water with a small quantity of randomly collected pulp. The latter is boiled in order to separate individual elements, is cooled and shaken vigorously when the cellular elements are uniformly dispersed. A drop of suspension has been pipetted off on a microscopic slide and covered with a cover glass. Twenty-five such slides out of 200 have been selected. They are examined under the microscope for 100 cellular elements in each. Different cellular elements present in bamboo pulp have been categorised into six types as described below: –

Type I : Fibres without any special features (fig I).

Type II : Fibres with special features as compressed areas with transverse markings in the form of buckles (fig. II).

Type III : Parenchyma cells or pith cells or cells of medulla (fig. III).

Type IV : Vessels—barrel shaped or discoid or cylindrical with numerous larger pits (fig. IV).

Type V : Fibro-vascular elements-spiral and girdle-shaped (fig. V). The occurrence of such elements is not known to have been reported previously.

Type VI : Slender epidermal cells with wavy or slightly corrugated margins (fig. VI).

All the tppes of elements are shown in Plate 3.

A differential count of 2500 elements has been made and the occurrence of each type has been

**Biology Division, Central Forensic Science Laboratory,**
**30, Gorachand Road, Calcutta–14.**

kept on record. The data thus obtained has been studied for percentage occurrence of each type and the standard error of the percentage has been calculated according to the following formula :—

$$\text{S.E. of Percentage} = \sqrt{\frac{p(100-p)}{n}}$$

The results are indicated in table I. In addition, Student's 't' test of significance of the percentage between types of cellular elements has been applied on the basis of the following formula :—

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\delta_1^2 + \delta_2^2}}$$

The results are indicated in table II.

The data has further been studied for various statistical constants e. g. mean, standard error, standard deviation and co-efficient of variation in order to assess the dispersion of each cellular type. The following formulae have been applied :—

(1) $\text{S.D.} = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$

(2) $\text{S.E.} = \frac{\delta}{\sqrt{n}}$

(3) $\text{C.V.} = \frac{100\delta}{m}$

The results are indicated in table III. The distribution of each type has been presented graphically (Plate: 1). In order to assess the significance of the difference between means, Student' 't' test has been attempted on the basis of the formula already mentioned. The results are indicated in table IV. The histogram of the percentage of each type has been shown in Plate 2.

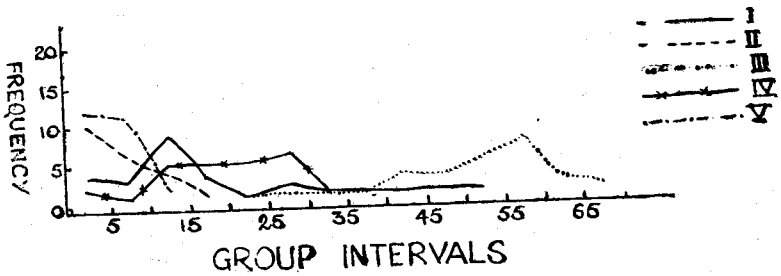


**Plate 1. Frequency Curve**

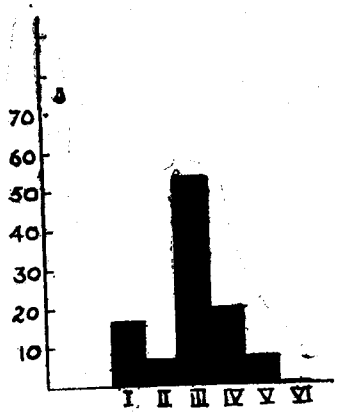


**Plate 2.**
**Histogram of Percentage Occurrence of Elements.**

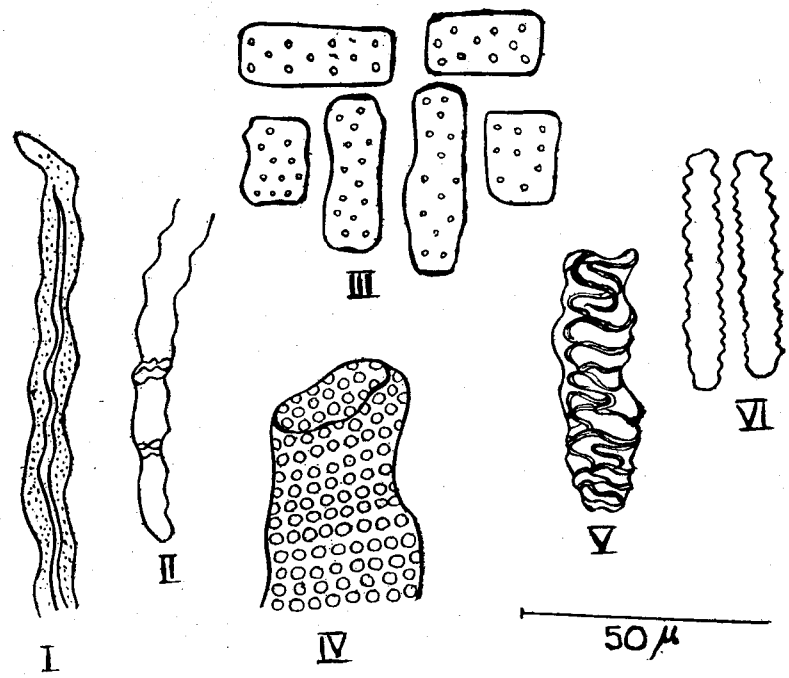


**Plate 3. Bamboo Pulp Eelements**

TABLE–I

**Percentage incidence of different bamboo pulp elements :**

| Sl.No. | Type of elements | Incidence out of 2500 : | Percentage ± S. E. |
|---|---|---|---|
| 1. | Type I | 416 | 16.64 ± 0.7449 |
| 2. | Type II | 163 | 6.52 ± 0.4938 |
| 3. | Type III | 1257 | 50.28 ±1.0 |
| 4. | Tppe IV | 494 | 19.76 ±0.7964 |
| 5. | Type V | 161 | 6.44 ±0.4909 |
| 6. | Type VI | 9 | 0.36 ±0.1198 |

TABLE–II

Student's 't' test of significance of percentage occurrence between types of bamboo pulp elements :

| | TYPE I | TYPE II | TYPE III | TYPE IV | TYPE V |
|---|---|---|---|---|---|
| TYPE II | (10.12) 11.32 * | | | | |
| TYPE III | (33.64) 26.98 * | (43.76) 39.24* | | | |
| TYPE IV | (3.12) 2.86* | (13.24) 14.13* | (30.52) 23.87* | ( | |
| TYPE V | (10.20) 11.43* | (0.08) 0.11 | (43.84) 39.35* | (13.32) 14.24* | |
| TYPE VI | (16.28) 21.58* | (6.16) 12.12* | (49.92) 49 56* | (19.40) 24.09* | (6 08) 12.03* |

The figures in ( ) indicate the difference between means.
*Significant

TABLE–III

**Statistical constants for the incidence of different bamboo pulp elements**

| Sl. No. | Types: | n | Range | Mean ± S. E. | S. D. | C. V. |
|---|---|---|---|---|---|---|
| 1. | I | 416 | 1 to 53 | 16.40 ± 2.34 | 11.725 | 71.49 |
| 2. | II | 163 | 1 to 18 | 7.55 ± 10.55 | 4.979 | 65.99 |
| 3. | III | 1257 | 21 to 68 | 49.15 ± 2175 | 10.875 | 4.43 |
| 4. | IV | 494 | 2 to 34 | 19.40 ± 1.588 | 7.940 | 40.93 |
| 5. | V | 161 | 1 to 13 | 6.00 ± 0.632 | 3.162 | 52.70 |
| 6. | VI | 9 | 1 to 2 | 1.286 | — | — |

TABLE–IV.

Student's 't' test of statistical significance between mean dispersion of different bamboo pulp elements :

| | TYPE I | TYPE II | TYPE III | TYPE IV |
|---|---|---|---|---|
| TYPE II | (8.855) 3.44* | | | |
| TYPE III | (32.752) 10. 4* | (41.607) 17.21* | | |
| TYPE IV | (3.00) 1.06 | (11.855) 6.22* | (29.752) 11.05* | |
| TYPE V | (10.40) 4.28* | ( .546) 1.26 | (43.152) 19.05 * | (13.04) 7.63* |

The figures in ( ) indicate the difference between means.
* Significant (P=0.05)

With a view to finding as to what extent one cellular type is related to the other, product-moment correlation (r) has been attempted on the basis of the following formula :—

$$r = \frac{\Sigma (x-\bar{x})(y-\bar{y})}{n\,\delta x \delta y}$$

The results are indicated in table V. The assessment of significance of correlation has been made by 't' method using the following formula—

$$t = r\,\frac{\sqrt{(N-2)}}{\sqrt{(1-r^2)}}$$

The results are presented in table VI.

**Discussion :**

The following facts become evident from the observation made on cellular elements constituting bamboo pulp :—

(1) Of the various types of elements, the parenchyma cells or pith cells or cells of medulla (type III) are found in maximum abundance (1257 out of 2500; 50.28%) in each slide while the epidermal cells with wavy or slightly corrugated margins (type VI) have been found to be extremely sparse (9 out of 2500; 0.36%) and occurring only in three out of 25 samples. Fibres with special features (type II) are found to be totally absent in three out of 25 samples whereas types I, III, IV, and V have been found to occur in each sample in variable proportions.

TABLE V.

Studies on correlation (r) between various types of elements present in bamboo pulp :

| Between Types : | ΣX | ΣX² | ΣY | ΣY² | ΣXY | r (co-efficient of correlation) : |
|---|---|---|---|---|---|---|
| I and II | 416 | 10472 | 163 | 1849 | 3925 | + 0.7259 |
| I and III | 416 | 10472 | 1257 | 66075 | 18250 | — 0.8349 |
| I and IV | 416 | 10472 | 494 | 11448 | 6645 | — 0.6438 |
| I and V | 416 | 10472 | 161 | 1275 | 2379 | — 0.3263 |
| I and VI | 416 | 10472 | 9 | 13 | 87 | — 0.3559 |
| II and III | 163 | 1849 | 1257 | 66075 | 7067 | — 0.7515 |
| II and IV | 163 | 1849 | 494 | 11448 | 2551 | — 0.5817 |
| II and V | 163 | 1849 | 161 | 1275 | 849 | — 0.4534 |
| II and VI | 163 | 1849 | 9 | 13 | 56 | — 0.0031 |
| III and IV | 1257 | 66075 | 494 | 11448 | 25126 | + 0.1307 |
| III and V | 1257 | 66075 | 161 | 1275 | 8345 | + 0.3021 |
| III and VI | 1257 | 66075 | 9 | 13 | 466 | + 0.0805 |
| IV and V | 494 | 11448 | 161 | 1275 | 3197 | + 0.0247 |
| IV and VI | 494 | 11448 | 9 | 13 | 212 | + 0.2663 |
| V and VI | 161 | 1275 | 9 | 13 | 63 | + 0.1045 |

TABLE VI.

't' Method for the assessment of significance of 'r' in between types of bamboo pulp elements :

| | TYPE I | TYPE II | TYPE III | TYPE IV | TYPE V |
|---|---|---|---|---|---|
| TYPE II | 5.062* | | | | |
| TYPE III | 7.275* | 5.463* | | | |
| TYPE IV | 4.035* | 3.430* | 0.632 | | |
| TYPE V | 1.655 | 2.440* | 1.520 | 0.118 | |
| TYPE VI | 1.718 | 0.015 | 0.387 | 1.325 | 0.504 |

*Significant.

(2) A study on the statistical significance of the mean percentage of each type reveals that excepting between types II and V, all the mean values have been significantly different from each other.

(3) The observation on frequency distribution shows that excepting types II, V, and VI, all other types have wide ranges of distribution and type III has the highest of it. The mean of the measure of dispersion has been found to be highest in type III (49.15 ± 2.175) while in type V it has been the least (6.0 ± 0.632). Frequency distribution of type VI has not been possible for study on account of its meagreness in occurrence.

(4) A study on the significance of the mean of dispersion of different types indicates that excepting between rypes I and IV as well as between types II and V. all the values of 't' have been found more than the level of statistical significance.

(5) Correlation studies made on pair of all the six types of cellular elements reveal that type I is significantly correlated with each of the types II, III, and IV, and so also the type II with each of the types III, and so also the type II with each of the types III, IV, and V. The degree of correlation between all other types are found to stand below the level of statistical significance.

**Acknowledgement :**

The authors are thankful to Dr. M. Jauhari, Director, Central Forensic Science Laboratory, Calcutta, for his keen interest, encouragements and facilities.

**References :**

1. Casey, J.P. (1952) : Pulp and Paper, Vol. II, Interscience.
2. Bulletin of the Indian Standards Institution (1966) : Methods of test for fibre analysis of paper and board, morphological characteristics; Appendix 'B'. Doc. : CDC 15 (1458) P2.