OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

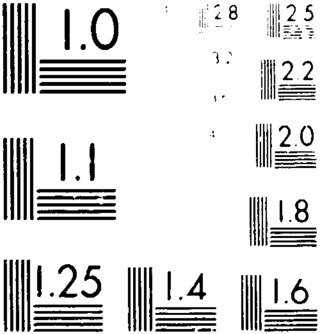
Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org


1.0
2.8
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6

10819

Distr.
LIMITED

ID/WG.352/2
7 October 1981

ENGLISH

United Nations Industrial Development Organization

International Experts Group Meeting
on Pulp and Paper Technology

Manila, Philippines, 3 - 8 November 1980

COUNTRY PAPER ON PULP AND PAPER RESEARCH IN THE PHILIPPINES*

by

Francisco N. Tamolang **

and

Jaime O. Escolano***

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Commissioner, Forest Products Research and Industries Development Commission (FORPRIDECOM), National Science Development Board (NSDB), College, Laguna 3720, Philippines.

*** Science Research Assistant Chief, Forest Products Research and Industries Development Commission (FORPRIDECOM), National Science Development Board (NSDB), College, Laguna 3720, Philippines.

V.81-30507

INTRODUCTION

The Forest Products Laboratory, the predecessor of the Forest Products Research and Industries Development Commission (FORPRIDECOM), was established in 1954 out of a felt need to develop the wood and other forest products industries of the Philippines. At that time, most of the products of our forests were exported in the form of raw materials as extracted from the forests such as logs, rattan, resins, etc.

At the time FORPRIDECOM was organized, there was only one integrated pulp and paper mill in the country, producing printing and writing paper from sugar-cane bagasse. The two other existing paper mills and others, which were eventually put up, used imported pulp and waste papers for the production of different types of paper products although a wide variety of raw materials are available for the industry.

There were several constraints at that time for the reluctance of capitalists to invest in integrated pulp and paper mills. Some of these constraints include the following: (a) the pulp and paper industry requires high capital investments compared to other industries; (b) the dearth of available data and information on the pulping and papermaking characteristics of local materials; (c) the risks involved due to the lack of highly trained technical manpower to operate and maintain integrated pulp and paper mills; and (d) it was deemed more profitable and less risky to import pulp than to produce it from local materials.

As originally envisioned, one of the major functions of FORPRIDECOM was to conduct research/investigations to determine the suitability of indigenous materials for the production of pulp and paper products. As such, FORPRIDECOM since its inception has been actively engaged in research along this area. Results of such studies have shown that it is technically feasible to produce almost all the paper requirements of the country from local fibrous materials and with the potential of exporting excess of these products to neighboring countries in Southeast Asia.

AREAS OF RESEARCH

The major areas of research, being conducted at FORPRIDECOM, may be grouped into three main categories. These include: (a) fiber morphological studies; (b) proximate chemical analysis of the fibrous raw materials; and (c) actual pulp and papermaking evaluation. The first two areas provide the necessary basic information from which the characterestics, the behavior, and the quality of the pulp to be produced can be predicted.

A. Fiber Morphology

It has been established that the physical properties of paper sheets are highly dependent on fiber characteristics (1-4)[3/]. In view of this, FORPRIDECOM has emphasized the importance of this phase of research. This has been a continuing activity and results of such investigations have indicated the potential raw materials for pulp and paper production (5-10).

3/ Underscored numbers in parentheses refer to literature cited.

Generally, long-fibered materials produce paper with high tearing strength. However, in the case of hardwoods, it is not necessarily the absolute value of fiber length which affects tearing resistance but more often the slenderness ratio (the ratio of fiber length to fiber diameter). The higher this ratio, the higher is the tearing strength (2).

The Runkel ratio, which is expressed as twice the cell wall thickness over the lumen diameter, also gives an indication of the papermaking qualities of a raw material. Materials with a Runkel ratio of one or less is considered good for papermaking (3). Fibers with thin cell walls (in relation to fiber diameter) collapse on drying and give denser sheets compared to stiffer thick-walled fibers. The higher the sheet density, the higher are the bursting and tensile strengths but the opacity is lower compared to low density sheets. Furthermore, the higher the flexibility of the fiber, the greater is the folding endurance (2).

B. Chemical Analysis

The determination of the proximate chemical composition of fibrous materials is a continuing project of FORPRIDECOM as this gives an indication of the expected behavior of the material during the pulping process and some quality aspects of the pulp to be produced. Results of the chemical analysis of various fibrous materials such as hardwoods, softwoods, bamboos, agricultural fibrous materials, etc. have been published (11-20).

Fibrous materials with high holocellulose, alphacellulose and hemicellulose contents but with low lignin, extractives, ash, and silica are desirable for paper pulp production. However, for dissolving pulp production, high hemicellulose content is undesirable. Materials with high lignin content would require more chemicals for pulping compared to those with low lignin. Those with high silica content are undesirable as these will give trouble in the chemical recovery system of a pulp mill. Chemical pulp fibers with high hemicellulose content produce papers with high sheet density and, consequently, give high folding, bursting and tensile strengths.

C. Pulping and Papermaking

In the evaluation of the different fibrous materials, the chemical, semi-chemical and chemi-mechanical pulping processes were used. The kraft or sulfate process has been used extensively since this process is suitable for most materials and the pulps produced have relatively high strength. As such, kraft pulps have more flexibility as to end-use as these can be used for almost all grades of paper and paperboard. Studies at FORPRIDECOM have proven the versatility of this process for the various materials tested (21-32).

The alkaline-sulfite and soda have been used successfully in the pulping of agricultural fibrous materials and grasses (33-41). Results show that the strength properties of the pulps produced were, in most instances, comparable to those obtained from the kraft process.

Encouraging results were obtained using the neutral sulfite semi-chemical (NSSC) process (42-44). This is particularly suitable for hardwoods and produces pulp with high yield and pulp strength properties approaching those of the kraft pulp from the same species. The principal use of this pulp is for corrugating medium due to its hard and dense sheets. Bleached pulps are also used for good-quality glassine and greaseproof papers. Printing and fine papers can also be made from this pulp when blended with softer pulps (2).

The cold soda process has also been tried at FORPRIDECOM (45-52). This is a simple pulping method which is normally carried out under ordinary temperature and atmospheric pressure. This involves the soaking or impregnating of the chips with caustic soda followed by mechanical fiberization in a disk mill. The pulp from this process is used in the production of corrugating medium, printing, tissue and towelling papers, and molded pulp products.

Chemi-mechanical pulping trials on some hardwoods were also conducted at FORPRIDECOM (53-55). This process consists of mild chemical treatment of the wood chips followed by disk refining of the softened chips. A high pulp yield (about 90%) is obtained from this process and the pulp produced can be used for newsprint, magazine and some grades of book paper.

RESEARCH THRUSTS OF FORPRIDECOM

In its desire to serve the local pulp and paper industry, FORPRIDECOM has included in its development program research thrusts which are relevant to the needs of the industry. These fields of researches cover: (a) search for long-fibered materials; (b) utilization of mixed hardwoods; (c) plantation and fast-growing hardwoods; (d) lesser-known or non-commercial species; and (e) development of fiber extraction machine.

A. Search for Long-Fibered Materials

The Philippines, like most developing countries, lacks the desirable softwood species which are the principal raw materials being used in temperate countries for the production of the various types of pulp and paper products. In view of this, FORPRIDECOM initiated studies to determine what indigenous materials with long fibers would be suitable substitutes for imported softwood pulps. Encouraging results were obtained in studies on local softwoods, long-fibered hardwoods, bamboos, and agricultural fibrous materials.

Based on the classification of the International Association of Wood Anatomist (56) fibers with length of 1.60-2.20 mm are considered long fibers; 2.21-3.00 mm as very long fibers; and above 3.00 mm as extremely long fibers.

Below is the list of the materials investigated which have good potential for utilization or are now utilized by the industry with corresponding fiber lengths:

Materials	Fiber Length mm
1. Softwoods (15, 23, 26, 32, 57)	
a. Almaciga [Agathis dammara (Lam.) Rich.] 4/	5.31
b. Benguet pine (Pinus insularis Endl.)	4.38
c. Mindoro pine (Pinus merkusii Jungh & de Vr.)	4.00

Materials	Fiber Length mm
2. Long-Fibered Hardwoods (5, 10, 27, 29, 30)	
a. Agoho (*Casuarina equisetifolia* Forst.)	1.67
b. Antipolo [*Artocarpus blancoi* (Elm.) Merr.]	1.74
c. Apanit (*Mastixia philippinensis* Wang.)	3.40
d. Balsa [*Ochroma pyramidale* (Cav.) Ulbr.]	1.73
e. Dita [*Alstonia scholaris* (L.) R.Br.]	1.71
f. Gubas (*Endospermum peltatum* Merr.)	1.64
g. Kapok [*Ceiba pentandra* (L.) Gaertn.]	1.61
h. Katmon (*Dillenia philippinensis* Rolfe)	2.75
i. Nato [*Palaquium luzoniense* (F. Vill.) Vid.]	1.65
j. Palosapis [*Anisoptera thurifera* (Blanco) Blume]	1.65
k. Red lauan (*Shorea negrosensis* Merr.)	1.72
l. Toog [*Combretodendron quadrialatum* (Merr.) Merr.]	2.38
m. Tuai (*Bischofia javanica* Blume)	2.14
3. Bamboos (24, 25, 31, 58)	
a. Bayog [*Dendrocalamus merrillianus* (Elm.) Elm.]	2.16
b. Bolo [*Gigantochloa levis* (Blanco)]	1.80
c. Buho [*Schizostachyum lumampao* (Blume) Merr.]	2.42
d. Giant Bamboo (*Gigantochloa aspera* Kurz.)	3.36
e. Kauayan kiling (*Bambusa vulgaris* Schrad.)	2.33
f. Kauayan tinik (*Bambusa blumeana* Schultes f.)	1.95
g. Pole-vault bamboos (*Phyllostachys nigra* Monro.)	1.86
h. Yellow bamboo [*Bambusa vulgaris* var. *striata* (Lodd.) Gamble]	1.66
4. Agricultural fibrous materials (12, 20, 35-39, 41, 51, 59, 60, 61)	
a. Abaca (*Musa textilis* Nee)	3.15 - 5.43
b. Alinsanay (*Musa* sp.)	4.88
c. Banana, Butuhan (*Musa balbisiana* Colla)	4.56

Materials	Fiber Length mm
d. Banana, Giant Cavendish (Musa Cavendishii Lamb Var. Hawaiiensis Teodoro)	4.10
e. Banana, Latundan [Musa sapientum L. var. cinerea (Blco.) Teodoro]	5.42
f. " , Matsing (Musa banksii f.v. Muel)	4.40
g. " , Pakol (Musa balbisiana Colla)	3.99
h. " , Saba (Musa paradisiaca var. Compressa Blanco)	4.95
i. Kenaf (Hibiscus canabinus Linn.)	3.22
j. Maguey (Agave cantala Roxt.)	2.55
k. Sabahon (Musa sp.)	4.94

B. Utilization of Mixed Tropical Hardwoods

Since the early sixties, FORPRIDECOM has been actively engaged in investigations to determine the pulping characteristics of naturally-occuring mixtures of Philippine hardwoods and other wood mixtures. Studies were also conducted on the production of newsprint, kraft wrapping, and other grades of paper from pulps of mixed hardwoods and/or mixtures of other materials (21, 22, 43, 54, 57, 62). These studies have shown the feasibility of using mixed hardwoods for pulp and paper. In fact, there are now three integrated pulp and paper mills in this country, using mixed hardwoods in their production.

C. Plantation and Fast-Growing Hardwoods

Realizing the importance of fast-growing species to the pulp and paper industry, FORPRIDECOM started preliminary investigations on the potentials of these species for the industry. These studies have indicated the feasibility of using the following species for pulp and paper production (16, 28, 30, 42, 46, 48, 49, 63-67):

1. African tulip (Spathodea campanulata Beauv.)
2. Anabiong (Trema orientalis L. Blume)
3. Bagras (Eucalyptus deglupta Blume)

4. Balsa [*Ochroma pyramidale* (Cav.) Ulbr.]

5. Binuang (*Octomeles sumatrana* Miq.)

6. Giant ipil-ipil [*Leucaena leucocephala* (Lamk.) de Wit]

7. Gubas (*Endospermum peltatum* Merr.)

8. Ilang-Ilang [*Cananga odorata* (Lam.) Hook f. & Thoms.]

9. Kaatoan bangkal [*Anthocephalus chinensis* (Lamk.) Rich. *ex* Walp.]

10. Lumbang [*Aleurites moluccana* (L.)]

11. Moluccan sau [*Albizia falcataria* (L.) Fosb.]

12. Yemana (*Gmelina arborea* Roxb.)

There is now an on-going project on the further evaluation of bagras, Kaatoan bangkal, giant ipil-ipil, Moluccan sau, and yemana for pulp and paper. Upon completion of this project, it is expected that more complete information on these species will be obtained.

D. Lesser-Known or Non-Commercial Hardwoods

This group of species, also sometimes known as lesser-used or secondary species, have not been left out in FORPRIDECOM's pulp and paper development program. Studies along this area have shown the potentials of the following species for pulp and paper production (27, 30, 47, 48, 68):

1. Agoho (*Casuarina equisetifolia* L.)

2. Anabiong [*Trema orientalis* (L.) Blume.

3. Apanit (*Mastixia philippinensis* Wang.)

4. Balakat-gubat [*Sapium luzonicum* (Vid.) Merr.]

5. Balanti [*Homalanthus populneus* (Gaisel.) Pax.]

6. Balsa [*Ochroma pyramidale* (Cav.) Urb.]

7. Basikong (*Ficus botryocarpa* Miq.)

8. Binuang (*Octomeles sumatrana* Miq.)

9. Buntan (*Engelhardia rigida* Blume)

10. Daha (*Macaranga caudatifolia* Elm.)

11. Dulit [*Canarium hirsutum* Willd. ssp. *hirsutum* var. *hirsutum forma* (Bl.) Leenh]

12. Hagimit [*Ficus minahassae* (Teijsm. and de Vr.) Miq.]

13. Katmon (*Dillenia philippinensis* Rolfe)

14. Kupang (*Parkia roxburghii* G. Don)

15. Malakalumpang (*Sterculia ceramica* R. Br.)

16. Malapapaya [*Polyscias nodosa* (Blume) Seem.]

17. Rarang [*Erythrina subumbrans* (Hassk.) Merr.]

18. Tan-ag (*Kleinhovia hospita* L.)

19. Tangisang-bayawak (*Ficus variegata* Blume)

20. Toog (*Combretodendron quadrialatum* (Merr.) Merr.]

21. Tuai (*Bischofia javanica* Blume)

E. Development of Fiber Extraction Machine

A new, efficient, and economical method of fiber extraction, developed by FORPRIDECOM researchers, was awarded Letters Patent No. 9200 by the Philippines Patent Office (69). This invention is expected to revolutionalize the abaca industry as this can continuously extract abaca fibers with a fiber yield higher by 50-60% compared to the other fiber extraction processes.

Due to its novelty, importance and relevance to countryside development, this invention won the top Presidential Award (First Prize) during the "Best Invention of the Year Contest" held in 1978.

TRANSFER OF APPROPRIATE TECHNOLOGY

FORPRIDECOM has not been contented with just conducting researches and confining its work to the laboratories. This agency has been actively involved in the transfer of appropriate technology not only for the pulp and paper industry but also for the other forest products and allied industries. This has been carried out by working in close collaboration with the industry through cooperative and/or technical assistance projects, consultancy, and in manpower/training/development for the industry.

Available technologies at FORPRIDECOM are also delivered to end-users through publications in scientific and technical journals, popular articles for laymen, releases in local and national newspapers, radio and television, and local and international conferences.

It is worth mentioning here that the Philippine pulp and Paper Industry is represented in the FORPRIDECOM Council. As such, we have a continuing dialogue with the industry and our research program has always been geared to or is guided by the needs of the industry.

——— o ———

- — -

LITERATURE CITED

1. Dinwoodie, J.M. 1965. The relationship between fiber morphology and paper properties: A review of literature. TAPPI 48 (8):440-447.

2. Food and Agriculture Organization. 1953. Raw materials for more paper. FAO, United Nations, Rome.

3. Runkel. R.O.H. 1949. Papier 3:476-490.

4. Tamolang, F.N. 1968. Hardwood fiber strength and pulp sheet properties. TAPPI 51(1):19-25.

5. Aday, J.U. 1980. Long-fibered Philippine hardwood species. The Phil. Lumberman 26(1):58, 60, 61, & 77.

6. Tamolang, F.N., _et al_. 1957. Fiber dimensions of certain broadleaved and coniferous woods, palms, and bamboos. TAPPI 40(8):671-676.

7. ____________, _et al_. 1958. Fiber dimensions of certain broadleaved and coniferous woods, palms, and bamboos. II TAPPI 41(10):614-621.

8. ____________, _et al_. 1960. Fiber dimensions of certain Philippine woods, bamboos, and agricultural crops and wastes and grasses. III, TAPPI 41(10):614-621.

9. ____________, _et al_. 1962. Fiber dimensions of certain Philippine woods, agricultural wastes and other plants. IV. TAPPI 45(2):135-142.

10. Forest Products, Research Institute. 1968. Some medium and long-fibered species which are promising for pulp and papermaking. FPRI. College, Laguna 3720.

11. Escolano, E.U., _et al_. 1978. Proximate chemical composition of giant ipil-ipil wood from different sources. FORPRIDECOM Digest 7(1);18-22.

12. ____________, _et al_. Proximate chemical composition of some commercial grades of abaca (_Musa textilis_ Nee) fibers. Phil. Jour. of Sci. 100 (2):107-114.

13. ____________, _et al_. The proximate chemical composition of sugarcane bagasse, fibers and pith. The Phil. Lumberman 22(12):4, 6, 8, 10.

14. ____________ and J.A. Semana. 1978. The proximate chemical composition of nine hardwood species from Davao Oriental The Phil. Lumberman 24(12):16, 18, 20,

15. Francia, P.C., _et al_. Proximate chemical composition of some Philippine coniferous woods. The Phil. Lumberman 16(11):25, 28, 30.

16. ____________, et al. 1973. Proximate chemical composition of some fast-growing woods from the Bislig forest. The Phil. Lumberman 19(12):16, 18 & 20.

17. Monsalud, N.R. and P. M. Nicolas. 1958. Proximate chemical analysis of some Philippine barks, bamboos, and woods. Phil. Journal of Sci. 87(2):119-140.

18. Reyes, A.C. 1960. The proximate chemical analysis of some Philippine woods. The Phil. Lumberman 6(1):18, 20, 22.

19. Semana, J.A. _et al_. 1966. Proximate chemical composition of Philippine mahogany woods. The Phil. Lumberman 14(2):20, 22, & 24.

20. ______________, *et al*. 1976. The proximate chemical composition of the fibers of some Philippine bananas. The Phil. Lumberman 22(11): 26, 28, 29-31.

21. Bawagan, P.V. and J.O. Escolano. 1963. Pulping and papermaking of naturally occuring mixtures of Philippine hardwoods. The Phil. Lumberman 9(1):76-83.

22. ______________, and J.O. Escolano. 1967. Kraft pulping of some Philippine wood mixtures and their pulp handsheet qualities. The Phil. Lumberman 13(2):20, 22, 24, 26-27.

23. ______________, *et al*. 1965. Bag and wrapping papers from Benguet pine (Pinus insulari Endl.) The Phil. Lumberman 11(3):50-52.

24. Escolano, J.O., *et al*. 1964. Pulping, bleaching and papermaking experiments on kauayan tinik (*Bambusa blumeana Schult*. F.). The Philippine Lumberman 19(4):33-36.

25. ______________ and J.A. Semana. 1970. Bag wrapping papers from kauayan-kiling (*Bambusa vulgaris* Schrad.)

26. ______________, and P. V. Bawagan. 1975. Kraft pulping and papermaking evaluation of mindoro pine. FORPRIDE Digest 4:45-52.

27. ______________, *et al*. 1974. Kraft pulping evaluation of some Philippine non-commercial hardwoods. The Phil. Lumberman 20(7): 36-40.

28. Estudillo, C.P. *et al*. 1972. Sulfate pulping studies on yemane (*Gmelina arborea* Roxb.). The Phil. Lumberman 18(4):18-32.

29. Monsalud, M.R. *et* al. 1965. Kraft pulping and papermaking characteristics of some Phil. commercial hardwoods. TAPPI 48(5):304-308.

30. Nicolas, P.M. *et al*. 1967. Kraft pulping of some Philippine hardwoods. TAPPI (50) (5):113A-115A.

31. Semana, J.A. *et al*. 1967. The kraft pulping qualities of some Philippine bamboos. TAPPI 50(8):416-419.

32. Zerrudo, J.V. 1975. Pulp and paper from Philippine conifers. Presented at thePhilippine Forest Research Society Symposium on Philippine conifers, Sept. 18, 1975, FORPRIDECOM, College, Laguna.

33. Nicolas, P.M., *et al*. 1965. Pulping studies on sugarcane bagasse. Proceeding of the Philippine Sugar Technologists 13th Annual Convention, Manila pp. 284-292.

34. ______________, *et al*. 1969. Pulping and papermaking qualities of cogon grass (*Imperata cylindrica* (Linn.) (Linn.) Beauv.). The Phil. Lumberman 14(2):25, 28 & 30.

35. Villanueva, E.P., *et al*. 1973. Some bleaching patterns applicable to abaca soda pulps. FORPRIDE Digest 1(4):12-18.

36. ______________, *et al*. 1970. Parchment paper from abaca fibers. Phil. Forests 4(1): 26, 27, 30-34.

37. ______________, *et al*. 1972. Chemical pulps from giant cavendish banana fibers: their properties and bleached requirements FORPRIDE Digest 1(2& 3):13-19.

38. Visperas, R.V. 1979. Maguey (Agava cantala Roxb). a source of long fibers pulp. Presented at the National Science & Tech. Week, Region I, Baguio City on July 11, 1979.

39. Ynalvez, L.A., et al. 1967. Some aspects of long fiber research. The Phil. Lumberman 13(8):23, 26 & 28.

40. Zerrudo, J.V. 1977. Indigenous materials for paper packaging. II. Sugarcane bagasse (Soda pulp). NSDB Technology Journal 3(2):29-39.

41. ______________, and J. O. Escolano. 1978. Indigeneous Materials for paper packaging. III. Abaca fibers. NSDB Technology Journal 3(1): 50-56.

42. Bawagan, P.V., et al. 1967. Semi-chemical neutral sulphite pulping and paperboard making of gubas. The Phil. Lumberman 14(2):25, 23, 30.

43. Escolano, J.O. et al. 1971. NSSC Pulping and papermaking of a hardwood mixture. Philippine Forests 5(2 & 3):16-18.

44. Garayblas, L.E.M., et al. 1970. The production of newsprint from sugarcane bagasse. The Chemists Quarterly 9(2):26-42.

45. Bawagan, P.V. and J.V. Zerrudo. 1969. Pulping variables of gubas cold-soda pulps. The Phil. Lumberman 15(11).

46. Monsalud, M.R. 1958. Standardized cold-soda pulping evaluation of three wood species: African tulip, almon, and paper mulberry. Forestry Leaves 10(4).

47. ______________, et al. 1960. Standardized cold-soda pulping evaluation of some Philippine cellulose raw materials. Forestry Leaves 12(1):43-68.

48. Nicolas, P.M. and J.R. Navarro. 1964. Standard cold soda pulping evaluation of Philippine woods and bamboos. TAPPI 47(2):98-105.

49. ______________ and C.H. Ballon. 1969. Cold-soda pulps from Kaaton bangkal. The Phil. Lumberman 15(3).

50. ______________, et al. 1969. Newsprint from pacol (Musa balbisiana Coll.) and Kaatoan bangkal /Anthocephalus chinensis) (Lamk) Rich ex Walp_/. Tropical Forestry and Industries 1(3):46, 48 & 50.

51. Villanueva, E.P., et al. 1978. The properties of high-yield bleached pulp from abaca fibers. Selected abaca Research: Fiber Properties, International Documentation Center, UPLB, College, Laguna, Philippines, pp. 193-200.

52. Zerrudo, J.V. and J.O. Escolano. 1977. Indigeneous materials for paper packaging. I. Sugarcane bagasse (Cold-soda pulp). NSDB, Technology Journal 2(2):44-50.

53. Bawagan, P.V., et al. 1965. Groundwood-type pulps from gubas (Endospermum peltatum Merr.) for newsprint manufacture. TAPPI 48(12):696-699.

54. Escolano, J.O., et al. 1972. Philippine pulp materials for newsprint. The Phil. Lumberman 18(11):25-30.

55. Nicolas, P.M. and C.B. Tadena. 1970. Bleached chemi-mechanical soda pulp from Kaatoan bangkal /Anthocephalus chinensis (Lamk). Rich. ex Walp._/ The Phil. Lumberman 16(10):14, 16, 18.

56. International Association of Wood Anatomists. 1937. Committee on Nomenclature, IAWA. Tropical Woods. 41:21.

57. Escolano, J.O. 1959. Production of bond and wrapping papers from Philippine woods, bamboos, and agricultural fibrous materials. Science Quarterly Digest 1(2): 3-13.

58. Semana, J.A. 1976. Bamboo pulp and papermaking. Presented at the Symposium on Bamboo sponsored by the Philippine Forest Research Society and the National Research Council of the Philippines, Sept. 29, 1976, College, Laguna.

59. Nicolas, P.M., et al. 1971. Pulping and papermaking qualities of alinsanay fibers. The Phil. Lumberman 17(4).

60. Escolano, J.O., et al. 1978. Prospects of wild bananas (Musa spp) for plantation and pulp and paper. Proceedings of the First IUFRO Conference on Wood Quality and Utilization of Tropical Species, College, Laguna, Philippines, pp. 256-270.

61. Monsalud, M.R., et al. 1965. Pulping and papermaking of kenaf (Hibiscus cannabinus Linn.) The Phil. Geographical Journal 9(3 & 4): 45-53.

62. ______________, et al. 1965. Properties of wrapping papers from Philippine fibrous materials as related to pulp blending. The Lumberman 11(3): 10, 12, 14, 16, 54-55.

63. Escolano, J.O., et al. 1974. Printing and Writing papers from three-year old Kaatoan bangkal. FORPRIDE Digest 3(3 & 4):41.

64. ______________ and E.P. Villanueva. 1973. African tulip for printing and writing paper manufacture. FORPRIDE Digest 2(3 & 4):41.

65. Semana, J.A. 1978. Fast growing plantation hardwoods for pulp and paper production. Proceedings of the International Conference on "Improved Utilization of Tropical Forests", Madison, Wisconsin, USA. pp. 314-330.

66. Semana, J.A. 1974. The characteristics of fast-growing hardwoods for pulp and paper. Proceedings of the Forest Research Symposium on Industrial Forest Plantations, Manila pp. 49-58.

67. Villanueva, E.P., et al. 1972. Pulpwood potentials of some Philippine reforestation species. Presented at the Seminar of the Philippine Forest Research on July 20, 1972.

68. Cruz de la, R.Z. and E.C. Fernandez. 1973. Study on the fiber morphology and pulping quality of balanti Homalonthus populness (Gaisel) Roxb). The Phil. Lumberman 19(1):34, 36, 38, 40, & 42.

69. Amio, E.C., et al. 1975. Process and machine for extraction and processing fibers from fiber-bearing materials of agricultural and minor products origin. Letter Patent No. 9200, Philippines Patent Office, Manila.