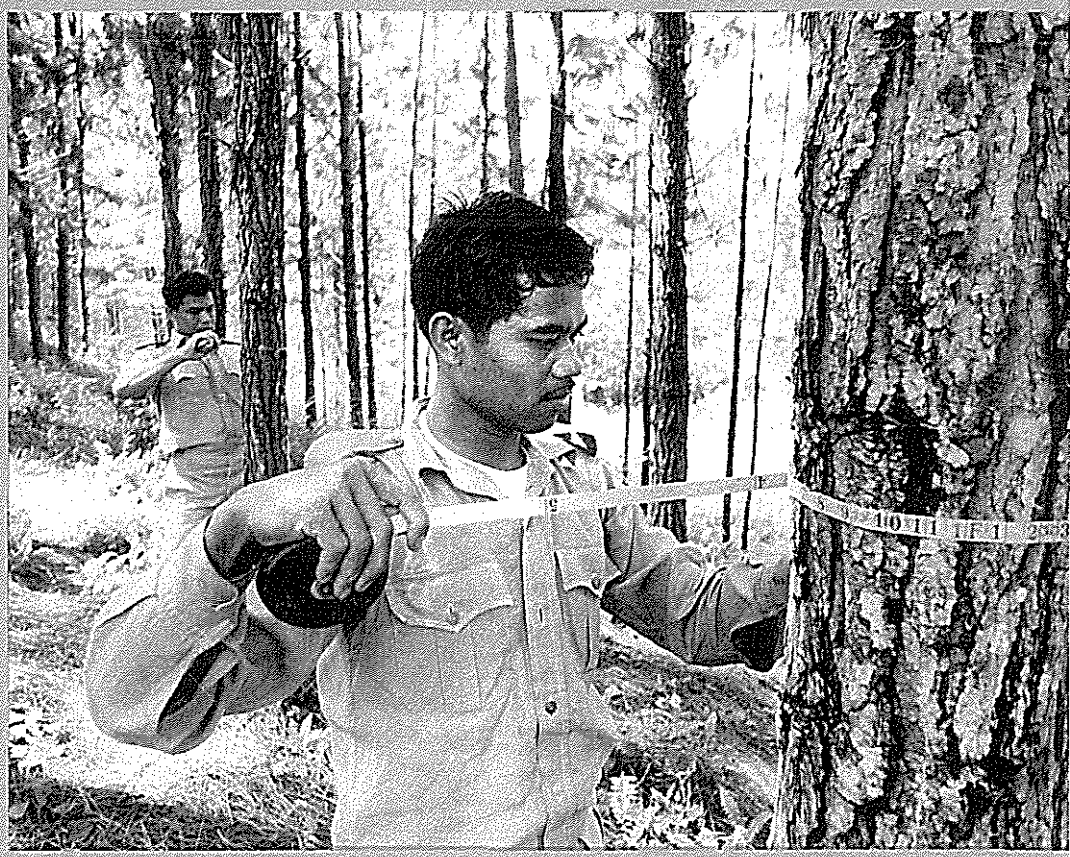
FAO FORESTRY PAPER 19/2

pulping and paper-making properties of fast-growing plantation wood species — 2



FOOD AND AGRICULTURE ORGANIZATION
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pulping and paper-making properties of fast-growing plantation wood species

volume 2

forestry industries division
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F O R E W O R D

This manual is mainly intended to provide information to tree plantation planners who are interested in the pulping and papermaking characteristics of the species considered for planting. The characteristics vary somewhat with growth conditions and age of the trees and the values given in the data sheets always refer to a specific sample of wood from a specific plantation. The conclusions drawn in the text from the data sheets pertain to these samples. The reader should accordingly bear in mind that samples from plantations with different growth conditions may exhibit differing characteristics, as evidenced repeatedly from the data sheets for some species.

Acknowledgements

The present volume of "Pulping and Papermaking Properties of Fast-Growing Plantation Wood species" has been based on the work carried out under a contract awarded to the Finnish Pulp and Paper Research Institute in Helsinki, Finland, who delegated the task of compilation and evaluation of the data to Dr. Bruno Lönnberg and Mr. Antero Varhimo among the staff of that Institute.

1. INTRODUCTION

1.1 BACKGROUND INFORMATION

The information presented in this volume is based mainly on available data published between July 1972 and June 1978. In addition, certain references which were not available at the time of preparation of the first volume of this book in 1974 (21) have been included here.

A list of references is given in Appendix I.

1.2 GENERAL INFORMATION ON THE DATA SHEETS

The data sheets give information on one or several samples of wood for each species. In the latter case, the data for each sample are presented separately on the same data sheet for comparison. The basic information given in the data sheets is divided into three main parts:

a) origin of wood sample including age, when known, and any special conditions;

b) wood characteristics of sample. This includes basic density, fibre dimensions and chemical characteristics;

c) pulping and papermaking characteristics of the wood sample. This may include a range of conditions applied in the same process as well as the corresponding range of properties of the pulps and/or different types of processes applied.

In addition to these data sheets which relate to one reference each, an evaluation of each species has been included in the form of a summary based on the information given in the data sheets on that species as well as additional information obtained. Some guidelines are also given as regards experience with respect to plantations and acclimatization of the species in different parts of the world.

The summary for each species shows the references from which the information has been obtained under "Plantation experience" and, in a few cases, under "Pulping characteristics". The references for "Wood characteristics" and the main references for "Pulping characteristics" are given on the relevant data sheets.

The definitions of the terms used are given in Appendix II and a list of the species included is given in Appendix III.

2. INTERPRETATION OF THE DATA SHEETS

2.1 COMPARISION OF PULPING AND PAPERMAKING DATA

Although the determinations of basic density, fibre dimensions and chemical characteristics of wood are fairly straightforward and reasonably well standardized so that values obtained in different laboratories are comparable, this is not so when it comes to determination of the papermaking characteristics of pulps. In spite of the standardisation work which has been carried out in this field, there still remains considerable discrepancy in strenght property values. The reason for this is basically that the strength properties of a test sheet of pulp depend, to a great extent, on the treatments given to the pulp before the actual determination of a certain strength value is carried out, as well as on the atmospheric conditions in the room where the determination is made. As regards the latter, three atmospheric conditions are used in the pulp and paper industry; the two most common are 23°C and 50% RH (relative humidity) in Canada and the USA and 20°C and 65% RH in Australia, Europe and New Zealand. In countries like India the conditions are 27°C and 65% RH. In other countries the standards vary with one of the three sets of conditions being used.

As regards the pretreatment of the pulp prior to testing, the factors which affect the results are as follows:

a) The equipment used for refining and/or beating of the pulp;

b) The freeness of the pulp after refining and/or beating, expressed either in Canadian Standard Freeness (CSF) or Schopper Riegler (SR) units;

c) The equipment used for making the sheet of paper for testing;

d) The extent of pressing of the wet sheet prior to drying and also against what surface the sheet has been pressed;

e) The way of drying of the sheets and also to what extent shrinkage of the sheet has been allowed or prevented during drying;

f) The grammage (basis weight) of the sheets used for testing;

g) The grammage used in the calculation of strenght properties (oven-dry or as conditioned);

h) The type of equipment used for the determination.

Several sets of combinations of these critical factors are in use in different countries and laboratories and this is the main reason for the discrepancy of the results of strength testing.

As regards the actual strength testing, once the conditions for beating and sheet making have been set as well as the atmospheric conditions, there still remains the variation due to different items of equipment for testing, but this is of minor importance in this content.

It is evident from the above that as regards the strength properties given in the data sheets, no direct comparison can be made of the values reported by different sources and consideration has to be given to the influence on the results by the factors mentioned above.

2.3 EVALUATION OF THE PULPING AND PAPERMAKING PROPERTIES

In order to facilitate understanding of the results given in the data sheets, an evaluation has been made of each species in the form of a summary where a general rating is used, with wordings like "under average", "good" and "excellent". These ratings refer only to hardwoods and softwoods separately. The basis for the comparison is an "average" pulp of a commercial grade, from either hardwood or softwood, of whichever type the species may be. Unfortunately, inclusion of reference data for this comparison cannot be given, as they would inevitably lead to misunderstanding due to the reasons given in Section 2.1.

The conclusions arrived at in the evaluation of the results apply only to the samples for which data have been given. It is possible that other wood samples of the same species would lead to other conclusions, due to difference in seed origin, as well as soil and climatic conditions. The age of the tree also exerts an influence on the results.

SUMMARIES AND DATA SHEETS FOR INDIVIDUAL SPECIES

Acacia auriculaeformis

Plantation experience

Indigenous to the islands off the north coast of Australia, this species grows fast on poor soils. It has been used successfully on steep slopes to check soil erosion. The species has been introduced in Tanzania, India, Indonesia and Malaysia. The present sample represents 10 year old trees from a plantation in Papua New Guinea.

References: 21, 22, 56

Wood characteristics

The density of the wood is within the range average to hardwoods. No other data on wood characteristics are given for the present sample.

Pulping characteristics

Sulphate pulping of the wood gives pulp in high yield even when cooked to fairly low residual lignin contents. The good strength values of the unbleached pulp correspond to those of poplar sulphate pulp and the sample exhibits much better characteristics than those of the sample referred to in the previous volume (25).

Scientific name: Acacia auriculaeformis	Common name: Country: Papua New Guinea	Reference: 56

Wood sample characteristics

Wood sample origin: Sample from plantations at Bainyik, East Sepik District.
10 years old, mixture of three butt logs

Density and fibre characteristics:

Basic density, kg/m^3 497
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	13.0 Na_2O
Kappa number	17.4
Yield (unscreened), %	54.9
Screenings, %	0.2
Brightness	
Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	100 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	12 (approx.)

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Acacia decurrens (Green Wattle)

Plantation experience

This species is native to south-west Australia, and it is cultivated extensively also in Africa, India and New Zealand because of its bark, which yields a good tanning agent. The present sample, 9 - 14 years old, represents a tree diameter of 200 mm and a tree height of nearly 20 m.

References: 21, 34

Wood characteristics

The medium-dense wood has very short fibres and a very low content of lignin. The extractives content is fairly high.

Pulping characteristics

The wood is easily cooked by the sulphate-process to a Kappa number common for hardwood pulps by application of a reasonable charge of chemicals. The pulp yield is very high in consequence of the low lignin content of the initial wood. The strength of the bleached pulp is in the range normal for poplar sulphate pulp.

Scientific name: Acacia decurrens	Common name: Green wattle Country: New Zealand	Reference: 34

Wood sample characteristics

Wood sample origin: Sample from the Tokoroa district
9-14 years old
5 trees, mean height 19.3 m,
mean diam. 227 mm (breast height)

Density and fibre characteristics:

Basic density, kg/m^3	457
Fibre length, µm x)	860
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.5
Solubility, %	
in water	4.6 (hot)
in 1 % NaOH	19.0
Ash, %	
Lignin, %	19.7
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	
Chemical consumption, %	15.0 Na_2O (charge)	
Kappa number	18.7-21.7	
Yield (unscreened), %	55.9-56.6	
Screenings, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Bleached

Sequence	D_cEHD	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness (Elrepho)	89.8-90.8	
Beater or refiner	Lampen	
Freeness	350 CSF	428 CSF
Tensile index, N m/g	97	90
Burst index, kPa m^2/g	6.6	6.0
Tear index, mN m^2/g	10.0	9.6

Additional information:

Scientific name: Acacia decurrens	Common name: Country: India	Reference: 40

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate
Chemical consumption, %	
Kappa number	20
Yield (unscreened), %	57.4
Screenings, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Bleached	
Sequence	
Chemical consumption, % Cl	12,9
Yield on bleaching, %	
Total yield, %	
Brightness	75
Beater or refiner	
Freeness	
Tensile index, N m/g	54,2
Burst index, kPa m^2/g	4,4
Tear index, mN m^2/g	6,8
Additional information:	

Acacia mollissis
(Black Wattle)

Plantation experience

Indigenous to south-west Australia. It is considered to yield the best tanning agent of all the Acacia spp. It has been planted extensively because of its tanbark in Australia, New Zealand, Africa and India. The wood has been widely used in South Africa and Australia. The present sample from New Zealand was taken from 16 year old trees of about 200 mm in diameter.

References: 21, 34

Wood characteristics

This high-density wood contains very short fibres and the lignin content is low.

Pulping characteristics

In accordance with the very low lignin content of the wood, it is easily pulped in the sulphate process and the pulp yield is very high at a low Kappa number. The brightness attained by a four-stage bleaching sequence is extremely high. The strength characteristics resemble those of a beech sulphate pulp.

Scientific name: Acacia mollissima	Common name: Black wattle Country: New Zealand	Reference: 34

Wood sample characteristics

Wood sample origin:

Sample from the Tokoroa district
16 years old
5 trees, mean height 19.9 m,
mean diam. 218 mm (breast height)

Density and fibre characteristics:

Basic density, kg/m^3	593
Fibre length, µm x)	880
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.3
Solubility, %	
in water	4.2 (hot)
in 1 % NaOH	18.1
Ash, %	
Lignin, %	18.1
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	
Chemical consumption, %	15 Na_2O (charge)	
Kappa number	18.7	
Yield (unscreened), %	57.9	
Screenings, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Bleached

Sequence	D_cEHD	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness (Elrepho)	90.0 -91. 1	
Beater or refiner	Lampen	
Freeness	350 CSF	432 CSF
Tensile index, N m/g	77	61
Burst index, kPa m^2/g	4.6	3.2
Tear index, mN m^2/g	9.3	8.4

Additional information:

Albizzia falcata

(Syn. Albizia falcataria)

Plantation experience

This tree is planted for shade to coffee and tea plantations throughout the Far East. Grows rapidly even in impoverished soil. Diameters up to 170 mm have been obtained at rotations of 3 years. It is grown for pulpwood in Malaysia and in the Philippines.

References: 21, 22

Wood characteristics

The wood density is very low and the fibre length is short to average for hardwoods. No chemical characteristics are given.

Pulping characteristics

The wood is easily cooked by the sulphate process to relatively low Kappa numbers by application of reasonable quantities of chemicals. The unbleached pulp yield is high and it indicates that the initial lignin content of the wood material is low. The pulp strenght compares well with poplar and eucalypt sulphate pulps. The loss in strength on bleaching has been considerable, but may be due to the bleaching conditions applied.

Scientific name: Albizia falcataria (Albizzia falcata)	Common name: Moluccan sau Country: Papua New Guinea	References: 56

Wood sample characteristics

Wood sample origin:

Brown River Forest Station, Port Moresby
7 years old, butt log of one tree

Density and fibre characteristics:

Basic density, kg/m^3	238
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	13.0 Na_2O
Kappa number	17.9
Yield (unscreened), %	54.9
Screenings, %	0.4

Brightness

Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	100 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	9 (approx.)

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m^2/g
Tear index, mN m^2/g

Additional information:

Scientific name: Albizia falcata (L.) Back	Common name: Moluccan sau Country: Philippines	Reference: 70

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	1 100
Fibre width, µm	24
Wall thickness, µm	3.5
Lumen width, µm	17
Length/width ratio	46
Runkel ratio	0.41
Flexibility ratio	0.71

Additional information:

Ready for harvest at 10 years. Grows rapidly even on impoverished soil. At 3 years: DBH 176 mm and height 16 m.

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C, sulfidity 25.5%, 15.6% act. alk.)
Chemical consumption, %	88.6 based on chem. charged
Kappa number Permanganate no.	10.9
Yield (unscreened), %	53.8
Screenings, %	0.0
Brightness	
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	90.5
Burst index, kPa m^2/g	5.45
Tear index, mN m^2/g	7.6

Bleached

Sequence	CEH
Chemical consumption, %	5.5 as Cl-charge
Yield on bleaching, %	93.3
Total yield, %	
Brightness	77.5
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	71.0
Burst index, kPa m^2/g	3.85
Tear index, mN m^2/g	5.7

Additional information:

Annona sericea
(Araticum)

Plantation experience

Annona is sparingly represented in Asia and Africa, but it is generously distributed with about 100 species in tropical America, Florida, the West Indies, Mexico, and tropical and subtropical South America. The trees are chiefly valuable for their edible fruits. The growth rate is unknown.

References: 32, 58

Wood characteristics

The basic density of the wood is normal, and the fibres are fairly long for a short hardwood (1.5 mm), relatively broad and have a fairly thick wall.

Pulping characteristics

The sulphate pulp yield obtained is low, probably due to the heavy chemical charge applied. The strength characteristics of the pulp are very good and compare well with eucalypt and birch sulphate pulps.

Scientific name: Annona sericeae	Common name: Araticum Country: Brazil	Reference: 32

Wood sample characteristics

Wood sample origin:

Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State

Density and fibre characteristics:

Basic density, kg/m^3	550
Fibre length, µm x)	1 530
Fibre width, µm	29.9
Wall thickness, µm	4.8
Lumen width, µm	20.3
Length/width ratio	
Runkel ratio	0.47
Flexibility ratio	0.68

Additional information:

Includes an anatomical description.

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	25.0 Na_2O (charge)
Kappa number x)	12.1
Yield (unscreened), %	42.3
Screenings, %	0.5
Brightness	
Beater or refiner	
Freeness	350 CSF
Tensile index, N m/g	147
Burst index, kPa m^2/g	7.8
Tear index, mN m^2/g	10.3

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

x) Permanganate Number

Anthocephalus cadamba
(Syn. Anthocephalus chinensis)

Plantation experience

Indigenous to India, Burma and Sri Lanka. This fast growing tree grows on alluvium along rivers. The growth reported in the Philippines is 36 m^3/ha·a at a rotation of 3 years. The samples referred to here are from the Philippines, North Borneo and Australia.

References: 14, 19, 21, 22, 41, 70

Wood characteristics

The wood density is medium or low and the fibre length is above average for hardwoods. No data on the lignin content are available, but previous information (25) indicates that the lignin content may be low.

Pulping characteristics

The wood is easily cooked in the sulphate process with a low charge of alkali. The resulting pulp is of average yield with strength characteristics corresponding to those of beech or poplar pulp. The bleaching response is good and the loss of strength during bleaching is minimal. The wood seems to be suitable for NSSC-pulp manufacture.

Scientific name: Anthocephalus cadamba	Common name: Country: North Borneo	References: 14

Wood sample characteristics

Wood sample origin:

Three logs from one tree, 20 years old
DBH 404 mm over bark

Density and fibre characteristics:

Basic density, kg/m^3	370 at breast height
Fibre length, µm x)	1 480
Fibre width, µm	38
Wall thickness, µm	5.6
Lumen width, µm	27
Length/width ratio	39
Runkel ratio	0.41
Flexibility ratio	0.71

Additional information:

x) 1000 µm = 1mm

Chemical characteristics: At breast height

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.3
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	80.9
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)	NSSC (145°C)
Chemical consumption, %	12.5 act. alkali as Na_2O	(15 % Na_2SO_3 + 5 % Na_2CO_3 (charge
Kappa number		
Yield (unscreened), %	50.3	66.1
Screenings, %	0.5	
Brightness		
Beater or refiner	Valley	Valley
Freeness	560	590
Tensile index, N m/g	78.3	22.1
Burst index, kPa m^2/g	4.8	0.8
Tear index, mN m^2/g	13.2	2.5

Bleached

Sequence	CEH
Chemical consumption, %	9.5 as Cl
Yield on bleaching, %	
Total yield, %	38.3
Brightness	80
Beater or refiner	
Freeness	710
Tensile index, N m/g	25.0
Burst index, kPa m^2/g	1.4
Tear index, mN m^2/g	6.8

Additional information:

Scientific name: Anthocephalus cadamba	Common name: Country: Philippines	Reference: 19

Wood sample characteristics

Wood sample origin:

Sample consisted of 8 logs, diameter 145 - 194 mm over bark; Age 7 - 8 a
Growth: 9 year old stand had a DBH of 253 mm and a height of 17.6 m

Density and fibre characteristics:

Basic density, kg/m^3	370
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.6
Solubility, %	
in water	
in 1 % NaOH	17.8
Ash, %	1.0
Lignin, %	
Holocellulose, %	66.0
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Prehydrolysis-sulphate (170°C)
Chemical consumption, %	11.3 act. alkali as Na_2O
Kappa number	21.2
Yield (unscreened), %	32.8
Screenings, %	0.0
Brightness	88.2 a-cellulose, %
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Bleached

Sequence	CEDED
Chemical consumption, %	7.9 added as Cl
Yield on bleaching, %	88.8
Total yield, %	29.2
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	24.4 viscosity, cp (bleached)
	96.0 a-cellulose, %

Scientific name: Anthocephalus cadamba (Rob.) Miq.	Common name: Philippine wonder tree Country: Australia	Reference: 41

Wood sample characteristics

Wood sample origin:

Humpty Doo, Darwin, N. Australia
2.5 year old trees from wind row planting
Diameters (bh) 14 - 20 cm
Heights 8.6 - 10.2 m
Butt, middle and top logs of 8 trees

Density and fibre characteristics:

Basic density, kg/m^3	332
Fibre length, µm x)	1 230
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

39% bark (by volume) of logs

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached		
Process	Sulphate	NSSC
Chemical consumption, %	14 (charge)	15–25 % Na_2CO_3 + 3.5–5.8 % Na_2CO_3 (charge)
Kappa number	20.0	124–87
Yield (unscreened), %	46.5	69–57
Screenings, %	0.5	0
Brightness		
Beater or refiner	PFI	203 mm Bauer lab. refiner
Freeness	300 CSF	300 CSF
Tensile index, N m/g	100	70–80
Burst index, kPa m^2/g	–	–
Tear index, mN m^2/g	9.5	8
Bleached		
Sequence	CEHD	
Chemical consumption, %	5.3 (% in CandH)	
Yield on bleaching, %	92.5	
Total yield, %	42.6	
Brightness	91.3 % Elrepho	
Beater or refiner	PFI	
Freeness	300 CSF	
Tensile index, N m/g	70	
Burst index, kPa m^2/g	–	
Tear index, mN m^2/g	9.5	
Additional information:	sulphidity 25%, 2 h at max. temp. 170°C	2-3 at max. temp. 170–180°C

Scientific name: Anthocephalus cadamba	Common name: Kaatoan bangkal Country: Philippines	References: 70

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	1 390
Fibre width, µm	33
Wall thickness, µm	4
Lumen width, µm	25
Length/width ratio	42
Runkel ratio	0.32
Flexibility ratio	0.76

Additional information:

"Miracle tree". Fast-growing. Height at 3 years 8-11 m. DBH 270 mm. Growth 36 m^3/ha·a

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C, 25.5% sulfidity, 15.6% act. alkali)
Chemical consumption, %	87.3 based on chem. charged
Kappa number	22
Yield (unscreened), %	47.5
Screenings, %	0.2
Brightness	
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	114.5
Burst index, kPa m^2/g	5.7
Tear index, mN m^2/g	8.0

Bleached

Sequence	CEH
Chemical consumption, %	6.6 as Cl-charge
Yield on bleaching, %	90.5
Total yield, %	
Brightness	77.0
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	85.0
Burst index, kPa m^2/g	3.5
Tear index, mN m^2/g	5.2

Additional information:

Aquilaria agallocha
(Agarwood)

Plantation experience

Agarwood or Eaglewood is the only timber tree of the Thyme family. It is found in the Indo-Malayan region, particularly Assam. No data on growth rates are available.

References: 33, 58

Wood characteristics

The fibre length and the lignin content are about average for hardwoods. The content of extractives soluble in ethanol-benzene is comparatively high. The wood density is not given for the present sample.

Pulping characteristics

At a relatively high Kappa number (29) the sulphate pulp yield obtained is still comparatively low for a hardwood. The strength characteristics of the unbleached pulp correspond roughly to those of beech pulp. The sample exhibits a considerable decrease in strength on bleaching, but this may well be caused by the apparently very severe bleaching conditions applied.

Scientific name: Aquilaria agallocha Roxb.	Common name: Agarwood Country: India	Reference: 33

Wood sample characteristics

Wood sample origin:

Mariani Range Shibsagar Forest Division, Assam, India

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	1 050
Fibre width, µm	17
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	62
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	4.5
Solubility, %	
in water	10.9 (hot)
in 1 % NaOH	17.1
Ash, %	0.7
Lignin, %	21.8
Holocellulose, %	72.4
Cross-Bevan cellulose, %	
Pentosans, %	16.1

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	14 (charge)
Kappa number	29.0
Yield (unscreened), %	49.2
Screenings, %	00.5
Brightness	
Beater or refiner	Lampen
Freeness	250 (?)
Tensile index, N m/g	73
Burst index, kPa m^2/g	4.7
Tear index, mN m^2/g	8.3

Bleached

Sequence	CEH
Chemical consumption, %	14.5% Cl (tot. charge)
Yield on bleaching, %	
Total yield, %	45.9
Brightness	
Beater or refiner	Lampen
Freeness	250
Tensile index, N m/g	59
Burst index, kPa m^2/g	4.6
Tear index, mN m^2/g	6.3

Additional information:

Araucaria angustifolia
(Parana Pine, Brazilian Pine)

Plantation experience

Native of Brazil, where it has been planted as well as in Argentina, Australia and East and South Africa. The growth increment is classified as low.

References: 21

Wood characteristics

This medium density wood has very long fibres, about 5 mm on the average. The fibre width is also remarkable. The lignin content is within the normal range for softwoods.

Pulping characteristics

The chemical charge required in sulphate pulping is fairly high, and the pulp yield obtained is considered high in comparison with the relatively high lignin content. Due to the long fibres the tear strength is exceptionally high. The tensile strength is quite low, obviously a result of the thick-walled fibres that do not provide adequate fibre bonding. For further information see reference 25.

Scientific name: Araucaria angustifolia	Common name: Country: Brazil	Reference: 26

Wood sample characteristics

Wood sample origin:

natural forest

Density and fibre characteristics:

Basic density, kg/m^3	420
Fibre length, µm x)	5 150
Fibre width, µm	47.11
Wall thickness, µm	6.44
Lumen width, µm	34.22
Length/width ratio	109
Runkel ratio	0.37
Flexibility ratio	0.73

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.2
Solubility, %	
in water	1.4
in 1 % NaOH	7.3
Ash, %	0.3
Lignin, %	29.3
Holocellulose, %	
Cross-Bevan cellulose, %	53.4
Pentosans, %	7.2

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	20
Kappa number	26.5
Yield (unscreened), %	51.1
Screenings, %	0.3
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	58.61
Burst index, kPa m^2/g	3.89
Tear index, mN m^2/g	17.0
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	x) at 600 g/om^3 apparent density

Bursera simaruba
(Gum Elemi)

Plantation experience

It is widely distributed in tropical and subtropical America. Growth is indicated to be 25 m^3/ha*a or in the medium class. No details are available. The particular sample referred to here is taken from a natural forest in Belize.

References: 48, 58

Wood characteristics

This wood of low to medium density contains short fibres and a lignin content in the normal range for hardwoods.

Pulping characteristics

The wood is not easily cooked in the sulphate process at 170°C, judging from the relatively high Kappa number of the resulting pulp. The pulp yield is comparatively low for a hardwood, especially in view of the high Kappa number. The strength characteristics of the pulp correspond to those of beech pulp.

Scientific name: Bursera simaruba	Common name: Country: Belize	Reference: 48

Wood sample characteristics

Wood sample origin:

From natural forests at Melinda
Age probably 8 - 9 years
Five trees sampled: diameter 255 mm
Growth 25 $m^3/ha \cdot a$

Density and fibre characteristics:

Basic density, kg/m^3	347
Fibre length, µm x)	820
Fibre width, µm	29
Wall thickness, µm	3.1
Lumen width, µm	23
Length/width ratio	28
Runkel ratio	0.27
Flexibility ratio	0.79

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.1
Solubility, %	
in water	
in 1 % NaOH	18.3
Ash, %	1.4
Lignin, %	20.5
Holocellulose, %	71.3
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	13.7 act. alkali as Na_2O
Kappa number	26.3
Yield (unscreened), %	49.0
Screenings, %	0.1
Brightness	
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	72
Burst index, kPa m^2/g	4.6
Tear index, mN m^2/g	7.0
Bleached	
Sequence	CEHD
Chemical consumption, %	9.6 as Cl
Yield on bleaching, %	
Total yield, %	46.1
Brightness	84
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	70
Burst index, kPa m^2/g	4.3
Tear index, mN m^2/g	6.8
Additional information:	

Cedrus atlantica
(Atlantic Cedar, Atlas Cedar)

Plantation experience

The genus is of European and Asian origin. This 14 year old wood sample is from an experimental plantation in Italy. No data on growth increment are available.

References: 13, 67

Wood characteristics

The sample is of medium density and contains fibres which are very short for a softwood. The lignin content of the wood is in the normal range for softwoods.

Pulping characteristics

The sulphate pulp yield obtained after cooking at 175°C is very low. The strength characteristics are not of such level expected from a softwood pulp. Bleaching by application of the sequence CEHEH did not give a pulp of acceptable brightness.

According to the evaluation of the present sample, the species is considered unsuitable for chemical pulping.

Scientific name: Cedrus atlantica	Common name: Country: Italy	References: 13

Wood sample characteristics

Wood sample origin:

From a center near Rome
Mean annual temperature 15°C
Mean annual precipitation 780 mm
Age 14 a

Usable height 11 m

Density and fibre characteristics:

Basic density, kg/m^3	412
Fibre length, µm x)	2 200
Fibre width, µm	28
Wall thickness, µm	4.5
Lumen width, µm	19
Length/width ratio	79
Runkel ratio	0.48
Flexibility ratio	0.68

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	1.3
Methanol	
Ethanol-benzene	5.0
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	0.4
Lignin, %	28.7
Holocellulose, %	66.1
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Hemicellulose, %	28.2

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (175°C)
Chemical consumption, %	18 charge of active alkali
Kappa number	35
Yield (unscreened), %	40
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	32 SR
Tensile index, N m/g	86
Burst index, kPa m^2/g	6.2
Tear index, mN m^2/g	10.1

Bleached

Sequence	CEHEH
Chemical consumption, %	10 charged as Cl
Yield on bleaching, %	
Total yield, %	
Brightness	68 GE
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Cupressus lusitanica
(Mexican Cypress)

Plantation experience

The species is indigenous to Central America, but is has long been cultivated in Europe. It has been introduced in Australia and East Africa.

References: 3, 21

Wood characteristics

The medium-dense wood from trees 7 or 7 - 15 years old contains fibres which are short for a softwood. The lignin content is not given, but the holocellulose content is 63 - 70% which indicates that the lignin content is medium or high.

Pulping characteristics

The sulphate pulps cooked to 60 - 70% yield exhibit strength characteristics which can be considered good, although not exceptionally so, for softwood high-yield pulp.

Scientific name: Cupressus lusitanica	Common name: Country: Kenya	References: 3

Wood sample characteristics

Wood sample origin:

Plantation-grown
Under 7 a and 7-15 a logs

Density and fibre characteristics:

Basic density, kg/m^3	380	370
Fibre length, µm x)	2 270	1 870
Fibre width, µm	39	37 dia.
Wall thickness, µm	3.8	4.6
Lumen width, µm	31	28
Length/width ratio	58	51
Runkel ratio		
Flexibility ratio		

Additional informations:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	0.70	1.35
Solubility, %		
in water		
in 1 % NaOH		
Ash, %		
Lignin, %		
Holocellulose, %	69.6	63.5
Cross-Bevan cellulose, %		
Pentosans, %		

Additional informations:

Pulping and papermaking characteristics

Unbleached	< 7 a	7-15 a
Process	Sulphate	Sulphate
Chemical consumption, % x)	7.2	7.2
Kappa number		
Yield (unscreened), %	61.2	70.2
Screenings, %	1.0	2.2
Brightness		
Beater or refiner	Valley	Valley
Freeness	450	440
Tensile index, N m/g	63.7	59.8
Burst index, kPa m^2/g	4.9	4.3
Tear index, mN m^2/g	8.3	9.8
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) Act. alkali

Eucalyptus alba

Plantation experience

This is one of the principal species of eucalyptus planted in Brazil for use in the pulp industry.

References: 22

Wood characteristics

The basic density of the wood is in the medium to high range of hardwoods used for pulping. The fibres are of short length, wide and the cell walls are slightly on the thick side. Nevertheless, the fibres are not too stiff (flexibility ratio ≈0.50). The chemical characteristics do not reveal anything that might cause difficulties in chemical pulping.

Pulping characteristics

The yields on sulphate pulping are low to average for eucalypts, with normal alkali charges. The pulp strengths are about normal for eucalypt sulphate pulps.

Scientific name: Eucalyptus alba (syn. E. urophylla)	Common name: Country: Brasil	Reference: 8

Wood sample characteristics

Wood sample origin:

a) 5 years old
b) 7 years old

Density and fibre characteristics:

	a)	b)
Basic density, kg/m^3	532 - 556	575
Fibre length, µm x)		
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	
Kappa number	21
Yield (unscreened), %	54.0 - 56.0
Screenings, %	
Brightness	
Beater or refiner	
Freeness	45 SR
Tensile index, N m/g	102 - 111
Burst index, kPa m^2/g	6.5 - 7.2
Tear index, mN m^2/g	12.2 - 13.0

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Eucalyptus alba (syn. E urophylla)	Common name: Country: Brasil	Reference: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	468
Fibre length, µm x)	890
Fibre width, µm	19.5
Wall thickness, µm	4.8
Lumen width, µm	9.8
Length/width ratio	46
Runkel ratio	0.98
Flexibility ratio	0.50

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.6
Solubility, %	
in water	2.2 (hot)
in 1 % NaOH	17.0
Ash, %	0.4
Lignin, %	23.9
Holocellulose, %	
Cross-Bevan cellulose, %	53.4
Pentosans, %	18.8

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O			12.0 Na_2O		
Kappa number x	11.0			16.0		
Yield (unscreened), %	50.1			51.1		
Screenings, %	0.1			0.2		
Brightness xx	42.2			31.0		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	87	95	98	85	99	102
Burst index, kPa m^2/g	5.4	6.3	6.7	5.2	6.1	6.6
Tear index, mN m^2/g	9.0	8.3	9.4	8.6	9.2	9.5

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %	93.6			93.5		
Yield on bleaching, %	46.8			47.6		
Total yield, %						
Brightness	85.7			90.1		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	82	88	91	75	82	86
Burst index, kPa m^2/g	4.6	5.1	5.3	4.5	4.7	4.9
Tear index, mN m^2/g	8.5	8.2	8.0	9.5	9.1	9.0

Additional information: x Permanganate number (ABCP C4/71)
xx ABCP P16/73

Eucalyptus calophylla

Plantation experience

No information available.

Wood characteristics

The basic density of the wood is somewhat high compared to hardwoods normally used for pulping. The fibres are longer than average for hardwoods.

Pulping characteristics

The yield on sulphate and NSSC pulping are relatively high and the pulps obtained exhibit good strength characteristics although somewhat inferior to normal eucalypt pulps. Reasonable results are also obtained by means of the chemi-thermomechanical pulping (CTMP) process.

Scientific name: Eucalyptus calophylla	Common name: Country: Australia	References: 36

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3 618
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	CTMP	
Chemical consumption, %	X	
Kappa number		
Yield (unscreened), %	86.7	85.3
Screenings, %		
Brightness	37.0	36.2
Beater or refiner	Bauer	
Freeness	104 CSF	54 CSF
Tensile index, N m/g	22	38
Burst index, kPa m^2/g		
Tear index, mN m^2/g	4.6	5.7

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: X Solution containing 1.6% NaOH and 1.25% Na_2SO_3
Liquor: wood ratio 5:1

Scientific name: Eucalyptus calophylla	Common name: Australia Country:	Reference: 55

Wood sample characteristics

Wood sample origin:

Sample from Pemberton and the Pimelia district
26 - 30 year old thinnings

Density and fibre characteristics:

Basic density, kg/m^3	607
Fibre length, µm x)	1 330
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		NSSC	NSSC
Chemical consumption, %	14.0 Na_2O (charge)		x	xx
Kappa number	24.1			
Yield (unscreened), %	54.4		73.4	72.5
Screenings, %				
Brightness				
Beater or refiner	Lampen		Lampen	
Freeness	338 CSF	573 CSF	374 CSF	267 CSF
Tensile index, N m/g	82	54	45	57
Burst index, kPa m^2/g	5.5	2.9	2.0	2.9
Tear index, mN m^2/g	11.8	8.7	5.8	7.9

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x 14 % Na_2SO_3 + 6 % $NaHCO_3$ (charge)
xx 18 % Na_2SO_3 + 6 % $NaHCO_3$ (")

Eucalyptus camaldulensis

Plantation experience

This is the most widely used eucalypt species in plantations together with E. globulus. The most successful plantations are in Spain, Portugal and North Africa. Good results have also been obtained in Turkey, Sri Lanka, Kenya, Rhodesia, Malawi, the Republic of South Africa, California, Florida, Brazil, Argentina and Chile. The species is very adaptable to climate and soil. A more detailed review and a list of references are given in the previous volume.

References: 21, 30

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. The fibres are relatively short, even for hardwoods, thin and of average wall thickness. Thus, the pulp made from this species should exhibit good opacity. The lignin content of the sample from Brazil is very high for a hardwood and may have an effect on the yield of chemical pulping.

Pulping characteristics

Relatively low alkali charges give low to medium yields in sulphate pulping. The strength properties are about the average for eucalypt pulp. The pulps are readily bleached and results on mill scale pulping correspond to the results obtained in laboratory tests.

NSSC pulping gives high yields and the pulps have excellent strength properties.

Scientific name: Eucalyptus camaldulensis	Common name: Country: Brasil	Reference: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	440
Fibre length, µm x)	780
Fibre width, µm	15.2
Wall thickness, µm	4.0
Lumen width, µm	7.1
Length/width ratio	51
Runkel ratio	1.13
Flexibility ratio	0.47

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.9
Solubility, %	
in water	1.7 (hot)
in 1 % NaOH	
Ash, %	0.8
Lignin, %	29.3
Holocellulose, %	
Cross-Bevan cellulose, %	50.0
Pentosans, %	17.2

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O			12.0 Na_2O		
Kappa number	11.3			18.5		
Yield (unscreened), %	46.9			52.2		
Screenings, %	0.1			3.3		
Brightness xx	40.5			34.3		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	79	86	89	78	93	101
Burst index, kPa m^2/g	4.9	6.0	6.0	5.6	7.2	8.0
Tear index, mN m^2/g	11.0	9.7	9.7	11.6	10.5	10.0

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %						
Yield on bleaching, %	95.3			89.1		
Total yield, %	44.6			43.6		
Brightness xx	87.0			88.5		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	76	77	80	82	85	86
Burst index, kPa m^2/g	4.4	4.5	4.6	5.5	5.6	5.4
Tear index, mN m^2/g	8.8	9.0	9.0	10.9	10.6	10.0

Additional information: x Permanganate Number (ABCP C4/71)
xx ABCP P16/73

Scientific name: Eucalyptus camaldulensis	Common name: Country: USA	Reference: 30

Wood sample characteristics

Wood sample origin:

Florida
10 years old (approximately)

Density and fibre characteristics:

Basic density, kg/m^3 529
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
Ether
Methanol
Ethanol-benzene

Solubility, %
in water
in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	NSSC	Sulphate[x]
Chemical consumption, %		
Kappa number ml	38	12
Yield (unscreened), %	74 (screened)	45
Screenings, %		
Brightness		
Beater or refiner		
Freeness	400 CSF	
Tensile index, N m/g	72	
Burst index, kPa m^2/g	4.5	
Tear index, mN m^2/g		

Bleached

Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		300 CSF
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		7.0
Tear index, mN m^2/g		9.3

Additional information: x Mill scale

Eucalyptus citriodora

Plantation experience

The species has been planted in Portugal, North Africa and Sri Lanka mainly as an ornamental tree. Good results have been obtained in South, West, Central and East Africa and Brasil, whereas it has failed to acclimatize in Kampuchea, India and Indonesia. The species is relatively adaptable. For detailed information and a list of references see the previous volume (21).

Wood characteristics

The wood is of relatively high density. It is also very hard and difficult to debark. The fibre length is about normal for hardwoods used for pulping. The fibres are thin and thick-walled, which may cause undesirable stiffness and lack of proper inter-fibre bonding in the paper. The lignin content is low, which implies ease of chemical pulping. The extractives content is on the other hand slightly on the high side for a hardwood.

Pulping characteristics

The alkali consumption in the sulphate process seems to be low. Yields are slightly below average for a hardwood. The strength properties of the pulps, except the tear index, are not up to the standards of good quality eucalypt sulphate pulps.

Scientific name: Eucalyptus citrodora	Common name: Country: Brasil	Reference: 29

Wood sample characteristics

Wood sample origin:

Sample from the plantations in "Estado de Minas Gerais"
7 and 13 years old

Density and fibre characteristics:

Basic density, kg/m^3	637 - 738
Fibre length, µm x)	915 - 943
Fibre width, µm	15.5 - 15.9
Wall thickness, µm	5.4 - 5.7
Lumen width, µm	4.4 - 4.8
Length/width ratio	59
Runkel ratio	2.3 - 2.6
Flexibility ratio	0.28 - 0.31

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether Methanol Ethanol-benzene	2.7 - 2.9
Solubility, %	4.1 - 4.5 (hot)
in water in 1 % NaOH	16.9 - 19.3
Ash, %	0.21 - 0.34
Lignin, %	15.3 - 17.8
Holocellulose, %	
Cross-Bevan cellulose, %	56.7 - 61.5
Pentosans, %	18.1 - 23.5

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13 - 13.25 Na_2O [x]		
Kappa number			
Yield (unscreened), %	47.8 - 49.2		
Screenings, %	3.2 - 4.8		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	72 - 77	83 - 84	87 - 90
Burst index, kPa m^2/g	3.8 - 4.8	5.3 - 5.8	6.0 - 6.5
Tear index, mN m^2/g	11.1 - 15.3	13.5 - 15.0	13.9 - 14.4

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: Charge to permanganate number 16.0 $\pm$ 1.0

Eucalyptus cloeziana

Plantation experience

Good results have been achieved in Brazil and Congo. Yet, sufficient experience has not been gained with the species. Profitable use is to be expected because of its rapid growth in relatively dry tropical climates. For addional references see the previous volume (21).

References: 9, 21

Wood characteristics

The basic density of the wood is in the range normal for pulpwood. The fibres are of average length and width for hardwoods, but thick-walled, which suggests a certain amount undesirable stiffness and lack of proper interfibre bonding in paper. The lignin content is high and may cause difficulties in chemical pulping.

Pulping characteristics

Sulphate pulp yields of about 50 percent are obtained with relatively low alkali charges. The strength properties of the pulps obtained are, however, not up to the standards of average eucalypt pulp.

Scientific name: Eucalyptus oloeziana	Common name: Country: Brazil	Reference: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	529
Fibre length, µm x)	860
Fibre width, µm	18.0
Wall thickness, µm	5.3
Lumen width, µm	7.4
Length/width ratio	47
Runkel ratio	1.43
Flexibility ratio	0.41

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	2.6	
Solubility, %		
in water	2.3	(hot)
in 1 % NaOH	11.8	
Ash, %	0.3	
Lignin, %	28.3	
Holocellulose, %		
Cross-Bevan cellulose, %	53.8	
Pentosans, %	15.5	

Additional information:

- Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O			12.0 Na_2O		
Kappa number x	11.2			17.9		
Yield (unscreened), %	50.1			52.4		
Screenings, %	0.1			1.0		
Brightness xx	39.4			32.5		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	73	80	84	70	76	80
Burst index, kPa m^2/g	4.1	4.7	5.0	4.1	4.7	5.0
Tear index, mN m^2/g	8.2	10.1	8.3	8.5	9.2	9.5

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %						
Yield on bleaching, %	94.8			91.8		
Total yield, %	47.4			47.2		
Brightness xx	86.4			89.0		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	57	66	70	78	83	86
Burst index, kPa m^2/g	2.6	3.3	3.6	4.4	4.8	5.0
Tear index, mN m^2/g	7.4	8.3	8.8	8.4	8.7	9.0

Additional information: x Permanganate Number (ABCP C4/71)
xx ABCP P16/73

SR

Eucalyptus cypellocarpa

Plantation experience

A species previously considered unsuitable, but nowadays accepted for pulping in New South Wales and Victoria, Australia. No references on the plantation experience of the species are available.

Wood characteristics

The basic density is around the upper limit for hardwoods used for pulping. No data on the fibre or chemical characteristics are available for the present sample.

Pulping characteristics

The yield of the sulphate pulp with a normal alkali charge is low for a hardwood. The strength properties are acceptable for many purposes though below average for good quality eucalypt pulp.

Scientific name: Eucalyptus cypellocarpa	Common name: Country: Australia	Reference: 71

Wood sample characteristics

Wood sample origin:

a) 25 years old

b) 25 - 30 years old

Density and fibre characteristics:

Basic density, kg/m^3 a) 576 b) 655
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
Ether
Methanol
Ethanol-benzene

Solubility, %
in water
in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	14.0 - 17.0 Na_2O (charge)
Kappa number	23.1 - 13.2
Yield (unscreened), %	48.4 - 46.6
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	350 CSF
Tensile index, N m/g	70 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	10.5 (approx.)

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Eucalyptus deanei

Plantation experience

No information available.

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping and the fibre length is about the average for hardwoods. The lignin content is high for hardwoods.

Pulping characteristics

A high alkali charge seems to be required to delignify the wood to a Kappa number which is normal for hardwood pulps and the yield of pulping is low for a hardwood. The strength characteristics of the pulp is slightly below the average for commercial eucalypt pulps.

Scientific name: Eucalyptus deanei	Common name: Country: Brazil	Reference: 8

Wood sample characteristics

Wood sample origin:

7 years old

Density and fibre characteristics:

Basic density, kg/m^3	513
Fibre length, µm x)	950
Fibre width, µm	18.0
Wall thickness, µm	4.5
Lumen width, µm	9.0
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.4
Solubility, %	
in water	1.6 (hot)
in 1 % NaOH	
Ash, %	0.4
Lignin, %	26.8
Holocellulose, %	
Cross-Bevan cellulose, %	53.8
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	
Kappa number x	15.1
Yield (unscreened), %	51.2
Screenings, %	
Brightness	
Beater or refiner	
Freeness	34 SR
Tensile index, N m/g	86
Burst index, kPa m^2/g	7.3
Tear index, mN m^2/g	14.7

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Permanganate number

Scientific name: Eucalyptus deanei	Common name: Country: Argentina	Reference: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estacion Experimental castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	462 - 576
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	0.3 - 2.5	1.7 - 4.6 (hot)
in 1 % NaOH	14.3 - 17.2	
Ash, %		
Lignin, %	23.4 - 30.1	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	17.5 - 19.5 NaOH	15.3 - 19.8 NaOH
Kappa number	17.0 - 23.0	22
Yield (unscreened), %	45.1 - 49.2	44.9 - 50.2
Screenings, %	0.7 - 1.0	0.7 - 3.2
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	86 - 102	
Burst index, kPa m^2/g	4.8 - 6.1	
Tear index, mN m^2/g	7.9 - 9.3	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness (Tappi)	67.5 - 72.5	81.9 - 84.6	86.7 - 87.5
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		89 - 100	93 - 104
Burst index, kPa m^2/g		5.7 - 6.8	5.9 - 7.0
Tear index, mN m^2/g		7.6 - 10.2	8.0 - 10.1

Additional information: x charge

Eucalyptus deglupta
(Mindanao Gum Kamarere)

Plantation experience

The species is indigenous to the Philippines, the Celebes, New Guinea, New Britain and New Ireland. Good results have been reported from Brazil, Sri Lanka, Cuba, India, Java, Malaysia, North Borneo and the Solomon Islands. It is fast-growing and has acclimatised well in tropical island climates.

References: 21, 22

Wood characteristics

The basic density is on the low side for hardwoods used for pulping.

Pulping characteristics

Sulphate pulping requires relatively low alkali charges and the yield in the kappa number 20 is about 50 percent. The strength properties of the pulp do not seem to reach the standards of good quality eucalyptus pulp. Bleached pulps of high brightness can be produced in satisfactory yields using the CEHD sequence.

Reasonable results, although inferior to those of E. regnans, have been obtained in chemi-thermomechanical pulping (CTMP).

Scientific name: Eucalyptus deglupta	Common name: Country: Australia	Reference: 36

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3 307
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	CTMP	
Chemical consumption, % x		
Kappa number		
Yield (unscreened), %	87.8	85.3
Screenings, %		
Brightness	32.0	
Beater or refiner	Bauer	
Freeness	372 CSF	277 CSF
Tensile index, N m/g	21	30
Burst index, kPa m^2/g		
Tear index, mN m^2/g	3.8	4.3

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Solution containing 1.6% NaOH and 1.25% Na_2SO_3
Liquor: wood ratio 5:1

Scientific name: Eucalyptus deglupta	Common name: Kamarere Country: Papua New Guinea	Reference: 56

Wood sample characteristics

Wood sample origin:

Samples from plantations at Keravat, New Britain
6 - 13 years old

Density and fibre characteristics:

Basic density, kg/m^3	313 - 423
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	12.5 - 13.5 Na_2O (charge)
Kappa number	19.0 - 19.5
Yield (unscreened), %	49.7 - 50.1
Screenings, %	0.4 - 0.7
Brightness	
Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	60 - 80 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	9.5 - 12.0 (approx.)

Bleached

Sequence	CEHD
Chemical consumption, %	2.7 - 2.9 Cl_2
Yield on bleaching, %	93.5 - 96.5
Total yield, %	45.7 - 46.9
Brightness	86.4 - 89.4
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Eucalyptus diversicolor

Plantation experience

The species occurs in considerable quantity in Western Australia. Typically, the tree reaches a height of 45 m and a girth of 5 m with good wood quality. Trees up to 87 m in height with diameters of 2 - 2.5 m have been measured. No data on cultivation of the species are available.

References: 55

Wood characteristics

The basic density is around the upper limit for hardwoods used for pulping. The fibres are longer than average for hardwoods.

Pulping characteristics

Pulps of low kappa number are obtained with normal alkali charges in the sulphate process. The yield is very high. The strength properties, with the exception of the tear index, are not comparable to the standards of good quality eucalypt pulp.

Application of the NSSC process gives pulps of good strength properties.

Reasonable results on chemi-thermomechanical pulping (CTMP) have been reported.

Scientific name: Eucalyptus diversicolor	Common name: Country: Australia	Reference: 36

Wood sample characteristics

Wood sample origin:

Samples from Pemberton and the Pimelia district
26 - 30 year old thinnings

Density and fibre characteristics:

Basic density, kg/m^3	644
Fibre length, µm x)	1 320
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	NSSC	NSSC
Chemical consumption, %	14.0 Na_2O (charge)	x	xx
Kappa number	12.3		
Yield (unscreened), %	56.2	73.4	72.9
Screenings, %			
Brightness			
Beater or refiner	Lampen	Lampen	
Freeness	388 CSF	264 CSF	322 CSF
Tensile index, N m/g	76	56	43
Burst index, kPa m^2/g	4.4	2.8	1.8
Tear index, mN m^2/g	11.5	7.4	6.2

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

x 14% Na_2SO_3 + 6% $NaHCO_3$ (charge)

xx 18% Na_2SO_3 + 6% $NaHCO_3$ (charge)

Scientific name: Eucalyptus diversicolor	Common name: Country: Australia	Reference: 55

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3 561
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan celluloee, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	CTMP	
Chemical consumption, %	x	
Kappa number		
Yield (unscreened), %	88.8	86.0
Screenings, %		
Brightness	20.9	20.8
Beater or refiner	Bauer	
Freeness	127 CSF	59 CSF
Tensile index, N m/g	24	37
Burst index, kPa m^2/g		
Tear index, mN m^2/g	4.6	5.3

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: Solution containing 1.6% NaOH and 1.25% Na_2SO_3
Liquor: wood ratio 5:1

Eucalyptus dunnii

Plantation experience

No information available.

Wood characteristics

The basic density and the fibre length are in the average range for hardwoods used for pulping. The data on other fibre dimensions indicate a certain amount of stiffness, which may affect the potential bonding in paper. The chemical characteristics do not indicate any difficulties on chemical pulping.

Pulping characteristics

The yield on sulphate pulping is good and the pulp obtained exhibits strength characteristics typical of a good eucalypt pulp; the tear index is exceptionally high but may be due to the sample being from a young tree.

Scientific name: Eucalyptus dunnii	Common name: Country: Brazil	References: 8

Wood sample characteristics

Wood sample origin:

5 years old

Density and fibre characteristics:

Basic density, kg/m^3	486
Fibre length, µm x)	1 120
Fibre width, µm	18.9
Wall thickness, µm	5.0
Lumen width, µm	8.9
Length/width ratio	59
Runkel ratio	1.12
Flexibility ratio	0.47

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.6
Solubility, %	
in water	1.8 (hot)
in 1 % NaOH	
Ash, %	0.5
Lignin, %	22.6
Holocellulose, %	
Cross-Bevan cellulose, %	56.3
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	
Chemical consumption, %		
Kappa number	17	33
Yield (unscreened), %	53.7	57.5
Screenings, %		
Brightness		
Beater or refiner		
Freeness	35 SR	40 SR
Tensile index, N m/g	82	92
Burst index, kPa m^2/g	6.9	7.8
Tear index, mN m^2/g	17.1	15.7

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Eucalyptus fastigata

Plantation experience

No information available.

Wood characteristics

The basic density is relatively low for hardwood pulpwood and the fibres are shorter than average.

Pulping characteristics

The sulphate process gives pulp in high yield at a normal Kappa number level using comparatively short cooking times. The pulps are easily bleached to high brightness and the strength characteristics are representative of average quality eucalypt pulp.

Scientific name: Eucalyptus fastigata	Common name: Country: New Zealand	Reference: 34

Wood sample characteristics

Wood sample origin:

Sample from the Tokoroa district
6 years old
15 trees, mean height 10.7 mean diam. 180 mm
(breast height)

Density and fibre characteristics:

Basic density, kg/m^3	380
Fibre length, µm x)	850
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.3
Solubility, %	
in water	
in 1 % NaOH	15.4
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	15.5 - 18.0 Na_2O (charge)
Kappa number	28.9 - 17.4
Yield (unscreened), %	55.2 - 52.5
Screenings, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Bleached

Sequence	D_CEHD	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness	90.5 - 92.8	
Beater or refiner	Lampen	
Freeness	350 CSF	432 CSF
Tensile index, N m/g	93	84
Burst index, kPa m^2/g	6.8	6.6
Tear index, mN m^2/g	9.3	9.4

Additional information:

Eucalyptus globulus
(Blue Gum)

Plantation experience

This is the most widely planted eucalypt species. The species grows best on deep soils free of carbonates in mild climates with uniform rainfall or with winter or summer maximum. The annual yields per ha are excellent. For a list of references see the previous volume (21).

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. The fibres are of low to average length and width for hardwoods, and thin walled, which suggests desirable flexibility and good inter-fibre bonding in paper. The lignin content is relatively low. The data on the Mexican samples differ from the others both in fibre and chemical characteristics.

Pulping characteristics

High yields are obtained in the sulphate process with relatively low alkali charges to produce pulps of the kappa number of 20. The strength properties of the pulps are very good and the pulps are readily bleached to high brightness levels.

Application of the NSSC process gives pulps of very good strength. The pulps have been bleached up to the brightness of about 80, but the overall yeild has then dropped to 50 percent. Magnesium bisulphite pulping in the semi-chemical-chemical range yeilds pulps of just acceptable strength properties.

Cold soda pulping yields good quality pulp. Pulping with bark present has no significant deleterious effect on the strength properties. The brightness obtained was lower, but acceptable levels are attained when bleaching with 2 percent available chlorine.

Scientific name: Eucalyptus globulus	Common name: Country: Brazil	References: 10

Wood sample characteristics

Wood sample origin:

Sample from Salesopolis - Sao Paulo
3 .5 years old

Density and fibre characteristics:

Basic density, kg/m^3	479
Fibre length, µm x)	1 030
Fibre width, µm	17.3
Wall thickness, µm	3.4
Lumen width, µm	10.6
Length/width ratio	60
Runkel ratio	0.641
Flexibility ratio	0.61

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.0 Na_2O (charge)		
Kappa number x	20.1		
Yield (unscreened), %	55.3		
Screenings, %	11.8		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	60 SR	83 SR
Tensile index, N m/g	105	116	115
Burst index, kPa m^2/g	8.1	9.0	9.3
Tear index, mN m^2/g	12.9	11.1	10.1

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information: x Permanganate Number

Scientific name: Eucalyptus globulus	Common name: Country: Australia	References: 23

Wood sample characteristics

Wood sample origin:

a) 4 - 6 years old stemwood
b) 4 - 6 years old stemwood (fertilized)
c) whole tree 6 years old (fertilized)

Density and fibre characteristics:

Basic density, kg/m^3	a) 512 - 528	b) 498 - 514
Fibre length, µm x)		
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water x	a) 3.1 - 6.0	b) 4.0 - 5.2
in 1 % NaOH	a) 18 - 21	b) 17 - 20
Ash, %		
Lignin, %	a) 17 - 19	b) 17
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %	a) 22	b) 21 - 22

Additional information: x boiling

Pulping and papermaking characteristics

Unbleached	a)	b)	b)	c)
Process	Sulphate	Sulphate	NSSC	NSSC
Chemical consumption, %		13 Na_2O		
Kappa number		16 - 20[x]	85 - 105	115
Yield (unscreened), %		53 - 56	67 - 72	67
Screenings, %				
Brightness				
Beater or refiner	Lampen			
Freeness	200 CSF	200 CSF	200 CSF	300 CSF
Tensile index, N m/g	110 - 122	121	96 - 108	57
Burst index, kPa m^2/g	8.5 - 8.6	8.7 - 8.9	6.1 - 7.0	3.4
Tear index, mN m^2/g	10.1 - 10.5	9.8 - 10.8	8.2 - 9.6	6.8
Bleached				
Sequence xx	HC-E-D-H			
Chemical consumption, %				
Yield on bleaching, %	91.6 - 94.9			
Total yield, %	46.5 - 52.7			
Brightness (GE)	88.0 - 90.6			
Beater or refiner	Lampen			
Freeness	350 CSF			
Tensile index, N m/g				
Burst index, kPa m^2/g	5.7 - 7.4			
Tear index, mN m^2/g	10.1 - 10.2			

Additional information:
x Kappa to max. screened yield
xx HC = 40% = total Cl_2 as $Ca(OCl)_2$, 60% as Cl_2 water

Scientific name: Eucalyptus globulus	Common name: Country: Mexico	Reference: 59

Wood sample characteristics

Wood sample origin:

Sample from the Eucalyptus Plantations of de la Escuela Nacional de Agricultura de Chapingo, Estado de Mexico
12 years old

Density and fibre characteristics:

Basic density, kg/m^3	580
Fibre length, µm x)	760
Fibre width, µm	15.3
Wall thickness, µm	3.3
Lumen width, µm	
Length/width ratio	
Runkel ratio	50
Flexibility ratio	0.58

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	4.7	
Solubility, %		
in water	4.9	5.7 (hot)
in 1 % NaOH	16.2	
Ash, %	0.6	
Lignin, %	21.8	
Holocellulose, %	74.4	
Cross-Bevan cellulose, %		
Pentosans, %	16.7	

Additional information: cellulose % 42.4

Pulping and papermaking characteristics

Unbleached

Process	NSSC
Chemical consumption, %	6.2 SO_2
Kappa number	95.6
Yield (unscreened), %	64.7
Screenings, %	
Brightness	37.7
Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	47.5
Burst index, kPa m^2/g	
Tear index, mN m^2/g	7.5

Bleached

Sequence	CECEH
Chemical consumption, %	17.5 Cl_2
Yield on bleaching, %	77.3
Total yield, %	50.0
Brightness	80.6
Beater or refiner	PFI
Freeness	250 CSF
Tensile index, N m/g	93
Burst index, kPa m^2/g	
Tear index, mN m^2/g	9.1

Additional information: Data are given on the results of a variety of pulping and bleaching conditions. The results above are obtained of the pulps cooked to the lowest kappa no. in the study.

Scientific name: Eucalyptus globulus	Common name: Country: Mexico	References: 69

Wood sample characteristics

Wood sample origin:

Sample from Campo Experimental "Siberia" in Chapingo, Estado de Mexico
12 years old

Density and fibre characteristics:

Basic density, kg/m^3	540
Fibre length, µm x)	990
Fibre width, µm	15.0
Wall thickness, µm	5.9
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	2.06	
Solubility, %		
in water	2.7	5.08 (hot)
in 1 % NaOH	13.05	
Ash, %	0.54	
Lignin, %	21.1	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %	15.4	

Additional information: cellulose % 46.5 (Tappi)

Pulping and papermaking characteristics

Unbleached

Process	Bisulphite (Mg)		
Chemical consumption, %	7.4 SO_2	6.2 - 11.0 SO_2	9.9 - 17.0 SO_2
Kappa number	109.7	114.5 - 66.3	87.0 - 43.6
Yield (unscreened), %	59.8	68.7 - 51.3	56.6 - 47.5
Screenings, %			
Brightness			
Beater or refiner	PFI		
Freeness	300 CSF	300 CSF	300 CSF
Tensile index, N m/g	39	37 - 49	48 - 56
Burst index, kPa m^2/g	1.6	1.5 - 3.0	2.0 - 3.3
Tear index, mN m^2/g	4.3	4.0 - 5.7	4.7 - 5.4

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information:

Eucalyptus grandis
(Rose Gum)

Plantation experience

This species is indigenous to New South Wales and Queensland in Australia. It is essentially a species of subtropical climates with good rainfall (1 - 1.8 metres), high humidity and no extremes of temperature other than light frosts in valleys. Development is best on friable or moist alluvial loams of good fertility with ample soil moisture. Under favourable conditions it grows rapidly, 2 m in height and 12 - 20 mm in diameter per year. Under typical Australian conditions individual trees attain a height of 45 - 55 metres with a diameter at breast height 1.2 - 1.5 metres.

It is extensively planted in the Republic of South Africa, Swaziland and Zambia and is adaptable to the southern Florida climate. Plantations exist also in Argentina, Brazil and India. The growth rate is good (Zambia), a 5-year old tree attains a height of 20 - 23 m with 16 - 20 cm diameter at breast height. In Florida it can be harvested on an 8-year rotation basis.

References: 8, 21, 30, 35, 38, 43, 54, 66

Wood characteristics

The wood is lighter, softer and more fissile than in most eucalypt species, moderate in strength and durability. The fibre length is in the range normal for hardwoods used for pulping. The fibres are relatively thin. There is, however, considerable difference in wall thickness between samples of different origin. In general the fibres seem to have reasonable flexibility and thus provide potential for good inter-fibre bonding in paper. Judging from the chemical composition, no special problems are expected in pulping although the lignin content of the Brazilian samples is slightly on the high side for hardwoods.

Pulping experience

As noted in the previous volume, the best results in sulphate pulping are obtained with fairly low alkali charges. The pulp yields are then within the range normal for hardwoods. The strength of the unbleached pulp is very good, although an influence of sample origin is observable. The bleached pulps are also of good strength. NSSC pulping seems to produce pulps of very good quality in normal yields. The results on chemi-thermomechanical pulping (CTMP) have been characterized as reasonable though inferior to those of E. regnans.

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Brazil	References: 8

Wood sample characteristics

Wood sample origin:

a) 5 - 16 years old
b) 5 - 7 years old

Density and fibre characteristics:

Basic density, kg/m^3	407 - 597
Fibre length, µm x)	840 - 1 280
Fibre width, µm	17.0 - 20.5
Wall thickness, µm	3.2 - 5.1
Lumen width, µm	7.8 - 12.2
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.8 - 2.6
Solubility, %	
in water	1.2 - 3.2 (hot)
in 1 % NaOH	
Ash, %	
Lignin, %	26.2 - 27.0
Holocellulose, %	
Cross-Bevan cellulose, %	55.0 - 56.4
Pentosans, %	17.3

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	
Kappa number	14.0 - 15.0
Yield (unscreened), %	49.6 - 54.5
Screenings, %	
Brightness	
Beater or refiner	
Freeness	40 - 45 SR
Tensile index, N m/g	66 - 116
Burst index, kPa m^2/g	5.0 - 6.5
Tear index, mN m^2/g	12.1 - 15.3

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Permanganate Number

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Brazil	References: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	439
Fibre length, µm x)	840
Fibre width, µm	19.0
Wall thickness, µm	4.4
Lumen width, µm	10.1
Length/width ratio	44
Runkel ratio	0.871
Flexibility ratio	0.53

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	3.2	
Solubility, %		
in water	3.3	(hot)
in 1 % NaOH	15.8	
Ash, %	0.3	
Lignin, %	26	
Holocellulose, %		
Cross-Bevan cellulose, %	54.2	
Pentosans, %	19.4	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O (charge)			12.0 Na_2O (charge)		
Kappa number x	11.8			18.0		
Yield (unscreened), %	50.2			51.3		
Screenings, %	0.1			1.2		
Brightness xx	41.5			31.7		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	102	114	120	105	109	110
Burst index, kPa m^2/g	6.5	7.2	7.5	7.9	8.3	8.5
Tear index, mN m^2/g	11.0	10.1	9.7	10.0	9.7	9.5

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %						
Yield on bleaching, %	94.6			91.0		
Total yield, %	47.4			45.6		
Brightness xx	86.0			88.0		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	82	90	94	105	118	120
Burst index, kPa m^2/g	4.9	5.6	5.9	7.2	7.5	8.0
Tear index, mN m^2/g	10.4	9.1	8.4	11.4	11.2	11.3

Additional information: x Permanganate Number (ABCP C4/71)
xx ABCP P16/73

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Brazil	References: 10

Wood sample characteristics

Wood sample origin:

Sample from Mogi Guacu - Sao Paulo
7 years old

Density and fibre characteristics:

Basic density, kg/m^3	581
Fibre length, µm x)	1 060
Fibre width, µm	18.6
Wall thickness, µm	3.2
Lumen width, µm	12.2
Length/width ratio	57
Runkel ratio	0.525
Flexibility ratio	0.66

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.6
Solubility, %	
in water	3.2 (hot)
in 1 % NaOH	13.7
Ash, %	
Lignin, %	26.2
Holocellulose, %	
Cross-Bevan cellulose, %	55.0
Pentosans, %	17.3

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.0 Na_2O (charge)		
Kappa number x	14.4		
Yield (unscreened), %	49.6		
Screenings, %	1.5		
Brightness			
Beater or refiner	Jokro		
Freeness	25 SR	45 SR	77 SR
Tensile index, N m/g	88	98	112
Burst index, kPa m^2/g	5.1	6.2	8.3
Tear index, mN m^2/g	14.2	13.8	13.0

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information: x Permanganate Number

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Australia	Reference: 36

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3 444
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process		CTMP	
Chemical consumption, %		x	
Kappa number			
Yield (unscreened), %		87.1	84.0
Screenings, %			
Brightness	(Elrepho)	28.2	32.4
Beater or refiner		Bauer	
Freeness		334 CSF	276 CSF
Tensile index, N m/g		24	30
Burst index, kPa m^2/g			
Tear index, mN m^2/g		4.3	4.3

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Solution containing 1.6 % NaOH and 1.25 % Na_2SO_3
Liquor: wood ratio 5 : 1

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: USA	References: 38

Wood sample characteristics

Wood sample origin:

Sample from the plantation in La Belle, Florida

Density and fibre characteristics:

Basic density, kg/m^3 430
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate x	
Chemical consumption, %	20.2 (charge)	
Kappa number	9.5	
Yield (unscreened), %		
Screenings, %		
Brightness		
Beater or refiner		
Freeness	400 CSF	500 CSF
Tensile index, N m/g		
Burst index, kPa m^2/g	4.1	3.5
Tear index, mN m^2/g	8.6	8.4

Bleached

Sequence	CEHD	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness (GE)	87.9	
Beater or refiner		
Freeness	400 CSF	500 CSF
Tensile index, N m/g		
Burst index, kPa m^2/g	3.0	2.4
Tear index, mN m^2/g	6.3	6.4

Additional information: x Mill trials, unbarked

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Argentina	References: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estación Experimental Castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	352 - 417
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %			
Ether			
Methanol			
Ethanol-benzene			
Solubility, %			
in water	1.9 - 2.1	3.8 - 4.3	(hot)
in 1 % NaOH	16.8 - 19.0		
Ash, %			
Lignin, %	21.7 - 26.8		
Holocellulose, %			
Cross-Bevan cellulose, %			
Pentosans, %			

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	18.0 - 19.5 NaOH	16.2 - 18.7 NaOH (charge)
Kappa number	17.5 - 20.5	22
Yield (unscreened), %	46.2 - 49.9	46.8 - 51.8
Screenings, %	0.9 - 1.2	1.5 - 3.5
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	102 - 128	
Burst index, kPa m^2/g	6.4 - 8.1	
Tear index, mN m^2/g	8.2 - 8.4	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness	68.8 - 71.1	83.1	86.4 - 87.2
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		119 - 133	112 - 134
Burst index, kPa m^2/g		7.4 - 7.9	7.2 - 8.6
Tear index, mN m^2/g		8.1 - 8.3	7.6 - 9.7

Additional information:

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Zambia	Reference: 54

Wood sample characteristics

Wood sample origin:

Sample from Chati forest
5.5 years old
average breast height
girth 74 cm

Density and fibre characteristics:

Basic density, kg/m^3	440 (405 - 480)
Fibre length, µm x)	780
Fibre width, µm	16.6
Wall thickness, µm	2.9
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.0
Solubility, %	
in water	2.1 (hot)
in 1 % NaOH	13.8
Ash, %	0.2
Lignin, %	23.2
Holocellulose, %	69.5
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Alpha cellulose % 41.2

Pulping and papermaking characteristics

Unbleached

Process	Sulphate					
Chemical consumption, %	9.5 Na_2O		12.0 Na_2O		13.0 Na_2O	
Kappa number	88.5		32.2		20.5	
Yield (unscreened), %	61.0		54.1		49.4	
Screenings, % x	5.4		3.6		0.3	
Brightness						
Beater or refiner	PFI		PFI		PFI	
Freeness	250 CSF	335 CSF	245 CSF	365 CSF	280 CSF	420 CSF
Tensile index, N m/g	102	95	125	118	130	110
Burst index, kPa m^2/g	7.0	6.2	9.0	7.9	8.4	7.2
Tear index, mN m^2/g	11.3	11.1	11.1	10.8	9.9	11.2

Bleached

Sequence	CEHD
Chemical consumption, %	7.4 Cl_2
Yield on bleaching, %	
Total yield, %	47.0
Brightness	84
Beater or refiner	PFI
Freeness	285 CSF
Tensile index, N m/g	103
Burst index, kPa m^2/g	7.4
Tear index, mN m^2/g	10.2
	PFI
	465 CSF
	77
	5.0
	9.7

Additional information: x on o.d. screened pulp

Eucalyptus macarthurii

Plantation experience

No information available.

Wood characteristics

The basic density and the chemical composition do not differ from those of hardwoods normally used for pulping.

Pulping characteristics

Sulphate pulping gives pulp in somewhat lower yield than usual for hardwoods. However, the strength characteristics are representative of good quality eucalypt pulp.

Scientific name: Eucalyptus	Common name: Country: Argentina	Reference: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estación Experimental castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	442 - 444
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	0.2 - 2.0	1.3 - 3.6 (hot)
in 1 % NaOH	13.5 - 17.3	
Ash, %		
Lignin, %	19.4 - 23.0	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	17.0 NaoH	16.4 - 17.2 NaOH (charge)
Kappa number	20 - 23	22
Yield (unscreened), %	47.8 - 50.7	47.7 - 51.3
Screenings, %	1.1 - 2.3	2.0 - 3.5
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	104 - 127	
Burst index, kPa m^2/g	6.8 - 8.3	
Tear index, mN m^2/g	8.2 - 9.0	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness	69.1 - 71.9	83.4 - 84.1	86.7 - 87.4
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		102 - 113	103 - 126
Burst index, kPa m^2/g		7.1 - 7.8	6.7 - 8.2
Tear index, mN m^2/g		8.5 - 9.6	7.7 - 11.0

Additional information:

Eucalyptus maculata

Plantation experience

No information available.

Wood characteristics

The basic density is higher than normal for hardwoods used for pulping and the fibre length is below average. The fibres are thin but thick-walled which indicates a certain stiffness and consequently, a low bonding potential in paper. The lignin content is somewhat below average for hardwoods.

Pulping characteristics

The yield figures obtained in sulphate pulping are slightly below average for hardwoods. Although the tensile and burst indices are below average for eucalypt sulphate pulp, the tear index is instead relatively high.

Scientific name: Eucalyptus maculata	Common name: Country: Brazil	Reference: 29

Wood sample characteristics

Wood sample origin:

Sample from the plantations in "Estado de Minas Gerais" 7 years old

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	885
Fibre width, µm	17.2
Wall thickness, µm	4.5
Lumen width, µm	8.1
Length/width ratio	52
Runkel ratio	1.1
Flexibility ratio	0.47

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	2.1
in water	4.6 (hot)
in 1 % NaOH	19.9
Ash, %	0.48
Lignin, %	17.5
Holocellulose, %	
Cross-Bevan cellulose, %	58.8
Pentosans, %	24.7

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.5 Na_2O		
Kappa number			
Yield (unscreened), %	48.7		
Screenings, %	3.7		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	70	86	95
Burst index, kPa m^2/g	4.4	6.0	7.0
Tear index, mN m^2/g	12.2	13.9	12.5

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information:

Scientific name: Eucalyptus maculata	Common name: Country: Australia	Reference: 71

Wood sample characteristics

Wood sample origin:

35 years old, half cross section

Density and fibre characteristics:

Basic density, kg/m^3 662
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	14.0 - 17.0 Na_2O (charge)
Kappa number	12.0 - 14.7
Yield (unscreened), %	49.0 - 53.3
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	350 CSF
Tensile index, N m/g	70 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	10.5 (approx.)

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Eucalyptus maidenii

Plantation experience

The species is one of the most adaptable eucalyptus species. It has not, however, been much used in plantations on a commercial scale. Very good results have been obtained in Italy, Portugal and Zaire and satisfactory in Kenya, Malawi, Rhodesia and the Republic of South Africa. In general, the best results have been obtained at appropriate altitudes in countries with a tropical climate. For additional information and a list of references see the previous volume (21).

Wood characteristics

The basic density of the wood is in the normal range of hardwoods used for pulping. No data on the fibre characteristics have been published lately. The chemical characteristics do not indicate any difficulties in chemical pulping.

Pulping characteristics

With normal alkali charges in the sulphate pulp is obtained in low to average yields. The pulps are readily bleached and the strength properties of both the unbleached and bleached pulps are of average level or slightly below for eucalypt sulphate pulps.

Scientific name: Eucalyptus maidenii	Common name: Country: Argentina	Reference: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estación Experimental Castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	539 - 576
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	1.1 - 3.7	2.7 - 6.3 (hot)
in 1 % NaOH	13.5 - 20.7	
Ash, %		
Lignin, %	21.8 - 23.2	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	16.5 - 20 NaOH	14.3 - 21.5 NaOH (charge)
Kappa number	18 - 22.5	22
Yield (unscreened), %	46.5 - 52.6	45.7 - 54.5
Screenings, %	1.0	0.8 - 4.0
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	94 - 98	
Burst index, kPa m^2/g	5.9 - 6.0	
Tear index, mN m^2/g	7.6 - 10.2	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness	66.6 - 68.5	81.9 - 82.1	85.6 - 86.9
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		100 - 103	98 - 99
Burst index, kPa m^2/g		6.0 - 6.2	6.3 - 6.5
Tear index, mN m^2/g		7.4 - 10.5	8.5 - 10.6

Additional information:

Eucalyptus marginata

Plantation experience

This species is one of the three main species in the hardwood forest zone in Western Australia. It is the principal timber tree of the state, large, attaining a height of 30 - 40 m and a diameter of 1.8 m. It occurs in relatively pure stands with a small admixture of E. calophylla and E. patens on all but the poorest sandy soils. No results on plantation experience of the species have been reported.

References: 55

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. The fibre length is about the average for hardwoods. No other data on the fiber dimensions or chemical composition of the species are available.

Pulping characteristics

The yield of the pulp in the sulphate process is low. The Kappa number obtained is, however, relatively high and pulping to a Kappa number of 20 would cause additional decrease in the yield. The strength properties are comparable to the average quality of eucalypt pulps.

Application of the NSSC process gives pulp acceptable for corrugating medium but not for paper.

Poor strength and reddish brown colour of cold soda and groundwood pulps would rule against the use of either of these processes.

Scientific name:	Common name:	Reference:
Eucalyptus marginata	Country: Australia	55

Wood sample characteristics

Wood sample origin:

Samples from Pemberton and the Pimelia district
26 - 30 year old thinnings

Density and fibre characteristics:

Basic density, kg/m^3	581
Fibre length, µm x)	1 150
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	NSSC	NSSC
Chemical consumption, %	14.0 Na_2O (charge)	x	xx
Kappa number	34.0		
Yield (unscreened), %	45.2	68.9	67.7
Screenings, %			
Brightness			
Beater or refiner	Lampen	Lampen	
Freeness	305 CFS	418 CFS	341 CFS
Tensile index, N m/g	95	45	49
Burst index, kPa m^2/g	6.3	2.0	2.2
Tear index, mN m^2/g	10.6	5.4	4.9

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x 14 % Na_2SO_3 + 6 % $NaHCO_3$ (charge)
xx 18 % " " " "

Eucalyptus nitens

Plantation experience

No information available.

Wood characteristics

The basic density and chemical composition data are in the range normal for hardwoods used for pulping, whereas the fibre length is somewhat below average.

Pulping characteristics

The sulphate process gives pulp in slightly below average yield which is easily bleached to high brightness. The strength characteristics of the unbleached and bleached pulp correspond to average quality eucalypt sulphate pulp.

Scientific name:	Common name:	References:
Eucalyptus nitens	Country: New Zealand	34

Wood sample characteristics

Wood sample origin:

Sample from the Tokoroa district
6 years old
20 trees, mean height 13.4 m, mean diam. 171 mm (breast height)

Density and fibre characteristics:

Basic density, kg/m^3	406
Fibre length, µm x)	800
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.1
Solubility, %	
in water	2.2 (hot)
in 1 % NaOH	17.2
Ash, %	
Lignin, %	22.5
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	14.0 - 16.0 Na_2O (charge)
Kappa number	37.2 - 21.4
Yield (unscreened), %	52.4 - 49.7
Screenings, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Bleached

Sequence	D_CEHD	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness	90.4 - 91.6	
Beater or refiner	Lampen	
Freeness	350 CSF	322 CSF
Tensile index, N m/g	84	92
Burst index, kPa m^2/g	6.2	6.8
Tear index, mN m^2/g	9.9	9.7

Additional information:

Eucalyptus ovata

Plantation experience

Good results have been obtained in Algeria and the Republic of South Africa. The species is possibly useful in the wetter Mediterranean climatic zones where the winter is too cold for other species. It has proved to be very resistant to frost and summer drought. For further information see the previous volume (21).

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. No data on the fibre characteristics are available. The chemical characteristics do not indicate difficulties in chemical pulping.

Pulping characteristics

Sulphate pulping gives good to normal yields with relatively small alkali charges when pulped to a Kappa number of 20. The strength properties of both the unbleached and bleached pulps are about the average for eucalypt pulps.

Scientific name: Eucalyptus ovata	Common name: Country: Argentina	Reference: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estación Experimental Castelar del Ministerio de Agricultura".

Density and fibre characteristics:

Basic density, kg/m^3	584
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	0.3	1.9 (hot)
in 1 % NaOH	14.2	
Ash, %		
Lignin, %	22.7	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics			
Unbleached			
Process	Sulphate	Sulphate	
Chemical consumption, %	16.5 NaOH	14.3 NaOH (charge)	
Kappa number	16.5	22	
Yield (unscreened), %	52.6	54.2	
Screenings, %	0.9	6.7	
Brightness			
Beater or refiner	Valley		
Freeness	40 SR		
Tensile index, N m/g	95		
Burst index, kPa m^2/g	5.5		
Tear index, mN m^2/g	10		
Bleached			
Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness (Tappi)	70.2	82.9	87.9
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		93	102
Burst index, kPa m^2/g		5.9	6.2
Tear index, mN m^2/g		10	9.2
Additional information:			

Eucalyptus paniculata

Plantation experience

No information available

Wood characteristics

The basic density of the wood is higher than that of hardwood normally used for pulping and the fibre length somewhat shorter than average, although there probably is an increase in these characteristics with age. The fibre dimensions imply an undesirable stiffness which reduces the bonding potential in paper. The lignin content in the older sample is high for a hardwood.

Pulping characteristics

The sulphate process gives pulp in comparatively low yield, especially in view of the amount of screenings obtained. The strength characteristics correspond in general to those of a beech sulphate pulp, except for the tear index which is very good.

Scientific name: Eucalyptus paniculata	Common name: Country: Brazil	Reference: 29

Wood sample characteristics

Wood sample origin:

Sample from the plantations in "Estado de Minas Gerais" 6 and 10 years old

Density and fibre characteristics:

Basic density, kg/m^3	680 - 721
Fibre length, µm x)	871 - 938
Fibre width, µm	16.7 - 16.9
Wall thickness, µm	6.0 - 6.2
Lumen width, µm	4.6 - 4.7
Length/width ratio	52 - 55
Runkel ratio	2.6 - 2.7
Flexibility ratio	0.27 - 0.28

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	0.95 - 1.32
Solubility, %	
in water	4.3 - 5.5 (hot)
in 1 % NaOH	15.4 - 16.1
Ash, %	0.38 - 0.64
Lignin, %	17.8 - 26.5
Holocellulose, %	
Cross-Bevan cellulose, %	58.4 - 63.0
Pentosans, %	19.6 - 25.0

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.0 Na_2O (charge)		
Kappa number			
Yield (unscreened), %	47.1 - 51.7		
Screenings, %	2.1 - 2.9		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	66 - 72	77 - 80	82 - 85
Burst index, kPa m^2/g	3.8 - 4.1	5.1 - 5.3	5.7 - 6.0
Tear index, mN m^2/g	12.3 - 12.8	12.1 - 14.4	11.4 - 13.8

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information:

Eucalyptus regnans

Plantation experience

The species is adaptable to various parts of the world including countries of inter-tropical zones. The growth is very rapid in early life. Fairly good results have been obtained in New Zealand, the Republic of South Africa and Argentina. For further information and references see the previous volume (25).

References: 21, 43

Wood characteristics

The density of the wood is lower than in most eucalypt species, but still in the normal range of hardwoods used for pulping. The fibres are of average length for hardwoods. No data on other fibre dimensions are available at hand. The chemical characteristics do not reveal anything that could cause difficulty in chemical pulping.

Pulping characteristics

The species is readily pulped in the sulphate process. The yields obtained with normal alkali charges are high as commonly found in eucalypts used for pulping. The strength properties of the unbleached pulps are good and they are readily bleached to high brightness levels without substantial loss in the strength properties. Cooking with saturated SO_2-vapor gives pulps of high brightness and strength comparable to commercial hardwood acid sulphite pulps.

Refiner pulps of poor quality are obtained. Thermomechanical pulping (TMP) yields considerably better but still unsatisfactory results. Chemi-thermomechanical pulping (CTMP) gives pulps of reasonable quality. At yields of 85 - 90 % a satisfactory range of properties are obtained indicating that CTMP could be considered as a component of newsprint, printing and writing papers and possibly other grades (39). The results on chemi-mechanical (cold soda) pulping have been characterized as reasonable.

Scientific name: Eucalyptus regnans	Common name: Country: New Zealand	Reference: 34

Wood sample characteristics

Wood sample origin:

Sample from the Tokoroa district
14 years old
10 trees, mean height 28.2 m, mean diam. 287 (breast height)

Density and fibre characteristics:

Basic density, kg/m^3	393
Fibre length, µm x)	1 000
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.0
Solubility, %	
in water	1.2 (hot)
in 1 % NaOH	12.8
Ash, %	
Lignin, %	21.3
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	
Chemical consumption, %	16.0 - 20.0 Na_2O (charge)	
Kappa number	13.6 - 23.9	
Yield (unscreened), %	53.4 - 53.8	
Screenings, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Bleached

Sequence	$D_C EHD$	
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness	91.2 - 92.7	
Beater or refiner	Lampen	
Freeness	350 CSF	420 CSF
Tensile index, N m/g	122	112
Burst index, kPa m^2/g	8.7	7.8
Tear index, mN m^2/g	9.1	9.7

Additional information:

Scientific name: Eucalyptus regnans	Common name: Country: Australia	References: 36

Wood sample characteristics

Wood sample origin:

12 years old

Density and fibre characteristics:

Basic density, kg/m^3	426
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Cold Soda		TMP		CTMP
Chemical consumption, %	4 NaOH	8 NaOH			x
Kappa number					
Yield (unscreened), %	92.8				83.4 - 86.2
Screenings, %					
Brightness		52.2	27.4	36.2	48.7 - 48.8
Beater or refiner	Bauer		PFI		
Freeness	109 - 309 CSF	294 CSF	543 CSF	358 CSF	176 - 250 CSF
Tensile index, N m/g	13 - 22	42	16	14	30 - 64
Burst index, kPa m^2/g	0.26 - 0.71	1.7	0.39	0.17	
Tear index, mN m^2/g	2.3 - 2.8	4.8	1.9	1.6	5.2 - 5.5

Bleached

Sequence	P
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	71.2 - 71.7
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Solution containing 1.6% NaOH and 1.25% Na_2SO_3
Liquor: wood ratio 5:1

Scientific name: Eucalyptus regnans	Common name: Country: Australia	Reference: 42

Wood sample characteristics

Wood sample origin:

Mt Hooglily, Victoria
27 years old, a single tree sample

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	SO_2 (vapor phase)			
Chemical consumption, % x			a)	b)
Kappa number	64	136	107	104
Yield (unscreened), %	62.5	79.9	78.4	79.6
Screenings, %				
Brightness (Elrepho)				
Beater or refiner	PFI	PFI	PFI	PFI
Freeness	350 CSF	350 CSF	350 CSF	350 CSF
Tensile index, N m/g	40	25	39	45
Burst index, kPa m^2/g	1.4	1.2	2.2	1.6
Tear index, mN m^2/g	4.5	2.7	3.1	3.4

Bleached

Sequence				
Chemical consumption, %				
Yield on bleaching, %				
Total yield, %				
Brightness				
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m^2/g				
Tear index, mN m^2/g				

Additional information:

x S consumption at 55% yield 32 kg S/tonne o.d. pulp produced

a) Chips impregnated with NH_4HSO_3 51.8% on o.d. wood

b) " " " Na_2SO_3 26.1% " " "

Scientific name: Eucalyptus regnans	Common name: Country: Argentina	Reference: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estacion Experimental Castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	490
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	0.9	1.9 (hot)
in 1 % NaOH	14.3	
Ash, %		
Lignin, %	20.3	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	17.0 NaOH	15.5 NaOH (charge)
Kappa number	16.5	22
Yield (unscreened), %	54.1	55.8
Screenings, %	1.0	5.8
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	136	
Burst index, kPa m^2/g	9.0	
Tear index, mN m^2/g	9.0	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness (Tappi)	78.0	87.1	89.9
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		130	122
Burst index, kPa m^2/g		8.4	8.7
Tear index, mN m^2/g		8.6	9.4

Additional information:

Eucalyptus robusta
(Swamp Mahogany)

Plantation experience

The species is very widespread throughout the world. Good results have been obtained in Brazil, Chile, India, Madagascar, Malawi, Malaysia, Mauritius and Zaire. It has been planted also in Cyprus, Florida, Italy, North Africa, Portugal and Spain. In general, the species grows well on deep, moist soils and shows fairly good adaptability to subtropical land and to intertropical high altitude zones. For additional information and a list of references see the previous volume (21).

References: 22

Wood characteristics

The basic density is in the range normal for hardwoods used for pulping. The fibres are of average length for hardwoods, wide and thin-walled, which implies a certain amount of flexibility and thus potential for good inter-fibre bonding in paper.

Pulping characteristics

The species has been pulped in the sulphate process with relatively low alkali charges to the normal Kappa number levels for hardwoods. The yields obtained are slightly below the average for hardwoods. The strength properties of the pulps range from average to good for eucalypt pulps.

NSSC pulping gives high yields with acceptable strength properties of the pulps obtained.

Scientific name: Eucalyptus robusta	Common name: Country: Brazil	Reference: 10

Wood sample characteristics

Wood sample origin:

Sample from Mogi das Cruzes - Sao Paulo
6.5 years old

Density and fibre characteristics:

Basic density, kg/m^3	452
Fibre length, µm x)	1 070
Fibre width, µm	19.0
Wall thickness, µm	3.4
Lumen width, µm	12.1
Length/width ratio	56
Runkel ratio	0.561
Flexibility ratio	0.64

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	11.5 - 14.5 Na_2O (charge)		
Kappa number x	26.7 - 14.8		
Yield (unscreened), %	50.2 - 48.2		
Screenings, %	8.1 - 2.7		
Brightness			
Beater or refiner	Jokro		
Freeness	15 SR	30 SR	50 SR
Tensile index, N m/g	10 - 40	73 - 120	90 - 136
Burst index, kPa m^2/g	1.0 - 1.5	6.1 - 7.0	7.6 - 8.0
Tear index, mN m^2/g	6.5 - 7.0	12.0 - 13.5	11.7 - 12.2

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information: x Permanganate Number

Scientific name: Eucalyptus robusta	Common name: Country: U.S.A.	Reference: 30

Wood sample characteristics

Wood sample origin:

Florida
10 years old (approximately)

Density and fibre characteristics:

Basic density, kg/m^3 449
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	NSSC	Sulphate[x]
Chemical consumption, %		13
Kappa number ml	37	48
Yield (unscreened), %	74 (screened)	
Screenings, %		
Brightness		
Beater or refiner		
Freeness	400 CSF	
Tensile index, N m/g	65	
Burst index, kPa m^2/g	3.6	
Tear index, mN m^2/g		
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		86
Beater or refiner		
Freeness		300 CSF
Tensile index, N m/g		5.9
Burst index, kPa m^2/g		8.5
Tear index, mN m^2/g		
Additional information:	x Mill trial	

Eucalyptus saligna

Plantation experience

Remarkable results have been achieved in more or less tropical areas, in Brazil and in the Republic of South Africa. Very encouraging results have been obtained in Argentina, Chile, Rhodesia, Nigeria, Malawi, Sri Lanka and Kenya. Plantations exist also in Congo, Zaire, Spain and Italy. The species is not very resistant to frost and several failures have been recorded with trials of this species in low-lying equatorial zones. For detailed information and a list of references see the previous volume (21).

Wood characteristics:

The density of the wood is in the range normal for hardwoods used for pulping and the wood can easily be debarked. There is considerable influence of provenance on the dimensions of the fibres. In general, the fibres are of average length, maybe slightly on the wide side and fairly thin-walled with flexibility ratios up to 0.68. This implies potentially good inter-fibre bonding in paper. The lignin content also varies considerably depending on the origin of the sample (from low to high compared with the average of hardwoods). The amount of extractives is high in some samples and may cause difficulties in pulping.

Pulping characteristics

The variations in fibre and chemical characteristics reflect also on the pulping results. The yield in sulphate pulping is about 50 percent and the strength properties vary from below average to good for eucalypt pulps.

The results obtained on Mg-bisulphite pulping indicate that the species can be considered a good raw material for the process in proper conditions. The quality of the cold soda pulps are good in respect of the high yields and low alkali charges used. The yields of thermomechanical pulps are high and quality comparable to the cold soda pulps obtained with very low alkali charges. The application of peroxide bleaching increases the brightness substantially, but no results are given on other properties of the bleached pulps.

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	Reference: 2

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached				
Process	Cold soda	Cold soda	TMP	TMP
Chemical consumption, %	2.7 Na_2O	0.9 Na_2O	0.7 Na_2O	-
Kappa number				
Yield (unscreened), %	90	93	94	96
Screenings, %				
Brightness	43	47	49.5	47.5
Beater or refiner				
Freeness	60 CSF	60 CSF	60 CSF	60 CSF
Tensile index, N m/g	41	23	25	20
Burst index, kPa m^2/g				
Tear index, mN m^2/g	4.0	2.3	3.1	2.1
Bleached				
Sequence	P	P	P	P
Chemical consumption, %	1.5 H_2O_2	1.5 H_2O_2	1.5 H_2O_2	1.5 H_2O_2
Yield on bleaching, %				
Total yield, %				
Brightness	62	69	63	62
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m^2/g				
Tear index, mN m^2/g				

Additional information:

Scientific name: Eucalyptus saligna	Common name:	Reference: 7
	Country: Brazil	

Wood sample characteristics

Wood sample origin:

Sample from the area of Mogi Guacu, Estado de Sao Paulo
5 years old

Density and fibre characteristics:

Basic density, kg/m^3	490 (434 - 588)
Fibre length, µm x)	1 130 (770 - 1 710)
Fibre width, µm	17.8 (15.0 - 25.0)
Wall thickness, µm	3.75 (2.5 - 6.25)
Lumen width, µm	
Length/width ratio	63
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether	0.4	
Methanol		
Ethanol-benzene	3.2	
Solubility, %		
in water	3.6	4.2 (hot)
in 1 % NaOH	18.0	
Ash, %	0.3	
Lignin, %	23.0	
Holocellulose, %		
Cross-Bevan cellulose, %	50.2	
Pentosans, %	17.8	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Bisulphite (Mg)		
Chemical consumption, %	4.0 - 6.0 SO_2 (charge)		
Kappa number	32.8 - 103.0		
Yield (unscreened), %	47.3 - 67.4		
Screenings, %	0.1 - 10.1		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	42 - 73	41 - 75	38 - 69
Burst index, kPa m^2/g	2.1 - 4.0	2.1 - 4.3	1.8 - 3.9
Tear index, mN m^2/g	6.0 - 9.1	5.4 - 9.0	4.8 - 8.1

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	Reference: 8

Wood sample characteristics

Wood sample origin:

4 - 20 years old

Density and fibre characteristics:

Basic density, kg/m^3	400 - 610
Fibre length, µm x)	760 - 1 130
Fibre width, µm	14.9 - 20.0
Wall thickness, µm	3.1 - 5.2
Lumen width, µm	5.4 - 12.9
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether Methanol Ethanol-benzene	1.6 - 4.0
Solubility, %	
in water in 1 % NaOH	1.6 - 7.4 (hot)
Ash, %	0.2 - 0.4
Lignin, %	18.7 - 28.4
Holocellulose, %	
Cross-Bevan cellulose, %	45.8 - 61.5
Pentosans, %	16.5 - 18.9

Additional information:

Pulping and papermaking characteristics

Unbleached		
Process	Sulphate	Bisulphite (Mg)
Chemical consumption, %		
Kappa number		31.0 - 101.1
Yield (unscreened), %	41.2 - 55.3	48.6 - 57.9
Screenings, %		
Brightness		
Beater or refiner		
Freeness	36 - 45 SR	45 SR
Tensile index, N m/g	58 - 122	41 - 75
Burst index, kPa m^2/g	5.3 - 8.2	2.1 - 4.3
Tear index, mN m^2/g	8.6 - 13.3	5.4 - 9.0
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information:

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	References: 10

Wood sample characteristics

Wood sample origin:

Sample from Mogi Guacu - Sao Paulo
5 years old

Density and fibre characteristics:

Basic density, kg/m^3	495
Fibre length, µm x)	1 010
Fibre width, µm	19.1
Wall thickness, µm	3.1
Lumen width, µm	12.9
Length/width ratio	53
Runkel ratio	0.481
Flexibility ratio	0.68

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.4
Solubility, %	
in water	3.0 (hot)
in 1 % NaOH	13.1
Ash, %	
Lignin, %	26.3
Holocellulose, %	
Cross-Bevan cellulose, %	54.1
Pentosans, %	17.8

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.0 Na_2O (charge)		
Kappa number	20.5		
Yield (unscreened), %	50.2		
Screenings, %	1.1		
Brightness			
Beater or refiner	Jokro		
Freeness	25 SR	40 SR	70 SR
Tensile index, N m/g	83	97	107
Burst index, kPa m^2/g	5.1	6.6	7.4
Tear index, mN m^2/g	11.6	12.5	12.7

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	Reference: 27

Wood sample characteristics

Wood sample origin:

Sample from the area of Mogi Guacu in the state of Sao Paulo
8 years old

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate x			Sulphate		
Chemical consumption, %	9.0 Na_2O (charge)			12.5 Na_2O (charge)		
Kappa number	20 - 60			30		
Yield (unscreened), %	47.5 - 50.9			50.0		
Screenings, %	0.5 - 5.3			3.4		
Brightness						
Beater or refiner	Jokro					
Freeness	30 SR	40 SR	50 SR	30 SR	40 SR	50 SR
Tensile index, N m/g	68 - 78	73 - 87	83 - 93	83	94	102
Burst index, kPa m^2/g	4.0 - 4.5	4.8 - 5.7	5.5 - 6.4	5.9	7.4	8.2
Tear index, mN m^2/g	10.7 - 13.4	11.5 - 12.0	12.0 - 12.1	14.0	12.2	12.0

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x Rapid alkaline pulping (Kleinert)

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	Reference: 29

Wood sample characteristics

Wood sample origin:

Sample from "Champion Papel e Cellulose S.A., Mogi Guacu
8 and 13 years old

Density and fibre characteristics:

Basic density, kg/m^3	530 - 610
Fibre length, µm x)	759 - 945
Fibre width, µm	15.8 - 18.4
Wall thickness, µm	4.6 - 5.2
Lumen width, µm	6.6 - 8.0
Length/width ratio	48 - 51
Runkel ratio	1.3 - 1.4
Flexibility ratio	0.42 - 0.43

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.6 - 1.7
Solubility, %	
in water	4.7 - 7.4 (hot)
in 1 % NaOH	17.8 - 20.8
Ash, %	0.2 - 0.3
Lignin, %	18.7 - 21.6
Holocellulose, %	
Cross-Bevan cellulose, %	57.4 - 61.5
Pentosans, %	16.9 - 18.8

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, %	13.0 - 14.0 Na_2O (charge)		
Kappa number	23		
Yield (unscreened), %	46.5 - 50.3		
Screenings, %	1.9 - 3.7		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	88	101	103
Burst index, kPa m^2/g	4.9	6.6	7.3
Tear index, mN m^2/g	12.8	13.3	12.5

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Eucalyptus saligna	Common name: Country: Brasil	Reference: 32

Wood sample characteristics

Wood sample origin:

Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais state

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	900
Fibre width, µm	19.8
Wall thickness, µm	4.3
Lumen width, µm	11.1
Length/width ratio	
Runkel ratio	0.78
Flexibility ratio	0.56

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate
Chemical consumption, %	25 Na_2O (charge)
Kappa number	18.5
Yield (unscreened), %	43.1
Screenings, %	0.03
Brightness	
Beater or refiner	
Freeness	350 CSF
Tensile index, N m/g	134
Burst index, kPa m^2/g	6.8
Tear index, mN m^2/g	11.1
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Scientific name: Eucalyptus saligna	Common name: Country: Argentina	References: 43

Wood sample characteristics

Wood sample origin:

Sample from "la Estacion Experimental Castelar del Ministerio de Agricultura"

Density and fibre characteristics:

Basic density, kg/m^3	369 - 474
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene		
Solubility, %		
in water	0.5 - 1.3	2.2 - 2.8 (hot
in 1 % NaOH	15.0 - 15.2	
Ash, %		
Lignin, %	25.9 - 29.5	
Holocellulose, %		
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	17.5 - 18.0 NaOH	16.5 - 17.5 NaOH (charge)
Kappa number	20.0 - 21.0	22
Yield (unscreened), %	50.5 - 51.0	50.7 - 52.0
Screenings, %	0.7 - 0.9	1.2 - 1.9
Brightness		
Beater or refiner	Valley	
Freeness	40 SR	
Tensile index, N m/g	102 - 134	
Burst index, kPa m^2/g	6.3 - 8.8	
Tear index, mN m^2/g	8.3 - 9.1	

Bleached

Sequence	CEH	CEHEH	CEHED
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness (Tappi)	70.6	82.9	86.5
Beater or refiner	Valley		
Freeness		40 SR	40 SR
Tensile index, N m/g		112	113
Burst index, kPa m^2/g		8.9	8.5
Tear index, mN m^2/g		7.9	9.5

Additional information:

Eucalyptus sieberi

Plantation experience

This is one of the main species available in New South Wales, Australia. Regeneration after fire in some areas has given rise to extensive stands of small trees. No reports on cultivation of the species are available.

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. No other wood data are available for the present sample.

Pulping characteristics

The pulp yield in the sulphate process is fairly good in view of the low Kappa number of the pulps obtained. The strength properties of the pulps do not seem to be below average although there is some variation in the results. In general, it seems that it is not necessary to remove the smooth inner bark of the logs to obtain satisfactory pulp. The bleachability of the pulp from unbarked logs is not significantly inferior to pulp made from debarked wood.

Scientific name: Eucalyptus sieberi	Common name: Country: Australia	References: 71

Wood sample characteristics

Wood sample origin:

a) 25 years old

b) composite sample of different ages

Density and fibre characteristics:

Basic density, kg/m^3 a) 555
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
Ether
Methanol
Ethanol-benzene

Solubility, %
in water
in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached	a)	b) Unbarked	Debarked
Process	Sulphate	Sulphate	Sulphate
Chemical consumption, % [x]	14 - 17 Na_2O	14.0 Na_2O	14.0 Na_2O
Kappa number	10.1 - 13.4	20.7	15.7
Yield (unscreened), %	50.1 - 51.4	48.9	50.6
Screenings, %			
Brightness			
Beater or refiner	PFI	PFI	PFI
Freeness	350 CSF	319 CSF	122 CSF	335 CSF	125 CSF
Tensile index, N m/g	105 (approx.)	57	87	69	93
Burst index, kPa m^2/g		3.1	5.4	3.7	5.6
Tear index, mN m^2/g	13 (approx.)	9.3	11.3	9.4	10.8
Bleached					
Sequence		CEHD		CEHD	
Chemical consumption, %					
Yield on bleaching, %					
Total yield, %		42.3		46.2	
Brightness (Elrepho)		84.3	83.4	84.7	
Beater or refiner		PFI		PFI	
Freeness		338 CSF	242 CSF	360 CSF	
Tensile index, N m/g		57	70	64	
Burst index, kPa m^2/g		3.4	4.3	3.9	
Tear index, mN m^2/g		9.1	9.0	9.4	

Additional information: x charge

Eucalyptus tereticornis

Plantation experience

Good results of this species have been obtained on a small scale in Indonesia and Zaire. It has successfully been raised in India and shown to be adaptable in Florida. The results in Brazil have been less successful. As an exotic it has been introduces in Italy, Spain, Portugal, Cyprus and North Africa. It has exhibited inferior growth in semi-arid zones and low resistance to drought. It cannot be acclimatized at low altitudes.

References: 21, 22, 29, 30

Wood characteristics

The wood of the present samples is of medium density for hardwoods although densities of 850 - 1 050 kg/m^3 have been reported in samples from natural stands in Australia and a density of about 650 kg/m^3 is considered normal for the species in India. The fibres are of average length, fairly thin and of normal wall thickness for hardwoods, which implies a good opacity in pulps made from the species. The chemical characteristics do not reveal anything that would cause diffioulties in chemical pulping. On the other hand, the wood has proved to be difficult to debark.

Pulping characteristics

Sulphate pulping requires relatively low alkali charges and gives low pulp yields compared to average hardwoods. The strength properties, especially the tear index, are good for both unbleached and bleached pulps. The opacity and brightness of the pulps are good. On the other hand, the costs of bleaching are somewhat higher than average. The yield of dissolving pulp is low, both the brightness and the a-cellulose level are comparable to those of average hardwoods. NSSC pulping gives high yields and pulps of acceptable quality. Please note that these findings refer only to the present samples of a density lower than normal for the species in general. Higher density species have in general exhibited lower strength values.

Scientific name: Eucalyptus tereticornis	Common name: Country: Brazil	Reference: 29

Wood sample characteristics

Wood sample origin:

Sample from the plantations in "Estado de Minas Gerais"
7 years old

Density and fibre characteristics:

Basic density, kg/m^3	512
Fibre length, µm x)	828
Fibre width, µm	14.8
Wall thickness, µm	4.2
Lumen width, µm	6.3
Length/width ratio	56
Runkel ratio	1.33
Flexibility ratio	0.43

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	0.56
Solubility, %	
in water	5.1 (hot)
in 1 % NaOH	17.2
Ash, %	0.30
Lignin, %	22.8
Holocellulose, %	
Cross-Bevan cellulose, %	60.2
Pentosans, %	19.3

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate		
Chemical consumption, % x	13.0 Na_2O		
Kappa number			
Yield (unscreened), %	46.2		
Screenings, %	2.1		
Brightness			
Beater or refiner	Jokro		
Freeness	30 SR	45 SR	60 SR
Tensile index, N m/g	77	88	98
Burst index, kPa m^2/g	5.1	6.4	7.3
Tear index, mN m^2/g	14.0	13.2	13.4

Bleached

Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information: x charge to Permanganate number 16.0 ± 1.0

Scientific name: Eucalyptus tereticornis	Common name: Country: U.S.A.	Reference: 30

Wood sample characteristics

Wood sample origin:

Florida
10 years old (approximately)

Density and fibre characteristics:

Basic density, kg/m^3 a) 577 b) 497 c) 497 - 545
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

	a)	b)	c)
Unbleached			
Process	NSSC	Sulphate	Sulphate
Chemical consumption, %			
Kappa number	38	9 x	12 - 20
Yield (unscreened), %	75 (screened)	32 (screened)	36 - 43
Screenings, %			
Brightness			
Beater or refiner			
Freeness	400 CSF		
Tensile index, N m/g	65		
Burst index, kPa m^2/g	3.6		
Tear index, mN m^2/g			
Bleached			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness		92	92 - 93
Beater or refiner			
Freeness			300 CSF
Tensile index, N m/g			
Burst index, kPa m^2/g			7.4 - 7.6
Tear index, mN m^2/g			13.0

Additional information:
x Tappi 40 ml
b) Dissolving pulp commercial
c) commercial bleached grade kraft pulp

Eucalyptus tessellaris

Plantation experience

No information available.

Wood characteristics

The basic density is in the range normal for hardwoods used for pulping and the fibre length somewhat below average. However, the latter may be due to the sample being from a tree only four years old. There would probably be an improvement in the other fibre dimensions with age as well, but taking the values as such, there would seem to be an undesirable stiffness in the fibres. The lignin content is somewhat high for a hardwood.

Pulping characteristics

The yield on sulphate pulping is below average for hardwoods. The quality of the pulp, both unbleached and bleached is below average for eucalypt pulp and resembles beech pulp. However, note that the sample is very young and the results should be seen in the light of this fact.

Scientific name: Eucalyptus tessellaris	Common name: Country: Brazil	Reference: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	560
Fibre length, µm x)	850
Fibre width, µm	16.2
Wall thickness, µm	5.0
Lumen width, µm	6.1
Length/width ratio	52
Runkel ratio	1.64
Flexibility ratio	0.38

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.1
Solubility, %	
in water	5.2 (hot)
in 1 % NaOH	17.2
Ash, %	0.6
Lignin, %	24.1
Holocellulose, %	
Cross-Bevan cellulose, %	49.6
Pentosans, %	20.6

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O (charge)			13.0 Na_2O (charge)		
Kappa number	17			23		
Yield (unscreened), %	46.1			47.5		
Screenings, %	0.1			0.5		
Brightness x	40.2			33.3		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	78	88	93	73	85	92
Burst index, kPa m^2/g	4.8	5.6	6.0	4.6	5.8	6.4
Tear index, mN m^2/g	8.6	9.0	8.4	11.3	10.2	9.6

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %						
Yield on bleaching, %	94.0			89.3		
Total yield, %	43.2			42.0		
Brightness x	86.6			89.3		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	61	66	69	60	64	66
Burst index, kPa m^2/g	3.2	3.6	3.8	3.3	3.9	4.1
Tear index, mN m^2/g	8.0	7.6	7.4	9.4	9.8	9.0

Additional information: x ABCP P16/73

Eucalyptus torelliana

Plantation experience

The species is native to N. Queensland, Australia and is exceptional in growing within the margin of tropical rainforests. Trial plantations have been established in Argentina, Brasil, Nigeria, Nyasaland, Sudan, Congo, Cyprus, India, Malaysia, Australia, Solomon Islands and Hawaii.

References: 22

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. It should be noted that the sample is taken for very young trees and consequently it can be expected that the fibre dimensions would be different in more mature trees. However, the sample as such contains comparatively short fibres with a certain amount of stiffness which would affect the potential bonding in paper. The chemical composition does not imply any difficulty on chemical pulping.

Pulping characteristics

The yield of pulp in the sulphate process is slightly under average for hardwoods. The strength characteristics of the pulp correspond to average quality eucalypt sulphate pulp.

Scientific name: Eucalyptus torelliana	Common name: Country: Brasil	References: 9

Wood sample characteristics

Wood sample origin:

Sample from the plantations in the region of Linhares
4 years old (average)

Density and fibre characteristics:

Basic density, kg/m^3	465
Fibre length, µm x)	810
Fibre width, µm	17.2
Wall thickness, µm	4.7
Lumen width, µm	7.8
Length/width ratio	47
Runkel ratio	1.21
Flexibility ratio	0.45

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.0
Solubility, %	
in water	2.9 (hot)
in 1 % NaOH	18.5
Ash, %	1.0
Lignin, %	22.0
Holocellulose, %	
Cross-Bevan cellulose, %	52.9
Pentosans, %	23.0

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			Sulphate		
Chemical consumption, %	14.0 Na_2O			13.0 Na_2O		
Kappa number	17			23		
Yield (unscreened), %	51.5			50.5		
Screenings, %	0.1			0.4		
Brightness x	33.8			28.8		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	85	101	109	80	83	94
Burst index, kPa m^2/g	5.4	6.5	7.1	5.1	6.0	6.4
Tear index, mN m^2/g	8.7	8.2	8.0	8.6	8.8	9.0

Bleached

Sequence	CEHDED			CEHDED		
Chemical consumption, %						
Yield on bleaching, %	95.0			91.5		
Total yield, %	48.8			45.8		
Brightness x	87.5			90.0		
Beater or refiner	Jokro					
Freeness	30 SR	45 SR	60 SR	30 SR	45 SR	60 SR
Tensile index, N m/g	75	82	86	75	79	81
Burst index, kPa m^2/g	4.0	4.7	5.0	5.4	5.5	5.6
Tear index, mN m^2/g	8.5	9.0	8.6	8.4	8.1	8.0

Additional information: x ABCP P16/73

Eucalyptus viminalis

Plantation experience

Remarkable growth rates have been obtained in the Mediterranean area, especially in Portugal. Encouraging results have also been obtained in California, Brazil, Chile, the Republic of South Africa and at high altitudes in India, Tanzania and Zaire. The species is fairly frost-hardy and mostly utilized in the cooler temperature subhumid sector of the summer rainfall zone. For additional information and references see the previous volume (21).

References: 10, 21

Wood characteristics

The basic density is in the normal range of hardwoods used for pulping. The fibre length is about the average for hardwoods. The fibres are of intermediate length, comparatively thin and thin-walled. A certain amount of flexibility and thus good inter-fibre bonding in paper is to be expected. Chemical data do not imply any difficulties in chemical pulping.

Pulping characteristics

Sulphate pulps with yields somewhat lower than average are obtained with relatively low alkali charges. The strength properties are about the average for eucalypt sulphate pulps. It has also been reported that after removal of leaves and twigs during the harvesting operation, the remainder material above ground is suitable for pulp and paper or fibreboard production.

Scientific name: Eucalyptus viminalis	Common name: Country: Brazil	Reference: 10

Wood sample characteristics

Wood sample origin:

Sample from Tres Barras - sc.
11 years old

Density and fibre characteristics:

Basic density, kg/m^3	512
Fibre length, µm x)	1 130
Fibre width, µm	16.8
Wall thickness, µm	3.4
Lumen width, µm	10.1
Length/width ratio	67
Runkel ratio	0.673
Flexibility ratio	0.60

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.6
Solubility, %	
in water	3.8 (hot)
in 1 % NaOH	12.2
Ash, %	
Lignin, %	23.2
Holocellulose, %	
Cross-Bevan cellulose, %	52.4
Pentosans, %	17.3

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate			
Chemical consumption, %	12 - 16 Na_2O (charge)			
Kappa number x	16.1 - 10.6			
Yield (unscreened), %	50.4 - 46.5			
Screenings, %	1.0 - 0.2			
Brightness				
Beater or refiner	Jokro			
Freeness	15	30 - 33 SR	44 - 48 SR	70 - 78 SR
Tensile index, N m/g	32 - 36	77 - 87	84 - 97	83 - 109
Burst index, kPa m^2/g	1.2 - 1.5	5.0 - 6.8	4.3 - 7.6	5.1 - 7.8
Tear index, mN m^2/g	5.8 - 6.8	10.2 - 11.4	10.9 - 12.4	10.2 - 11.2

Bleached

Sequence				
Chemical consumption, %				
Yield on bleaching, %				
Total yield, %				
Brightness				
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m^2/g				
Tear index, mN m^2/g				

Additional information: x Permanganate Number

Gmelina arborea
(Yemane)

Plantation experience

The species is widely cultivated in areas such as South America, Africa and South-East Asia. The tree grows on various soils but seems to thrive best in valleys on moist fertile alluvium with good drainage. The samples referred to here are from Belize, Nigeria, Papua New Guinea and the Philippines. For example, the growth in Belize was 35 $m^3/ha \cdot a$ at a rotation of 8 years.

References: 21, 48

Wood characteristics

The wood density exhibits great variation from below average to average for hardwood for pulping. The lignin content of the samples vary from high to very high, and the fibres are short or very short. The fibres are comparatively broad, and in certain cases the fibre wall is extremely thick.

Pulping characteristics

The wood is easily pulped by the sulphate process to low Kappa numbers, to high or very high yields. The tear index of the pulp is of medium class, except for those trees that provide very thick walled fibres. The bleaching response is quite good, but the pulp strength may be sensitive to the bleaching process. The wood species is more suitable for TMP and CTMP than for FMP, but the pulp brightness is relatively low. It should be noted that it is used for chemical pulping in Brazil and plans exist for its use for pulping in Nigeria.

Scientific name: Gmelina arborea	Common name:	Reference: 6
	Country: Africa - no further information available	

Wood sample characteristics

Wood sample origin:

38 logs, average diameter 140 mm
Approximate age 10 a

Density and fibre characteristics:

Basic density, kg/m^3	430
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	0.7 - 0.9
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached			
Process	RMP	TMP	CTMP
Chemical consumption, %			
Kappa number			
Yield (unscreened), %			
Screenings, %			
Brightness	52.3	51.5	43.0
Beater or refiner			
Freeness	103	124	156
Tensile index, N m/g	13	20	32
Burst index, kPa m^2/g	0.4	0.7	1.5
Tear index, mN m^2/g	1.6	3.1	4.8
Bleached			
Sequence	hydrosulfite	hydrosulfite	peroxide
Chemical consumption, %	2	1	1.7
Yield on bleaching, %			
Total yield, %			
Brightness	61.9	59.6	58.4
Beater or refiner			
Freeness	119	147	264
Tensile index, N m/g	13	16	27
Burst index, kPa m^2/g	0.4	-	1.0
Tear index, mN m^2/g	1.9	2.2	3.7
Additional information:			

Scientific name: Gmelina arborea Roxb.	Common name: Yemane Country: Philippines	Reference: 20

Wood sample characteristics

Wood sample origin:

Samples from forest plantation of the Paper Industry Corporation of the Philippines in Surigao, Mindanao

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	980
Fibre width, µm	30
Wall thickness, µm	5
Lumen width, µm	20
Length/width ratio	33
Runkel ratio	0.50
Flexibility ratio	0.67

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

	(Cook 223)	(Cook 4)
Unbleached		
Process	Sulphate (170°C, sulfidity 15%)	Sulphate (170°C, sulfidity 25.5%)
Chemical consumption, %	83.1 based on chem. charged	95.6
Kappa number	11.4	10.4
Yield (unscreened), %	55.7	55.8
Screenings, %	0.1	0.1
Brightness		
Beater or refiner	Valley	Valley
Freeness	400	400
Tensile index, N m/g	97	120
Burst index, kPa m^2/g	5.85	7.0
Tear index, mN m^2/g	6.2	5.5
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information:

Scientific name: Gmelina arborea Roxb.	Common name: Country: Belize	Reference: 48

Wood sample characteristics

Wood sample origin:

From plantation at Silkgrass
Age 8 a
Five trees sampled: diameter 258 mm
Growth 35 m^3/ha.a

Density and fibre characteristics:

Basic density, kg/m^3	391
Fibre length, µm x)	850
Fibre width, µm	26
Wall thickness, µm	2.8
Lumen width, µm	20
Length/width ratio	33
Runkel ratio	0.28
Flexibility ratio	0.77

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.9
Solubility, %	
in water	
in 1 % NaOH	13.6
Ash, %	0.7
Lignin, %	24.7
Holocellulose, %	67.9
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	13.7 act. alkali as Na_2O
Kappa number	24.7
Yield (unscreened), %	50.2
Screenings, %	0.0
Brightness	
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	82
Burst index, kPa m^2/g	5.6
Tear index, mN m^2/g	10.0
Bleached	
Sequence	CEHD
Chemical consumption, %	8.9 as Cl
Yield on bleaching, %	
Total yield, %	47.4
Brightness	86
Beater or refiner	PFI
Freeness	515
Tensile index, N m/g	66.8
Burst index, kPa m^2/g	4.1
Tear index, mN m^2/g	8.1
Additional information:	

Scientific name: Gmelina arborea	Common name: Country: Papua New Guinea	Reference: 56

Wood sample characteristics

Wood sample origin:

Sample from the plantation at Brown River Forest Station, Port Moresby
5 years old, one dominant tree (butt, middle and top logs)

Density and fibre characteristics:

Basic density, kg/m^3	346
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	13.0 Na_2O (charge)
Kappa number	18.6
Yield (unscreened), %	52.8
Screenings, %	0.7
Brightness	
Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	105 (approx.)
Burst index, kPa m^2/g	
Tear index, mN m^2/g	11 (approx.)

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Gmelina arborea Roxb.	Common name: Country: Nigeria	References: 62 - 65

Wood sample characteristics

Wood sample origin:

Samples collected at Ifara Plantation Farm
Age 8 a, diameter 240 mm

Density and fibre characteristics:

Basic density, kg/m^3	550
Fibre length, µm x)	760
Fibre width, µm	30
Wall thickness, µm	3.5
Lumen width, µm	23
Length/width ratio	28
Runkel ratio	0.31
Flexibility ratio	0.77

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether	2.8	
Methanol	4.2	
Ethanol-benzene (1:2)	4.0	
Solubility, %		
in water	3.1	(cold) 5.2 (hot)
in 1 % NaOH	15.3	
Ash, %	0.9	
Lignin, %	29.7	
Holocellulose, %	79.6	
Cross-Bevan cellulose, %		
Pentosans, %	14.0	

Additional information:

Pulping and papermaking characteristics

Unbleached	(165°C/120°C, 0.8 MPa)	(150°C, 0.5 MPa)	(170°C)
Process	Soda-oxygen (pulp II)	H_2S-kraft (pulp II)	NSSC (pulp II)
Chemical consumption, %			
Kappa number	38.4	24.7	chlorine number 30.2
Yield (unscreened), %	52.8	52.7	78.6
Screenings, %			
Brightness	35.4	23.6	37.9
Beater or refiner	PFI	PFI	PFI
Freeness SR	30	30	30
Tensile index, N m/g	75.8	94.0	107.6
Burst index, kPa m^2/g	4.93	6.65	7.97
Tear index, mN m^2/g	7.56	8.64	8.88
Bleached			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information:

Scientific name: Gmelina arborea Roxb.	Common name: Country: Nigeria	Reference: 62 - 65

Wood sample characteristics

Wood sample origin:

Same as previous sample

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached			
Process	Sulphate (165°C)	Sulphate (165°C)	Sulphate-oxygen (1MPa/110°C)
Chemical consumption, %			
Kappa number	20.1	21.1	20.9) after cooking
Yield (unscreened), %	52.5	52.5	52.5)
Screenings, %	3.9	1.9	
Brightness (SCAN)	31.4		
Beater or refiner	PFI		
(Freeness) SR	29		
Tensile index, N m/g	86.4		
Burst index, kPa m^2/g	6.36		
Tear index, mN m^2/g	9.46		
Bleached			
Sequence	CEDED	CEDED	
Chemical consumption, %	8.4 as act. Cl	4.1 as active Cl	
Yield on bleaching, %	95.6	97.9	
Total yield, %			
Brightness	91.2	92.5	
Beater or refiner	PFI	PFI	
(Freeness) SR	22	22	
Tensile index, N m/g	74.7	68.9	
Burst index, kPa m^2/g	5.05	4.64	
Tear index, mN m^2/g	10.1	8.48	
Additional information:			

Scientific name: Gmelina arborea Roxb.	Common name: Yemane Country: Philippines	References: 70

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	1 300
Fibre width, µm	31
Wall thickness, µm	3.5
Lumen width, µm	24
Length/width ratio	42
Runkel ratio	0.29
Flexibility ratio	0.77

Additional information:

Straight bole. Resistant to fire

At 3 years: DBH 194 mm. Growth over 100 m^3/ha·a

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C, 25.5% suldifity, 15.6% act. alk.)
Chemical consumption, %	95.6 based on chem. charged
Kappa number x	11.4
Yield (unscreened), %	55.8
Screenings, %	1.1
Brightness	
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	94.5
Burst index, kPa m^2/g	4.65
Tear index, mN m^2/g	6.6
Bleached	
Sequence	CEH
Chemical consumption, %	3.7 as Cl-charge
Yield on bleaching, %	96.0
Total yield, %	
Brightness	77.0
Beater or refiner	Valley
Freeness	500
Tensile index, N m/g	65.0
Burst index, kPa m^2/g	5.4
Tear index, mN m^2/g	5.4
Additional information:	x Permanganate Number

Scientific name: Guazuma crinita Mart.	Common name: Bolaina Country: Peru	References: 37

Wood sample characteristics

Wood sample origin:

Sample size 20 kg
Length growth 2 - 3 m
(Diameter 150 mm)

Density and fibre characteristics:

Basic density, kg/m^3	338
Fibre length, µm x)	1 410
Fibre width, µm	26
Wall thickness, µm	4.6
Lumen width, µm	
Length/width ratio	54
Runkel ratio	
Flexibility ratio	

Additional information: Vessel length 390 µm
" width 240 µm

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	1.0
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	0.2
Lignin, %	21.6
Holocellulose, %	
Cross-Bevan cellulose, %	49.9 cellul.
Pentosans, %	

Additional information:

Hemicellulose, %	27.3

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (165°C)
Chemical consumption, %	15 charge of act. alkali as Na_2O
Kappa number	21.0
Yield (unscreened), %	49.2
Screenings, %	5.3
Brightness	29
Beater or refiner	Valley
Freeness	30 SR
Tensile index, N m/g	94.0
Burst index, kPa m^2/g	6.9
Tear index, mN m^2/g	9.0

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: Fibre weight 74 µg/m

Paulownia fortunei

Plantation experience

The usable height of the tree is 6.5 m at 2 years rotation. The wood sample studied is taken from an experiemental plantation in Italy.

References: 13

Wood characteristics

The wood density of this very young sample is very low and the fibres are probably due to the age of the sample, shorter than average for hardwoods. The lignin content is in the range normal for hardwoods, but the extractives content is high.

Pulping characteristics

This particular wood sample was converted into high-yield NSSC and sodium bisulphate pulps as well as refiner mechanical pulp (RMP). The results indicate that there is promise for practical use of this species as raw material for chemimechanical pulps for various purposes.

Scientific name: Paulownia fortunei	Common name: Country: Italy	References: 13

Wood sample characteristics

Wood sample origin:

From a trail plantation near Rome
Mean annual temperature 15°C
Mean annual precipitation 780 mm
Age 2 a
Usable height 6.5 m

Density and fibre characteristics:

Basic density, kg/m³	227
Fibre length, µm x)	840
Fibre width, µm	33
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	25
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	0.98
Ether	
Methanol	
Ethanol-benzene	6.4
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	0.2
Lignin, %	21.0
Holocellulose, %	73.2
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Hemicellulose, %	27.1

Pulping and papermaking characteristics

Unbleached

Process	NSSC (165°C)	Na-bisulphite	RMP
Chemical consumption, %	18		
Kappa number			
Yield (unscreened), %	75	73	
Screenings, %			
Brightness	60 GE	60 GE	
Beater or refiner	40 SR	40 SR	115 CSF
Freeness	85	80	22
Tensile index, N m/g	4.5	4.4	0.8
Burst index, kPa m^2/g	5.7	4.9	3.5
Tear index, mN m^2/g			

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Pinus caribaea
(Caribbean Pine)

Plantation experience

This species is native to British Honduras, Central America, Cuba and the south-eastern parts of the United States. The wood is naturally durable and it may, if desired, be successfully treated with wood preservatives. The species consists of three different varieties (P. caribaea var bahamensis, var caribaea and var hondurensis), which are slightly different with respect to soil and climate requirements. The present samples are from Bahamas, Cuba, Belize, Brazil, Tanzania, Sabah and Fiji and they represent almost only plantation trees 6 - 24 years old. In Tanzania the annual growth was 20 m^3/ha at about 6 years rotation. See also the previous volume (21).

References: 21, 46, 67

Wood characteristics

The wood density of trees older than about 20 years is in the medium range or high range. The fibres are of short to average length for softwood, but their width is comparatively large. The wall thickness may be considered as common for softwoods. The lignin content of the wood is around average or slightly higher than for softwoods in general.

Pulping characteristics

The sulphate pulps yield is low (40 - 45%) at Kappa numbers regarded as typical or low for chemical sulphate pulps (25 - 30). The pulp strength indicated by the tear index corresponds to that of Scandinavian pine whereas the corresponding tensile strength resembles that of U.S. southern pine pulp. A four-stage bleaching sequence seems to give acceptable brightness with normal charges of chlorine, but there is some risk of losses in tear strength loss.

Scientific name: Pinus caribaea var hondurensis	Common name: Country: Sabah	Reference: 15

Wood sample characteristics

Wood sample origin:

Six trees (9.5 a). Seed from British Honduras DBH 169 mm under bark

Density and fibre characteristics:

Basic density, kg/m^3	445
Fibre length, µm x)	
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	0.9
Solubility, %	
in water	2.9 hot
in 1 % NaOH	
Ash, %	
Lignin, %	30.2
Holocellulose, %	61.7
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached		
Process	Sulphate	Prehydrolysis-kraft xx)
Chemical consumption, % x)	20 (170°C)	20 (170°C)
Kappa number	27.8	22.2
Yield (unscreened), %	40.1	34.7
Screenings, %	0.0	0.1
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		
Bleached		
Sequence	CEDED	CEDED
Chemical consumption, %	8.0 (chlorine)	9.4 (available Cl)
Yield on bleaching, %		
Total yield, %	38.1	32.7
Brightness	61.2 (Elrepho)	82.6
Beater or refiner Alpha-cell, %	88.0	96.2
Visc., cp	16.9	10.1
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) Active alkali charge as Na_2O xx) Time to 170°C 1 h, at 0.5 h

Scientific name: Pinus caribaea	Common name: Country: Brazil	Reference: 26

Wood sample characteristics

Wood sample origin:

Plantation
8 years

Density and fibre characteristics:

Basic density, kg/m^3	353
Fibre length, µm x)	3 610
Fibre width, µm	54
Wall thickness, µm	5.1
Lumen width, µm	44
Length/width ratio	67
Runkel ratio	0.23
Flexibility ratio	0.81

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.7
Solubility, %	
in water	1.3
in 1 % NaOH	11.0
Ash, %	0.3
Lignin, %	30.8
Holocellulose, %	
Cross-Bevan cellulose, %	46.3
Pentosans, %	8.9

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	20
Kappa number	25
Yield (unscreened), %	44.5
Screenings, %	1.6
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	63.27
Burst index, kPa m^2/g	4.42
Tear index, mN m^2/g	15.0

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) at sheet density 600 kg/m^3

Scientific name: Pinus caribaea	Common name: Country: Tanzania	Reference: 46

Wood sample characteristics

Wood sample origin:

Trial plantation 70 km from Dar-Es-Salaam, 80 m above sea level.
DBH 143 mm, mean annual increment 20 m^3/ha.a. Age 6.5 a.
15 logs from five trees

Density and fibre characteristics:

Basic density, kg/m^3	380
Fibre length, µm x)	2 800
Fibre width, µm	51
Wall thickness, µm	4.9
Lumen width, µm	
Length/width ratio	55
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.4
Solubility, %	
in water	
in 1 % NaOH	10.5
Ash, %	
Lignin, %	28.7
Holocellulose, %	60.7
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	**Sulphate**	**Sulphate semichemical**
Chemical consumption, % x)	14.2	10 (charge)
Kappa number	28.1	
Yield (unscreened), %	42.3	61
Screenings, %	0.3	
Brightness		
Beater or refiner	PFI	PFI
Freeness	500	410
Tensile index, N m/g	76.0	69.4
Burst index, kPa m^2/g	5.3	5.3
Tear index, mN m^2/g	14.0	13.4
Bleached		
Sequence	CEHD	
Chemical consumption, %	10.1 (chlorine)	
Yield on bleaching, %	95.3	
Total yield, %	40.1	
Brightness	78.7 (Elrepho)	
Beater or refiner	PFI	
Freeness	500	
Tensile index, N m/g	78.0	
Burst index, kPa m^2/g	5.2	
Tear index, mN m^2/g	12.5	

Additional information: x) Na_2O active alkali

Scientific name: Pinus caribaea var bahamensis	Common name: Country: Bahamas	Reference: 47

Wood sample characteristics

Wood sample origin:

Sample from a natural forest on Great Abaco Island.
30 - 50 years old.

Density and fibre characteristics:

Basic density, kg/m^3	520
Fibre length, µm x)	2 700
Fibre width, µm	41
Wall thickness, µm	7.5
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.9
Solubility, %	
in water	
in 1 % NaOH	12.5
Ash, %	
Lignin, %	27.4
Holocellulose, %	64.2
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

a cellulose % 48.4

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	
Chemical consumption, %	14.0 Na_2O	13.3 Na_2O
Kappa number	32.5	42.6
Yield (unscreened), %	40.5	42.9
Screenings, %	0.8	3.2
Brightness		
Beater or refiner	PFI	PFI
Freeness	300 CSF	300 CSF
Tensile index, N m/g	71	69
Burst index, kPa m^2/g	4.5	4.4
Tear index, mN m^2/g	15.5	13.0

Bleached x

Sequence	CEHD
Chemical consumption, %	9.9 Cl
Yield on bleaching, %	95.0
Total yield, %	38.4
Brightness (Elrepho)	78
Beater or refiner	PFI / PFI
Freeness	210 CSF / 440 CSF
Tensile index, N m/g	70 / 62
Burst index, kPa m^2/g	4.3 / 3.9
Tear index, mN m^2/g	11.8 / 13.2

Additional information: x unbleached pulp; kappa 25.4, yield 40.4%

Scientific name: Pinus caribaea var caribaea	Common name:	Reference: 50
	Country: Cuba	

Wood sample characteristics

Wood sample origin:

Sample from 12 year old plantation at Topes de Collantes, Las Villas , 10 trees sampled

Density and fibre characteristics:

Basic density, kg/m^3	433
Fibre length, µm x)	2 370
Fibre width, µm	52
Wall thickness, µm	5.0
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.7
Solubility, %	
in water	
in 1 % NaOH	12.0
Ash, %	
Lignin, %	28.9
Holocellulose, %	58.3
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	14.8 act. alkali as Na_2O
Kappa number	26.2
Yield (unscreened), %	42.3
Screenings, %	0.0
Brightness	
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	63
Burst index, kPa m^2/g	4.3
Tear index, mN m^2/g	10.2

Bleached

Sequence	CEHD
Chemical consumption, %	9.8 as Cl
Yield on bleaching, %	96.0
Total yield, %	40.6
Brightness	83
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	58
Burst index, kPa m^2/g	3.8
Tear index, mN m^2/g	9.6

Additional information:

Scientific name: Pinus caribaea	Common name:	References: 51
	Country: Belize	

Wood sample characteristics

Wood sample origin:

From plantations in the Coastal Plain. Five trees sampled at five heights in the stem.
Samples from Melinda plantation
11, 17 and 24 year old trees

Density and fibre characteristics:

Basic density, kg/m^3	478	557	593
Fibre length, µm x)	2 060	2 330	3 060
Fibre width, µm	45	49	46
Wall thickness, µm	4.8	5.4	5.9
Lumen width, µm			
Length/width ratio	46	48	67
Runkel ratio			
Flexibility ratio			

Additional information:

Diameter, mm	204	318	230
Height, m	12.5	16.0	15.7

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %			
Ether			
Methanol			
Ethanol-benzene	1.2	2.1	4.3
Solubility, %			
in water			
in 1 % NaOH	10.5	11.4	13.3
Ash, %			
Lignin, %	28.1	27.3	26.3
Holocellulose, %	60.7	61.7	60.9
Cross-Bevan cellulose, %			
Pentosans, %			

Additional information:

Pulping and papermaking characteristics

Unbleached	11	17	24 a	11	17	24 a
Process		Sulphate			Sulphate	
Chemical consumption, % x)	13.6	13.4	13.2	14.5	14.1	14.2
Kappa number	39.5	37.9	39.3	28.8	28.0	30.1
Yield (unscreened), %	46.6	45.3	44.9	43.1	43.8	42.4
Screenings, %	1.0	1.1	1.9	0.3	0.2	0.4
Brightness						
Beater or refiner	PFI	PFI	PFI	PFI	PFI	PFI
Freeness	500	500	500	500	500	500
Tensile index, N m/g	74	74	69	69	69	66
Burst index, kPa m^2/g	5.2	5.6	4.9	4.7	4.9	4.6
Tear index, mN m^2/g	17.5	17.7	20.7	15.9	16.5	19.0
Bleached						
Sequence						
Chemical consumption, %						
Yield on bleaching, %						
Total yield, %						
Brightness						
Beater or refiner						
Freeness						
Tensile index, N m/g						
Burst index, kPa m^2/g						
Tear index, mN m^2/g						

Additional information: x) Active alkali as Na_2O

Scientific name: Pinus caribaea Mor. var hondurensis	Common name:	Reference: 53
	Country: Fiji	

Wood sample characteristics

Wood sample origin:

Sample from Drasa plantation, 9 years dd.
Diameter (10% height) 184 and 124 mm under bark for fast and slow grown trees respectively

Density and fibre characteristics:

Basic density, kg/m^3	421	442
Fibre length, µm x)		
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	1.3	1.1
Solubility, %		
in water	2.0	2.3
in 1 % NaOH	11.2	11.0
Ash, %		
Lignin, %	28.6	28.6
Holocellulose, %	60.2	60.2
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached	Fast	Slow grown
Process	Sulphate	Sulphate
Chemical consumption, % x)	15.0	14.1
Kappa number	26.5	28.0
Yield (unscreened), %	42.3	43.3
Screenings, %	0.1	0.1
Brightness		
Beater or refiner	PFI	PFI
Freeness	445	470
Tensile index, N m/g	65.3	74.5
Burst index, kPa m^2/g	4.3	5.0
Tear index, mN m^2/g	10.8	12.8
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) Active alkali as Na_2O

Pinus elliottii
(Slash Pine)

Plantation experience

Indigenous to the coastal plains of the south-eastern United States, this is one of the "southern pines". It is used in its natural habitat for afforestation of denuded land. It yields also high quality commercial turpentine containing a high proportion of beta pinene. It has been introduced in many countries, such as Brazil, Malawi and New Zealand from where the present samples have been taken. The results have been less satisfactory in Kenya and Malaysia. The growth rate obtained in New Zealand was almost 30 m^3/ha•a at 25 years rotation.

References: 21, 49, 68

Wood characteristics

The wood density varies very much from low to medium obviously due to differences in provenance and growing conditions. The fibres are mostly long and comparatively broad, but the fibre walls are of normal thickness. The lignin content is around average for softwoods.

Pulping characteristics

The sulphate pulp yield is on the average somewhat low but higher than that obtained with Caribbean pine, compared at the same degree of delignification. Typical yields are 44 - 46 percent. The strength characteristics of the pulps are in the range typical of U.S. southern pine pulps. The sample from New Zealand exhibits an extremely good tear index. The bleaching response is quite acceptable provided that proper bleaching sequences and suitable chlorine charges are used.

Scientific name: Pinus elliottii	Common name: Country: Malawi	Reference: 4

Wood sample characteristics

Wood sample origin:

16 years old

Density and fibre characteristics:

Basic density, kg/m^3 398 - 415
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, % x	18.5 Na_2O
Kappa number	28.6 - 30.4
Yield (unscreened), %	46.0 - 46.4
Screenings, %	0.5 - 0.8
Brightness	
Beater or refiner	PFI
Freeness	30 SR
Tensile index, N m/g	75 - 83
Burst index, kPa m^2/g	6.7 - 7.2
Tear index, mN m^2/g	19.5 - 15.0

Bleached xx

Sequence	D/CEHDED
Chemical consumption, % x	10.5 Cl, 3.5 NaOH
Yield on bleaching, %	94.2
Total yield, %	46.4
Brightness	89.7
Beater or refiner	Valley
Freeness	30 SR
Tensile index, N m/g	91
Burst index, kPa m^2/g	7.7
Tear index, mN m^2/g	15.0

Additional information: x charge

xx mixed sample, kappa of unbleached pulp 35.4

Scientific name: Pinus elliottii Engelmann var. elliottii	Common name: Slash pine Country: U.S.A.	Reference: 26

Wood sample characteristics

Wood sample origin:

Plantation
18 years
statistical treatment
samples from 25 woods/species, 5 repetitions

Density and fibre characteristics:

Basic density, kg/m^3	482 ± 9
Fibre length, µm x)	3 460 ± 170
Fibre width, µm	48.70 ± 2.93
Wall thickness, µm	6.87 ± 0.78
Lumen width, µm	34.96 ± 3.98
Length/width ratio	71 ± 6
Runkel ratio	0.397 ± 0.080
Flexibility ratio	0.72 ± 0.04

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	4.6 ± 1.7
Solubility, %	
in water	1.3 ± 0.4
in 1 % NaOH	9.9 ± 2.0
Ash, %	0.4 ± 0.2
Lignin, %	27.2 ± 0.6
Holocellulose, %	
Cross-Bevan cellulose, %	48.5 ± 0.6
Pentosans, %	11.3 ± 0.5

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	20
Kappa number	25
Yield (unscreened), %	44.0 ± 0.5
Screenings, %	0.2 ± 0.1
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	99.06 ± 6.70
Burst index, kPa m^2/g	7.87 ± 0.35
Tear index, mN m^2/g	15.3 ± 0.5

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) at sheet density 0.600 g/cm^3

Scientific name: Pinus elliottii var. elliottii	Common name: Slash pine Country: Brasil	Reference: 26

Wood sample characteristics

Wood sample origin:

8 years
plantation

Density and fibre characteristics:

Basic density, kg/m^3	307 ± 8
Fibre length, µm x)	3 140 ± 35
Fibre width, µm	45.31 ± 2.68
Wall thickness, µm	5.41 ± 0.53
Lumen width, µm	34.88 ± 2.97
Length/width ratio	69 ± 8
Runkel ratio	0.37 ± 0.074
Flexibility ratio	0.77 ± 0.04

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.9 ± 0.6
Solubility, %	
in water	1.5 ± 0.7
in 1 % NaOH	7.1 ± 1.4
Ash, %	0.3 ± 0.2
Lignin, %	29.8 ± 1.1
Holocellulose, %	
Cross-Bevan cellulose, %	49.1 ± 1.8
Pentosans, %	9.2 ± 1.1

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C) bleachable
Chemical consumption, %	20
Kappa number	26.5 ± 2
Yield (unscreened), %	44.6 ± 3.3
Screenings, %	0.3 ± 0.2
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	59.58 ± 1.62
Burst index, kPa m^2/g	4.47 ± 0.23
Tear index, mN m^2/g	12.7 ± 0.6

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) at sheet density 0.600 g/cm^3

Scientific name: Pinus elliottii	Common name: Slash pine Country: Brasil	Reference: 39

Wood sample characteristics

Wood sample origin:

Plantation
10 year old

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	3 200
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	6.5
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Analysis of pitch

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C) industrial scale	
Chemical consumption, %	20.19 (Na_2O)	
Kappa number	74	
Yield (unscreened), %		
Screenings, %		
Brightness		
Beater or refiner	Hydradisc (600 HP)	Jordan (250 HP)
Freeness	x) 19° SR	xx)
Tensile index, N m/g	81	
Burst index, kPa m^2/g	3.5	3.7
Tear index, mN m^2/g	12.5	13.5

Bleached

Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) 80 g/cm^3 xx) 160 g/cm^3 (board)

Scientific name: Pinus elliottii	Common name:	Reference: 49
	Country: Malawi	

Wood sample characteristics

Wood sample origin:

From 1 000 ha plantation in Vipya
Temperature 14–20 °C, annual rainfall 115–1 650 mm
Elevation 1 500 m above sea level
Medium growth trees (5) 15 years old

Diameter 195 mm

Density and fibre characteristics:

Basic density, kg/m^3	355
Fibre length, µm x)	2 030
Fibre width, µm	54
Wall thickness, µm	5.0
Lumen width, µm	44
Length/width ratio	38
Runkel ratio	
Flexibility ratio	

Additional informations:

Growth 14.0 m^3/ha·a

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.5
Solubility, %	
in water	
in 1 % NaOH	11.5
Ash, %	
Lignin, %	
Holocellulose, %	58.4
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, % x)	13.8
Kappa number	27.6
Yield (unscreened), %	46.1
Screenings, %	0.0
Brightness	
Beater or refiner	
Freeness	500
Tensile index, N m/g	73.0
Burst index, kPa m^2/g	5.0
Tear index, mN m^2/g	11.0

Bleached

Sequence	CEH
Chemical consumption, %	7.0 added Cl
Yield on bleaching, %	
Total yield, %	41.2
Brightness	68
Beater or refiner	
Freeness	500
Tensile index, N m/g	74.0
Burst index, kPa m^2/g	5.2
Tear index, mN m^2/g	10.0

Additional information: x) Act. alkali as Na_2O

Scientific name: Pinus elliottii	Common name: Slash pine Country: New Zealand	Reference: 68

Wood sample characteristics

Wood sample origin:

Sample from Tairua Forest
Wood age 25 a
Growth rate 29 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	370 (inner) 450 (outer wood)
Fibre length, µm x)	3 000 - 4 500
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	6.0
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	
Kappa number	30
Yield (unscreened), %	45.3
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	70
Burst index, kPa m^2/g	6.2
Tear index, mN m^2/g	21.7
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Pinus halepensis
(Cyprus Pine)

Plantation experience

In its natural habitat the species is found mainly in Cyprus, Turkey, Syria and Iraq. It grows from sea level up to 1 500 m. The tree has been used extensively for afforestation. Plantations have shown promise in Australia and in south-east Africa. The present sample of 14 years old trees was taken in Italy.

Reference: 13, 21

Wood characteristics

The wood of medium density contains fibres which are somewhat shorter than average for a softwood. The lignin content is about average for softwoods.

Pulping characteristics

The sulphate cook performed at 175°C temperature and by application of reasonable quantities of chemicals gave pulps of normal degree of delignification, but in low yield. The strength properties are somewhat inferior to those of Scandinavian pine pulp. The brightness obtained after bleaching cannot be considered satisfactory in view of the five-stage sequence applied.

Scientific name: Pinus halepensis	Common name: Country: Italy	Reference: 13

Wood sample characteristics

Wood sample origin:

From a center near Rome
Mean annual temperature 15°C
Mean annual precipitation 780 mm
Age 14 a
Usable height 9 m

Density and fibre characteristics:

Basic density, kg/m^3	465
Fibre length, µm x)	2 420
Fibre width, µm	33
Wall thickness, µm	5.5
Lumen width, µm	22
Length/width ratio	73
Runkel ratio	0.50
Flexibility ratio	0.67

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	1.7
Methanol	
Ethanol-benzene q	3.3
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	0.4
Lignin, %	26.8
Holocellulose, %	70.1
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Hemicellulose, %	29.0

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (175°C)
Chemical consumption, %	18 charge as act. alkali
Kappa number	35
Yield (unscreened), %	43
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	32 SR
Tensile index, N m/g	84
Burst index, kPa m^2/g	6.1
Tear index, mN m^2/g	11.5

Bleached

Sequence	CEHEH
Chemical consumption, %	10 charged as Cl
Yield on bleaching, %	
Total yield, %	
Brightness	78 GE
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Pinus insularis
(Benguet Pine)

Plantation experience

The present sample is from Luzon in the Philippines. The stem diameter at 30 years was 200 mm.

References: 11

Wood characteristics

Density and fibre dimensions are not available; the lignin content is around average for a softwood. The extracting content is comparatively low.

Pulping characteristics

The yield of sulphate pulp is high compared with values common for softwood sulphate pulps. The strength properties of the pulp are almost comparable to those of Scandinavian pine pulp.

Scientific name: Pinus insularis Eldl.	Common name: Benguet pine Country: Philippines	Reference: 11

Wood sample characteristics

Wood sample origin:

From Mountain Province in Luzon.
Age of sample 30 a (growth-rings)
Diameter 200 mm

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.87
Solubility, %	
in water	
in 1 % NaOH	14.1
Ash, %	0.21
Lignin, %	26.2
Holocellulose, %	69.7
Cross-Bevan cellulose, %	
Pentosans, %	11.1

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	13.6
Kappa number	27.4
Yield (unscreened), %	49.6
Screenings, %	0.7
Brightness	
Beater or refiner	
Freeness	470
Tensile index, N m/g	11.9
Burst index, kPa m^2/g	8.0
Tear index, mN m^2/g	13.4

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Pinus kesiya

Plantation experience

The species is indigenous to Indochina. Acclimatization has been promising in South and East Africa, and partly also in Australia, but it has failed to acclimatize in Fiji, Malaysia, Borneo and Uganda. The present samples are from India and Malawi. The Indian sample represents one tree about 30 years old and with a diameter of 300 mm.

References: 12, 21

Wood characteristics

The wood density is low to average for softwoods and the fibre length is about average. The lignin content is within the range normal for softwoods.

Pulping characteristics

The yield of pulping is low to average for softwoods and the strength characteristics correspond to those of Scandinavian pine pulps. The bleaching response is good.

Scientific name: Pinus kesiya	Common name: Country: Malawi	Reference: 4

Wood sample characteristics

Wood sample origin:

Density and fibre characteristics:

Basic density, kg/m^3 324
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, % x)	20.0 Na_2O
Kappa number	30.7
Yield (unscreened), %	46.0
Screenings, %	0.4
Brightness	
Beater or refiner	PFI
Freeness	30 SR
Tensile index, N m/g	87
Burst index, kPa m^2/g	7.8
Tear index, mN m^2/g	12.5

Bleached xx)

Sequence	D/CEHDED
Chemical consumption, % x)	9.3 Cl, 3.1 NaOH
Yield on bleaching, %	95.0
Total yield, %	46.8
Brightness	89.9
Beater or refiner	Valley
Freeness	30 SR
Tensile index, N m/g	101
Burst index, kPa m^2/g	8.3
Tear index, mN m^2/g	11.5

Additional information:

x) Charge

xx) Mixed sample, kappa of unbleached pulp 30.0

Scientific name: Pinus khasya	Common name: Country: India	Reference: 12

Wood sample characteristics

Wood sample origin:

From experimental plot in Mayurbhanj. Annual rainfall 1 450 - 1 700 mm. Evevation 600-900 m above sea-level.
One tree sampled: diameter 318 mm
Tree age 30-35 a

Density and fibre characteristics:

Basic density, kg/m^3	498 at 3 m height
Fibre length, µm x)	3 560
Fibre width, µm	52
Wall thickness, µm	6.1
Lumen width, µm	
Length/width ratio	68
Runkel ratio	
Flexibility ratio	0.76

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.44
Solubility, %	
in water	
in 1 % NaOH	12.7
Ash, %	1.7
Lignin, %	30.1
Holocellulose, %	58.4
Cross-Bevan cellulose, %	
Pentosans, %	10.3

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	13.6 act. alkali
Kappa number	20.7
Yield (unscreened), %	41.3
Screenings, %	0.2
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Bleached

Sequence	CEHH
Chemical consumption, %	7.5 total Cl
Yield on bleaching, %	92
Total yield, %	37.8
Brightness	79 Elrepho
Beater or refiner	Valley
Freeness	24 SR
Tensile index, N m/g	71.1
Burst index, kPa m^2/g	3.5
Tear index, mN m^2/g	15.8

Additional information:

Pinus merkusii
(Mindoro Pine)

Plantation experience

This Malaysian species is the only pine species crossing the equator. This species grows at elevations over 500 m and the growth reported is 20 $m^3/ha \cdot a$ at 25 years rotation. The present samples are both from Zambales in the Philippines.

References: 18, 45, 58

Wood characteristics

The wood density is somewhat above average for softwoods; the fibres are long and the lignin content about average. The fibres are broad and the fibre walls are extremely thick. The extractives content is in the range normal for softwoods.

Pulping characteristics

The sulphate pulp yield is low to average for softwoods. The tear factor of the pulp is very high, whereas the tensile strength is less satisfactory. However, the pulp corresponds in this respect to many U.S. southern pine pulps.

Scientific name: Pinus merkusii Jungh. & de Vr.	Common name: Mindoro pine Country: Philippines	References: 18

Wood sample characteristics

Wood sample origin:

Sample from the province of Zambales
Elevation > 500 m x)
Growth 22 m^3/ha·a at 25 a x)

Density and fibre characteristics:

Basic density, kg/m^3	560
Fibre length, µm x)	4 000
Fibre width, µm	44
Wall thickness, µm	8
Lumen width, µm	28
Length/width ratio	91
Runkel ratio	0.57
Flexibility ratio	0.64

Additional information:

x) 1000 µm = 1mm
General info (not specific for sample)

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	4.4
Solubility, %	
in water	2.1 hot
in 1 % NaOH	17.4
Ash, %	0.3
Lignin, %	28.0
Holocellulose, %	65.2
Cross-Bevan cellulose, %	
Pentosans, %	9.5

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	13.2 active alkali
Kappa number	21.2
Yield (unscreened), %	45.9
Screenings, %	0.7
Brightness	
Beater or refiner	
Freeness	400
Tensile index, N m/g	93.5
Burst index, kPa m^2/g	7.0
Tear index, mN m^2/g	18.8

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Pinus merkusii	Common name: Country: Philippines	Reference: 45

Wood sample characteristics

Wood sample origin:

Two trees from Zambales Mountains.
Growth-rings (age) 80–100

Density and fibre characteristics:

Basic density, kg/m^3	474–580
Fibre length, µm x)	2 970
Fibre width, µm	44
Wall thickness, µm	7.6
Lumen width, µm	
Length/width ratio	68
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.9
Solubility, %	
in water	
in 1 % NaOH	10.9
Ash, %	
Lignin, %	
Holocellulose, %	64.6
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (165°C)
Chemical consumption, %	13.6 act. alkali
Kappa number	25.3
Yield (unscreened), %	40.8
Screenings, %	0.1
Brightness	
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	60.0
Burst index, kPa m^2/g	3.9
Tear index, mN m^2/g	20.0
Bleached	
Sequence	CEH
Chemical consumption, %	7.5 added Cl
Yield on bleaching, %	
Total yield, %	39.4
Brightness	65.4
Beater or refiner	PFI
Freeness	550
Tensile index, N m/g	59.9
Burst index, kPa m^2/g	4.2
Tear index, mN m^2/g	15.6
Additional information:	

Pinus oocarpa
(Ocote Pine)

Plantation experience

The species grows at subtropical elevations in Mexico and in the mountains of Belize, Guatemala, Honduras, Nicaragua and Salvador. Successful acclimatization has been reported from Kenya and varying success from South Africa. The samples referred to are from a plantation in Brazil and from a natural stand in Belize.

References: 21, 52, 58

Wood characteristics

The wood density is around average for softwoods and the fibre length is in the high range. The fibres found in the young cultivated trees, 6 - 13 years old, are broad and extremely thick-walled. The content of lignin and extractives are typical for softwoods.

Pulping characteristics

The unscreened sulphate pulp yield is about average; the cultivated trees for some reason give pulps of very high screenings content. The tear index is very high, whereas the tensile strength on the other hand is fairly low, a common characteristic of U.S. southern pine pulps. A four stage bleaching sequence gives an acceptable brightness without detrimental effects on the pulp strength.

Scientific name: Pinus oocarpa	Common name: Country: Brazil	Reference: 28

Wood sample characteristics

Wood sample origin:

Plantation in Agudos
Tree age 6, 12 and 13 years

Density and fibre characteristics:

Basic density, kg/m^3	362	412	441
Fibre length, µm x)	2 960	3 630	3 800
Fibre width, µm	43	48	49
Wall thickness, µm	5.7	7.8	9.0
Lumen width, µm	31	32	31
Length/width ratio	69	76	78
Runkel ratio	0.37	0.49	0.58
Flexibility ratio	0.72	0.67	0.63

Additional information:

Density measured on unextr. wood

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached	**Age years:**	6	12	13
Process		Sulphate (170°C)	do.	do.
Chemical consumption, %				
Kappa number		23.5	23.5	23.5
Yield (unscreened), %		44.6	47.7	49.7
Screenings, %		5.1	4.3	5.1
Brightness				
Beater or refiner				
Freeness	Sheet density	500	500	500
Tensile index, N m/g		4.9	5.2	5.9
Burst index, kPa m^2/g		3.4	4.3	4.3
Tear index, mN m^2/g		21.0	21.5	24.0
Bleached				
Sequence				
Chemical consumption, %				
Yield on bleaching, %				
Total yield, %				
Brightness				
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m^2/g				
Tear index, mN m^2/g				

Additional information:

Scientific name: Pinus oocarpa var ochoterenai	Common name:	Reference: 52
	Country: Belize	

Wood sample characteristics

Wood sample origin:

Sample from stand of natural regeneration, Plot 8 in Mountain Pine Ridge, altitude 600 m
Twenty trees selected. Average age 30 a, mean height of trees 20 m

Density and fibre characteristics:

Basic density, kg/m^3	530
Fibre length, µm x)	2 740
Fibre width, µm	50
Wall thickness, µm	6.9
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.8
Solubility, %	
in water	
in 1 % NaOH	15.1
Ash, %	
Lignin, %	
Holocellulose, %	28.7
Cross-Bevan cellulose, %	67.5
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (165°C)
Chemical consumption, %	12.9 active alkali as Na_2O
Kappa number	28.8
Yield (unscreened), %	44.1
Screenings, %	0.2
Brightness	
Beater or refiner	BFI
Freeness	500
Tensile index, N m/g	77
Burst index, kPa m^2/g	5.2
Tear index, mN m^2/g	20.0

Bleached

Sequence	CEHD
Chemical consumption, %	10.8 as Cl
Yield on bleaching, %	
Total yield, %	41.5
Brightness	80 Elrepho
Beater or refiner	PFI
Freeness	500
Tensile index, N m/g	74
Burst index, kPa m^2/g	5.4
Tear index, mN m^2/g	19.5

Additional information:

Pinus patula
(Patula Pine)

Plantation experience

The species is confined to elevations of 1 800 to 2 500 m on the moist mountains on the eastern side of the Mexican plateau between 19° and 21° north latitude. It is also found in Guatemala up to 3 000 m. It is well adapted to conditions in the mountains of eastern South Africa, where it has been planted since 1907. The species is introduced also in India, Australia and New Zealand. The present samples are from plantations in Kenya, Malawi and New Zealand, where the annual growth was as high as 30 m^3/ha.

References: 21, 49, 58, 68

Wood characteristics

The wood density is in the range normal for softwoods used for pulping (350 kg/m^3). The fibre length is about average, i.e. comparable with that of forest pine in northern Europe. Longer fibres have also been reported for older trees. The other fibre dimensions are quite similar to those of the "southern pines".

Pulping characteristics

By application of normal quantities of alkali in the sulphate cook, pulp is obtained in average yields (44 - 48 %). The tear index of chemical pulp is very high and on the whole, the strength characteristics resemble those of U.S. southern pine pulps. The three-stage bleaching has not been sufficient to produce brightness values over 70 units.

Scientific name: Pinus patula	Common name: Country: Kenya	Reference: 3

Wood sample characteristics

Wood sample origin:

Plantation-grown
Under 7 a and 7-15 a logs

Density and fibre characteristics:

Basic density, kg/m^3	360	330
Fibre length, µm x)	2 070	3 010
Fibre width, µm	49	55
Wall thickness, µm	5.8	6.0
Lumen width, µm	37	43
Length/width ratio	42	55
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	1.58	0.39
Solubility, %		
in water		
in 1 % NaOH		
Ash, %		
Lignin, %		
Holocellulose, %	67.1	65.5
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached	< 7 a	7-15 a
Process	Semi-kraft	Semi-kraft
Chemical consumption, % x)	12.7	13.3
Kappa number		
Yield (unscreened), %	52.8	59.9
Screenings, %	2.0	4.3
Brightness		
Beater or refiner	Valley	Valley
Freeness	500	470
Tensile index, N m/g	93.1	97.3
Burst index, kPa m^2/g	6.8	6.9
Tear index, mN m^2/g	13.1	12.6
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) Active alkali

Scientific name: Pinus patual	Common name: Country: Malawi	Reference: 4

Wood sample characteristics

Wood sample origin:

a) 12 years old
b) 15 years old
c) 16 years old

Density and fibre characteristics:

Basic density, kg/m^3 a) 353 b) 410 c) 349-387
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm

Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached	a)	b)	c)
Process	Sulphate	Sulphate	Sulphate
Chemical consumption, % x)	17.0 Na_2O	17.0 Na_2O	18.5 Na_2O
Kappa number	42.2	32.4 - 31.1	31.0
Yield (unscreened), %	48.1	44.8 - 45.8	47.6
Screenings, %	1.3	0.7 - 1.1	1.2
Brightness			
Beater or refiner	PFI	PFI	PFI
Freeness	30 SR	30 SR	30 SR
Tensile index, N m/g	87	79	83
Burst index, kPa m^2/g	7.8	7.2	7.5
Tear index, mN m^2/g	14.5	16.5	17.5

Bleached xx)		
Sequence	D/C EHDED	D/C EHDED
Chemical consumption, % x)	11.9 Cl, 3.7 NaOH	13.8 Cl, 3.2 NaOH
Yield on bleaching, %	94.3	93.4
Total yield, %	46.5	45.9
Brightness	90.1	89.2
Beater or refiner	Valley	Valley
Freeness	30 SR	30 SR
Tensile index, N m/g	97	89
Burst index, kPa m^2/g	8.0	7.7
Tear index, mN m^2/g	15.0	15.5

Additional information:
x) Charge
xx) Mixed sample (12-16 years old), kappa of unbleached pulp 38.6

Scientific name: Pinus patula	Common name: Country: Malawi	References: 49

Wood sample characteristics

Wood sample origin:

From 20 000 ha plantation in Vipya
Temperature 14-20°C, annual rainfall 1 150 - 1 650 mm
Elevation 1 500 m above sea-level
Medium growth trees (5) 15 years old

Diameter 199 mm

Density and fibre characteristics:

Basic density, kg/m^3	440
Fibre length, µm x)	2 040
Fibre width, µm	51
Wall thickness, µm	4.9
Lumen width, µm	41
Length/width ratio	40
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.3
Solubility, %	
in water	
in 1 % NaOH	12.4
Ash, %	
Lignin, %	
Holocellulose, %	60.4
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process		Sulphate
Chemical consumption, %	x)	13.2
Kappa number		24.6
Yield (unscreened), %		44.1
Screenings, %		0.0
Brightness		
Beater or refiner		
Freeness		500
Tensile index, N m/g		78.0
Burst index, kPa m^2/g		5.5
Tear index, mN m^2/g		20.0

Bleached

Sequence	CEH
Chemical consumption, %	7 added chlorine
Yield on bleaching, %	
Total yield, %	42.0
Brightness	63
Beater or refiner	
Freeness	500
Tensile index, N m/g	80.0
Burst index, kPa m^2/g	5.6
Tear index, mN m^2/g	17.5

Additional information: Act. alkali as Na_2O

Scientific name: Pinus patula	Common name: Country: New Zealand	References: 68

Wood sample characteristics

Wood sample origin:

Sample from Rotoehu Forest
Wood age 25 a
Growth rate 30 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	360 (inner)	480 (outer wood)
Fibre length, µm x)	2 600	4 900
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	3.0
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	
Kappa number	30
Yield (unscreened), %	48.7
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	550
Tensile index, N m/g	74
Burst index, kPa m^2/g	6.2
Tear index, mN m^2/g	17.9
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Pinus radiata
(Monterey Pine)

Plantation experience

This tree has been planted in Chile, Italy, Kenya, New Zealand, etc. A Mediterranean type climate, like in its natural habitat (southern California), seems to offer the most favourable growing conditions. The growth of the tree is in the medium range, and yeilds up to 40 m^3/ha•a at a rotation of 25 years have been reported in New Zealand.

References: 21, 68

Wood characteristics

The density of wood in mature trees is about average for softwood. The average fibre length is between 2 and 4 mm depending upon tree age. Fibres of about 2 mm length were reported for trees 7 and 7 - 15 years old and cultivated in Kenya. No data on lignin contents are available.

Pulping characteristics

Mechanical pulp of suitable brightness and strength has been prepared from this wood. Chemimechanical sulphate pulps with average tear strength have been cooked to high yields, 60 - 65 percent. Chemical sulphate pulps obtained at average pulp yield show high tear values at low degrees of beating.

Scientific name: Pinus radiata	Common name: Country: Kenya	Reference: 3

Wood sample characteristics

Wood sample origin:

Plantation-grown
Under 7 a and 7-15 a logs

Density and fibre characteristics:

Basic density, kg/m^3	280	360
Fibre length, µm x)	2 240	2 150
Fibre width, µm	48	42
Wall thickness, µm	4.2	4.6
Lumen width, µm	40	33
Length/width ratio	47	51
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %		
Ether		
Methanol		
Ethanol-benzene	0.80	2.06
Solubility, %		
in water		
in 1 % NaOH		
Ash, %		
Lignin, %		
Holocellulose, %	63.6	61.4
Cross-Bevan cellulose, %		
Pentosans, %		

Additional information:

Pulping and papermaking characteristics

Unbleached	< 7 a	7-15 a
Process	semi-kraft	semi-kraft
Chemical consumption, % x)	7.1	7.1
Kappa number		
Yield (unscreened), %	67.8	62.6
Screenings, %	3.7	0.5
Brightness		
Beater or refiner	Valley	Valley
Freeness	490	440
Tensile index, N m/g	50.4	46.0
Burst index, kPa m^2/g	3.6	3.3
Tear index, mN m^2/g	8.0	7.5
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information: x) Act. alkali

Scientific name: Pinus radiata	Common name: Country: Australia	References: 16

Wood sample characteristics

Wood sample origin:

From Flynn Creek Tree Farm, Gippsland, Victoria
age 10 a

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm

Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate 177°C			
Chemical consumption, %	13 - 15 Na_2O	22 sulphidity		
Kappa number	35			
Yield (unscreened), %	50			
Screenings, %	2			

Brightness

Beater or refiner	Lampen mill	fertilized[x]	sterilized[x]	fertilized & sterilized[x]
Freeness	600	600	600	600
Tensile index, N m/g	68.0	100.3	100.2	65.0
Burst index, kPa m^2/g	7.2	7.6	7.7	5.0
Tear index, mN m^2/g	13.8	13.1	12.2	18.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m^2/g
Tear index, mN m^2/g

Additional information: x soil fertilizer treatment: P 250 kg/ha, K 630 kg/ha
soil sterilization: chloropiorin & bromide 336 kg/ha

Scientific name: Pinus radiata	Common name: Country: Chile	Reference: 17

Wood sample characteristics

Wood sample origin:

From mountains Nahuelbata, Bio-Bio

Density and fibre characteristics:

Basic density, kg/m^3
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Mechanical pulp
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	60 (Elrepho)
Beater or refiner	
Freeness	105
Tensile index, N m/g	28
Burst index, kPa m^2/g	
Tear index, mN m^2/g	5.2

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Pinus radiata	Common name: Country: Italy	Reference: 31, 60

Wood sample characteristics

Wood sample origin:

Sample from state forest "Sette Fratelli",
Cagliari, Sardinia
Wood age 33 a

Density and fibre characteristics:

Basic density, kg/m^3	510
Fibre length, µm x)	4 000
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	3.10
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m^2/g
Tear index, mN m^2/g

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m^2/g
Tear index, mN m^2/g

Additional information:

Scientific name: Pinus radiata	Common name: Monterey pine Country: New Zealand	Reference: 68

Wood sample characteristics

Wood sample origin:

Sample from Kaingaroa Forest
Wood age 25 a
Growth rate 40 $m^3/ha \cdot a$

Density and fibre characteristics:

Basic density, kg/m^3	370 (inner)	420 (outer wood)
Fibre length, µm x)	2 100 - 3 900	
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	2.0
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	
Kappa number	30
Yield (unscreened), %	47.8
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	625
Tensile index, N m/g	89
Burst index, kPa m^2/g	7.4
Tear index, mN m^2/g	14.3
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Pinus taeda
(Loblolly Pine)

Plantation experience

This species is native to the eastern and southern U.S.A. It is the fastest growing species of the "southern pines". In its natural habitat it is planted on deforested land. Successful acclimatization has been reported from many countries in Africa, Asia and Australia. The results have been less good in Kenya. The present samples are from plantations in the U.S.A., Brazil and New Zealand. In New Zealand the growth was 30 $m^3/ha \cdot a$ at 25 years rotation.

References: 21, 68

Wood characteristics

The wood density is in the range normal for softwoods used for pulping. The fibre length is slightly below average. The lignin content is in the range normal for softwoods.

Pulping characteristics

The sulphate pulp yield is low to average for softwoods. The strength characteristics are typical for a U.S. southern pine pulp.

Scientific name: Pinus taeda	Common name: Country: Brazil	Reference: 26

Wood sample characteristics

Wood sample origin:

Plantation
11 years

Density and fibre characteristics:

Basic density, kg/m^3	340
Fibre length, µm x)	2 780
Fibre width, µm	43.81
Wall thickness, µm	4.96
Lumen width, µm	34.28
Length/width ratio	63
Runkel ratio	0.289
Flexibility ratio	0.78

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.1
Solubility, %	
in water	1.8
in 1 % NaOH	8.0
Ash, %	0.4
Lignin, %	28.8
Holocellulose, %	
Cross-Bevan cellulose, %	48.8
Pentosans, %	10.4

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	20
Kappa number	25
Yield (unscreened), %	47.6
Screenings, %	0.4
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	58.19
Burst index, kPa m^2/g	4.46
Tear index, mN m^2/g	14.6

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) at sheet density 0.600 g/cm^3

Scientific name: Pinus taeda L.	Common name: Loblolly pine Country: U.S.A.	Reference: 26

Wood sample characteristics

Wood sample origin:

Plantation
16 years

Density and fibre characteristics:

Basic density, kg/m^3	399
Fibre length, µm x)	2 870
Fibre width, µm	46.16
Wall thickness, µm	5.14
Lumen width, µm	35.87
Length/width ratio	62
Runkel ratio	0.290
Flexibility ratio	0.78

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	4.8
Solubility, %	
in water	1.5
in 1 % NaOH	10.8
Ash, %	0.4
Lignin, %	27.9
Holocellulose, %	
Cross-Bevan cellulose, %	45.5
Pentosans, %	12.5

Additional information:

Pulping and papermaking characteristics

Unbleached	
Process	Sulphate (170°C)
Chemical consumption, %	20
Kappa number	23
Yield (unscreened), %	42.0
Screenings, %	0.4
Brightness	
Beater or refiner	Jokro
Freeness	x)
Tensile index, N m/g	82.94
Burst index, kPa m^2/g	6.56
Tear index, mN m^2/g	15.4
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) at sheet density 0.600 g/cm^3

Scientific name: Pinus taeda	Common name: Loblolly pine Country: New Zealand	Reference: 68

Wood sample characteristics

Wood sample origin:

Sample from Ratoehu Forest
Wood age 25 a
Growth rate 30 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	330 (inner)	410 (outer wood)
Fibre length, µm x)	2 600 - 4 700	
Fibre width, µm		
Wall thickness, µm		
Lumen width, µm		
Length/width ratio		
Runkel ratio		
Flexibility ratio		

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	3.0
Ether	
Methanol	
Ethanol-benzene	
Solubility, %	
in water	
in 1 % NaOH	
Ash, %	
Lignin, %	
Holocellulose, %	
Cross-Bevan cellulose, %	
Pentosans, %	

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate (170°C)
Chemical consumption, %	
Kappa number	30
Yield (unscreened), %	45.2
Screenings, %	
Brightness	
Beater or refiner	PFI
Freeness	575
Tensile index, N m/g	80
Burst index, kPa m^2/g	7.0
Tear index, mN m^2/g	15.2

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Piptadenia communis
(Jacave)

Plantation experience

Piptadenia, with about 80 species, is abundantly represented in tropical South America, sparingly in tropical Africa and Asia and in New Guinea. The larger trees supply good timber of local utility, but their principal value is in the bark which is an important source of tanning material. Some species are planted for shade and decorative purposes in parks and along highways. The trees are at their best in northern Argentina and in Paraguay and Brazil.

References: 58

Wood characteristics

The species has very short fibres that are comparatively thin, but thick-walled.

Pulping characteristics

The wood requires a high alkali charge in sulphate cooking in order to arrive at acceptable levels of screenings. The pulp yield is low for a hardwood. The unbleached pulp exhibits strength characteristics similar to eucalypt pulp.

Scientific name: Piptadenia communis	Common name: Jacave Country: Brazil	Reference: 32

Wood sample characteristics

Wood sample origin:

Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	770
Fibre width, µm	18.2
Wall thickness, µm	3.5
Lumen width, µm	10.9
Length/width ratio	
Runkel ratio	0.65
Flexibility ratio	0.60

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	25 Na_2O (charge)
Kappa number x)	13.6
Yield (unscreened), %	48.8
Screenings, %	0.04
Brightness	
Beater or refiner	
Freeness	350 CSF
Tensile index, N m/g	113
Burst index, kPa m^2/g	5.2
Tear index, mN m^2/g	7.8

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) Permanganate Number

Piptadenia rigida

Plantation experience

The species is one of the best known Piptadenia species, generally considered to be the true Angico of southern Brazil. See Piptandenia communis.

References: 58

Wood characteristics

The species has short fibres that are thin, but thick-walled.

Pulping characteristics

A high charge of alkali is required for sulphate cooking, and the pulp is obtained in comparatively low yield for a hardwood. The strength characteristics of the pulp resemble those of eucalypt pulp.

Scientific name: Piptadenia rigida	Common name: Country: Brazil	Reference: 32

Wood sample characteristics

Wood sample origin:

Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State

Density and fibre characteristics:

Basic density, kg/m^3	
Fibre length, µm x)	1 130
Fibre width, µm	14.8
Wall thickness, µm	4.0
Lumen width, µm	6.8
Length/width ratio	
Runkel ratio	1.17
Flexibility ratio	0.46

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Sulphate
Chemical consumption, %	25 Na_2O (charge)
Kappa number x)	12.8
Yield (unscreened), %	45.3
Screenings, %	0.8
Brightness	
Beater or refiner	
Freeness	350 CSF
Tensile index, N m/g	118
Burst index, kPa m^2/g	6.7
Tear index, mN m^2/g	9.9

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information: x) Permanganate Number

Populus deltoides
(Eastern Cottonwood)

Plantation experience

It is a North American species that flourishes in the upper parts of the Mississippi and Missouri valleys. The tree is often planted for windbreaks, shade and pulpwood in the U.S.A., but particularly in Argentina and Chile. The present sample is from the Parana river alluvials, and its growth is reported as higher than 20 $m^3/ha \cdot a$.

References: 57, 58, 67

Wood characteristics

This low-density wood has fibres of about average length for hardwoods. The fibre width seems normal. The lignin content is about normal for hardwoods.

Pulping characteristics

The refiner mechanical pulp made from the wood exhibits comparatively low strength values. Impregnation of the fibre material with sodium hydroxide at ambient temperature reduces the brightness, but increases the strength properties to acceptable levels.

Scientific name: Populus deltoides CV. 1 - 63/51	Common name: Alamocarolino mejorado Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
20 - 25 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	335
Fibre length, µm x)	1 034
Fibre width, µm	22.1
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	46.8
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.30
Solubility, %	
in water	2.62
in 1 % NaOH	22.22
Ash, %	0.89
Lignin, %	23.72
Holocellulose, %	72.98
Cross-Bevan cellulose, %	56.41
Pentosans, %	20.11

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Mechanical	Cold soda (25°C)
Chemical consumption, %		4 - 20 g NaOH/l
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	60	48 - 45
Beater or refiner	Sprout Waldron	Bauer 606
Freeness	65 SR	65 SR
Tensile index, N m/g	15.3	17 - 45
Burst index, kPa m^2/g	0.6	-
Tear index, mN m^2/g	1.3	1.5 - 2.7

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Populus X euramericana

Plantation experience

The present samples represent various poplar hybrids, all grown in the Parana river delta in Argentina. No detailed information of the hybrids is available. The growth is reported to exceed 20 $m^3/ha \cdot a$.

References: 57

Wood characteristics

The wood characteristics - density 350 kg/m^3, fibre length about 1 mm and width 20 µm - are common for poplar species. The lignin content is also normal for hardwoods.

Pulping characteristics

The wood species have been tested as fibre sources for refiner mechanical pulp (RMP). According to the results, the RMP is of unacceptable strength, but by introduction of chemicals in the process the pulp strength can be improved considerably.

Scientific name: Populus 3 species	Common name: Poplar Country: Argentina	Reference: 25

Wood sample characteristics

Wood sample origin:

Delta of Parana River
mean values for 3 species of poplar
P. euramericana CV "1 - 154"
P. euramericana CV "1 - 214"
P. deltoides CV "1 - 63/51"

Density and fibre characteristics:

Basic density, kg/m^3	345
Fibre length, µm x)	1 038
Fibre width, µm	23
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	45
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.29
Solubility, %	
in water	2.55
in 1 % NaOH	20.86
Ash, %	1.01
Lignin, %	23.06
Holocellulose, %	72.35
Cross-Bevan cellulose, %	58.28
Pentosans, %	19.6

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Mechanical
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	
Beater or refiner	
Freeness	65 SR
Tensile index, N m/g	17
Burst index, kPa m^2/g	-
Tear index, mN m^2/g	1.5
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Scientific name: Populus euroamericana CV. 1 - 214	Common name: Alamo 214 Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
20 - 25 $m^3/ha \cdot a$

Density and fibre characteristics:

Basic density, kg/m^3	319
Fibre length, µm x)	994
Fibre width, µm	23.8
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	41.8
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.33
Solubility, %	
in water	2.50
in 1 % NaOH	21.22
Ash, %	0.99
Lignin, %	23.21
Holocellulose, %	70.95
Cross-Bevan cellulose, %	58.35
Pentosans, %	19.85

Additional information:

Pulping and papermaking characteristics

Unbleached

Process	Mechanical
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	57
	Sprout Waldron Bauer 606
Beater or refiner	
Freeness	65 SR
Tensile index, N m/g	15.5
Burst index, kPa m^2/g	0.6
Tear index, mN m^2/g	1.5

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	

Additional information:

Scientific name: Populus euroamericana CV. 1 - 154	Common name: Alamo AN Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
20 - 25 $m^3/ha \cdot a$

Density and fibre characteristics:

Basic density, kg/m^3	380
Fibre length, µm x)	1 086
Fibre width, µm	22.8
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	47.6
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.23
Solubility, %	
in water	2.52
in 1 % NaOH	19.14
Ash, %	1.15
Lignin, %	22.24
Holocellulose, %	73.13
Cross-Bevan cellulose, %	66.07
Pentosans, %	18.90

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	Mechanical	Cold soda (25°C)
Chemical consumption, %		4 - 20 g NaOH/l
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	53.5	41 - 33
Beater or refiner	Sprout Waldron 12" Bauer 606	Bauer 606
Freeness	65 SR	65 SR
Tensile index, N m/g	17.20	24 - 54
Burst index, kPa m^2/g	0.7	3.0 - 2.7
Tear index, mN m^2/g	1.9	
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		
Additional information:		

Salix alba

Plantation experience

The present sample is from Argentina. The stand density in the delta of Parana exceeded 1 000 trees/ha, and the capacity and growth were 200 m^3/ha and more than 15 m^3/ha.a respectively.

References: 57

Wood characteristics

As far as wood density, fibre dimensions and lignin content are concerned, the samples exhibit values typical of hardwoods.

Pulping characteristics

The refiner mechanical pulp and the cold soda pulp exhibit typical for poplars and willows. The sulphate process using a low alkali charge gives pulp in low yiled and strength properties similar to those of beech pulp.

Scientific name: Salix alba var. Calva	Common name: Sauce alamo Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
1 650 - 1 100 plants/ha
180 - 230 m^3/ha
15 - 20 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	404
Fibre length, µm x)	1 094
Fibre width, µm	22.3
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	49.1
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.02
Solubility, %	
in water	3.50
in 1 % NaOH	19.96
Ash, %	0.99
Lignin, %	21.78
Holocellulose, %	75.13
Cross-Bevan cellulose, %	56.39
Pentosans, %	19.61

Additional information:

Pulping and papermaking characteristics

Unbleached		
Process	Mechanical	Cold soda (25°C)
Chemical consumption, %		4 - 20 g NaOH/l
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	51.6	59 - 54
Beater or refiner	Bauer 606	
Freeness	60 SR	65 SR
Tensile index, N m/g	17.8	25 - 64
Burst index, kPa m^2/g	0.7	-
Tear index, mN m^2/g	2.3	2.0 - 3.5
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information:

Salix X argentinensis
(Willow Hybrid)

Plantation experience

More than 200 species of Salix have been described, mostly of temperate regions, but ranging from the tropics to the arctic circle. They are chiefly shrubs and small poorly formed trees, but a few of them attain large dimensions. The pliable young shoots of some species are employed in making baskets and mats to protect river banks. They are often planted along streams and irrigation ditches to prevent erosion. The present samples of natural willow hybrids are from 200 m^3/ha stands in the delta of Parana. The growth rate exceeds 15 m^3/ha·a.

References: 57, 58

Wood characteristics

The wood density is comparatively low for a hardwood, and the fibre length about or slightly below average. The lignin content is relatively constant irrespective of hybrid, and about average for hardwoods.

Pulping characteristics

The strength characteristics of the refiner mechanical pulp are unsatisfactory, but treatment with sodium hydroxide at low temperatures or NSSC-pulping at high temperatures considerably improve these values.

Scientific name: Salix X argentinensis cv. Hibrido X salix alba A-114-1	Common name: Sauce A-114-1 Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
15 - 20 m^3/ha•a

Density and fibre characteristics:

Basic density, kg/m^3	295
Fibre length, µm x)	879
Fibre width, µm	18.0
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	48.8
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.71
Solubility, %	
in water	3.48
in 1 % NaOH	20.35
Ash, %	0.83
Lignin, %	21.28
Holocellulose, %	74.76
Cross-Bevan cellulose, %	60.09
Pentosans, %	20.67

Additional information:

Pulping and papermaking characteristics			
Unbleached	**Mechanical**	**Cold soda (75°C)**	**NSSC (170°C)**
Process			
Chemical consumption, %			25 - 50 Na_2SO_3/l
Kappa number			
Yield (unscreened), %			
Screenings, %			
Brightness	45	45 - 28	43 - 40
Beater or refiner	Sprout Waldron 12"	Bauer 606	Bauer 606	Bauer
Freeness	65 SR	65 SR	65 SR
Tensile index, N m/g	11.5	21 - 68	79.5 - 89.5
Burst index, kPa m^2/g	0.6	1.0 - 4.0	5.7 - 8.4
Tear index, mN m^2/g	1.4	2.2 - 3.3	3.5 - 3.8
Bleached			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			
Additional information:			

Scientific name: Salix X argentinensis cv. Hibrido	Common name: Sauce hibrido Country: Argentina	References: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
180 - 230 m^3/ha
15 - 20 m^3/ha·a
natural hybrid

Density and fibre characteristics:

Basic density, kg/m^3	370
Fibre length, µm x)	940
Fibre width, µm	25.8
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	36.4
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	3.23
Solubility, %	
in water	4.37
in 1 % NaOH	21.00
Ash, %	1.00
Lignin, %	22.16
Holocellulose, %	71.93
Cross-Bevan cellulose, %	57.14
Pentosans, %	20.86

Additional information:

Pulping and papermaking characteristics	
Unbleached	
Process	Mechanical
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	45
Beater or refiner	Sprout Waldron 12" Bauer 606
Freeness	65 SR
Tensile index, N m/g	20.27
Burst index, kPa m^2/g	0.8
Tear index, mN m^2/g	2.4
Bleached	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m^2/g	
Tear index, mN m^2/g	
Additional information:	

Scientific name: Salix X argentinensis cv. Mestizo	Common name: Sauce mestizo Country: Argentina	References: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
180 - 230 m^3/ha
15 - 20 m^3/ha·a
Natural hybrid

Density and fibre characteristics:

Basic density, kg/m^3	409
Fibre length, µm x)	1 031
Fibre width, µm	25.5
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	40.4
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.92
Solubility, %	
in water	2.40
in 1 % NaOH	21.11
Ash, %	0.89
Lignin, %	23.24
Holocellulose, %	74.52
Cross-Bevan cellulose, %	58.51
Pentosans, %	20.26

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	Mechanical	
Chemical consumption, %		
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	50.8	
Beater or refiner	Sprout Waldron 12"	Bauer 606
Freeness	65 SR	
Tensile index, N m/g	17.69	
Burst index, kPa m^2/g	0.7	
Tear index, mN m^2/g	2.4	
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		
Additional information:		

Scientific name: Salix X argentinensis cv. H. santafesino	Common name: Hibrido Santafesino Country: Argentina	References: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
180 - 230 m^3/ha
15 - 20 m^3/ha·a
Natural hybrid

Density and fibre characteristics:

Basic density, kg/m^3	362
Fibre length, µm x)	962
Fibre width, µm	21.0
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	46.1
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	1.78
Solubility, %	
in water	2.73
in 1 % NaOH	18.00
Ash, %	0.64
Lignin, %	21.77
Holocellulose, %	73.69
Cross-Bevan cellulose, %	60.16
Pentosans, %	22.44

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	Mechanical	NSSC (170°C)
Chemical consumption, %		25 - 50 g Na_2SO_3/l
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	50	43 - 40
Beater or refiner	Sprout Waldron 12" Bauer 606	Bauer 606
Freeness	60 SR	65 SR
Tensile index, N m/g	13.60	77.5 - 83.0
Burst index, kPa m^2/g	0.6	5.2 - 5.6
Tear index, mN m^2/g	1.7	4.2 - 3.5
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		
Additional information:		

Salix babylonica var. sacramento
(Sauce Americano)

Plantation experience

The sample is taken from a 200 m^3/ha stand in the delta of Parana. The growth rate exceeds 15 m^3/ha·a.

References: 57

Wood characteristics

The wood density and the fibre length are higher than values normally found for willows; they are 450 kg/m^3 and 1.3 mm respectively. The lignin content is in the range normal for hardwoods.

Pulping characteristics

The refiner mechanical pulp exhibits strength characteristics which are not quite up to standard. Treatment before refining with sodium hydroxide considerably improves the strength characteristics of the pulp to a very good level.

Scientific name: Salix babylonica var. sacramento	Common name: Sauce Americano Country: Argentina	Reference: 57

Wood sample characteristics

Wood sample origin:

Delta of Parana River
180 - 230 m^3/ha
15 - 20 m^3/ha·a

Density and fibre characteristics:

Basic density, kg/m^3	463
Fibre length, µm x)	1 316
Fibre width, µm	21.5
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	61.2
Runkel ratio	
Flexibility ratio	

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %	
Ether	
Methanol	
Ethanol-benzene	2.75
Solubility, %	
in water	3.19
in 1 % NaOH	18.37
Ash, %	0.84
Lignin, %	22.53
Holocellulose, %	71.03
Cross-Bevan cellulose, %	56.66
Pentosans, %	18.83

Additional information:

Pulping and papermaking characteristics		
Unbleached		
Process	Mechanical	Cold soda (25°C)
Chemical consumption, %		4 - 20 g NaOH/l
Kappa number		
Yield (unscreened), %		
Screenings, %		
Brightness	52	
Beater or refiner	Sprout Waldron/Bauer 606	Bauer 606
Freeness	65 SR	60 SR
Tensile index, N m/g	21.30	25 - 64
Burst index, kPa m^2/g	0.8	-
Tear index, mN m^2/g	2.3	3.6 - 4.1
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		
Additional information:		

Sesbania grandifolia

Plantation experience

The tree grows during 4.5 years up to above 10 m in height and over 200 mm in diameter at breast height, under irrigated plantation conditions. The present sample is from Australia.

References: 41

Wood characteristics

The medium-density wood contains average length fibres. No chemical characteristics are available for the present sample.

Pulping characteristics

Sulphate pulp has been obtained in comparatively low yield and its strength characteristics correspond roughly to those of beech sulphate pulp. The bleaching response is quite acceptable, but strength losses occur particularly as regards the tensile strength. NSSC pulping gives pulp with good strength characteristics.

Scientific name: Sesbania grandifolia Pers.	Common name: Country: Australia	References: 41

Wood sample characteristics

Wood sample origin:

Kimberley Research Station, Kununurra, W. (Order River Irrigation Area) Australia
4.5 years old trees from irrigated plantation
Diameters (bh) 20 - 33 cm
Heights 10.8 - 12.9 m
Butt, middle and top logs of 7 trees

Density and fibre characteristics:

Basic density, kg/m^3	356
Fibre length, µm x)	1 140
Fibre width, µm	
Wall thickness, µm	
Lumen width, µm	
Length/width ratio	
Runkel ratio	
Flexibility ratio	

Additional information:

15 - 19 % bark (by volume) of logs

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
- Ether
- Methanol
- Ethanol-benzene

Solubility, %
- in water
- in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached		
Process	Sulphate	NSSC
Chemical consumption, %	15 (charge)	15 - 25% Na_2SO_3+3.5 - 5.8% Na_2CO_3 (charge)
Kappa number	21.1	150 - 129
Yield (unscreened), %	46.3	71 - 60
Screenings, %	0.4	0
Brightness		
Beater or refiner	PFI	203 mm Bauer lab. refiner
Freeness	300 CSF	300 CSF
Tensile index, N m/g	75	50 - 70
Burst index, kPa m^2/g	-	-
Tear index, mN m^2/g	9	6 - 7
Bleached		
Sequence	CEHD	
Chemical consumption, %	5.4 (% Cl in Cand H)	
Yield on bleaching, %	95.3	
Total yield, %	43.8	
Brightness	88.7 % Elrepho	
Beater or refiner	PFI	
Freeness	300 CSF	
Tensile index, N m/g	55	
Burst index, kPa m^2/g	-	
Tear index, mN m^2/g	8	
Additional information:	Sulphidity 25%, 2 h at max.temp. 170°C	2 - 3 h at max.temp. 170 - 180°C

Terminalia brassii

Plantation experience

Terminalia, with about 200 named species of shrubs and medium-sized to very large trees, is of pantropical distribution. Numerous American forms of Terminalia are imperfectly known. Their combined range extends from the West Indies and Mexico to southern Brazil and northern Argentina. The trees are often tall and well formed. The timber is of good quality, but it is not extensively used.

References: 22, 58

Wood characteristics

The wood is of low density. Fibre dimensions and the lignin content of the wood sample are not reported.

Pulping characteristics

The sulphate cook gives normal yield at suitable Kappa number levels. The pulp yield is low for hardwood sulphate pulps. The chemical charge is quite normal for hardwoods. The strength characteristics of the pulp are similar to Scandinavian birch pulp.

Scientific name: Terminalia brassii	Common name: Country: Papua New Guinea	References: 56

Wood sample characteristics

Wood sample origin:

Sample from Keravat, New Britain
a) 4, b) 6 and c) 9 year old

Density and fibre characteristics:

Basic density, kg/m^3 a) 302 b) 267 c) 287
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached	a	b	c
Process	Sulphate	Sulphate	Sulphate
Chemical consumption, %	16 x)	16 x)	16 x)
Kappa number	22.4	19.4	19.5
Yield (unscreened), %	48.0	48.5	48.5
Screenings, %	0.3	0.1	-
Brightness			
Beater or refiner	PFI	PFI	PFI
Freeness	300 CSF	300 CSF	300 CSF
Tensile index, N m/g	115	135	135
Burst index, kPa m^2/g			
Tear index, mN m^2/g	9.6	7.8	8.9
Bleached			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m^2/g			
Tear index, mN m^2/g			

Additional information: x) Total alkali charge as Na_2O

Scientific name: Terminalia brassii	Common name: Country: Solomon Island	References: 22

Wood sample characteristics

Wood sample origin:

Sample from trees a) 30 and b) 12 years old

Density and fibre characteristics:

Basic density, kg/m^3 a) 325 b) 370
Fibre length, µm x)
Fibre width, µm
Wall thickness, µm
Lumen width, µm
Length/width ratio
Runkel ratio
Flexibility ratio

Additional information:

x) 1000 µm = 1mm

Chemical characteristics:

Extractives, %
  Ether
  Methanol
  Ethanol-benzene

Solubility, %
  in water
  in 1 % NaOH

Ash, %
Lignin, %
Holocellulose, %
Cross-Bevan cellulose, %
Pentosans, %

Additional information:

Pulping and papermaking characteristics

Unbleached	a	b
Process	Sulphate	Sulphate
Chemical consumption, %	16 x)	16 x)
Kappa number	36.3	33.4
Yield (unscreened), %	48.0	49.3
Screenings, %	0.1	0.7
Brightness		
Beater or refiner	PFI	PFI
Freeness	205	220
Tensile index, N m/g	95	95
Burst index, kPa m^2/g	8	9
Tear index, mN m^2/g	13	13
Bleached		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m^2/g		
Tear index, mN m^2/g		

Additional information:

Appendix I

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Appendix II

DEFINITION OF TERMS USED

I. Wood sample characteristics

Basic density	The ratio of oven dry weight of the sample to its green (wet) volume.
Runkel ratio	2 x fibre wall thickness/lumen width
Flexibility ratio	Lumen width/fibre width
Holocellulose	The residue after extraction and delignification, either with chlorine or chlorite. It is supposed to represent the total content of carbohydrates in the wood - cellulose + hemicellulose (non-cellulosic carbohydrates) - but usually some carbohydrates are lost during the delignification treatment and some lignin is retained.
Cross-Bevan cellulose	The residue in percent of oven dry wood after treatment with a succession of chlorine, sulphur dioxide water, sodium sulphite and a 17.5% solution of sodium hydroxide. It is an approximation of the cellulose content of the wood but can sometimes be seriously in error.

II. Pulping and Paper-making Characteristics

II.1. Unbleached

Processes:

Sulphate	A process for digestion of the wood with sodium hydroxide and sodium sulphide as chemicals at temperatures between 150°C and 170°C. The pulp obtained with a very low charge of chemicals and at high yield is called crude sulphate pulp.
Chemical soda	A process of digestion of the wood with sodium hydroxide alone as cooking chemical at temperatures between 90°C and 170°C.

Cold soda	A chemi-mechanical or semi-mechanical process where the wood is impregnated with sodium hydroxide at ambient temperature and thereafter given a mechanical treatment in order to obtain defibration of the chips.
NSSC	A semi-chemical process, Neutral Sulphite Semi-Chemical, and as the name suggests, it comprises treatment of the wood chips with a sodium sulphite solution with an addition of sodium carbonate in order to arrive at neutral or slightly alkaline conditions. This treatment is carried out at elevated temperatures and followed by mechanical treatment.
Sodium bisulphite	A semi-chemical or chemical process with sodium bisulphite as cooking chemical is carried out at slightly acid conditions. The temperature range is usually 130-160°C. If the yield is left high, a mechanical treatment is given as a second stage (semi-chemical or high-yield bi-sulphite pulp).
Groundwood	A mechanical pulping process where defibration is achieved by grinding wood billets on a stone grinder.
Refiner mechanical pulp (RMP)	A mechanical pulping process where defibration of the chips is obtained by means of refining in disc refiners.
Thermomechanical pulp (TMP, CTMP)	See "RMP". The refining is made at elevated temperatures (TMP). Chemical treatment at low temperatures followed by refining at elevated temperatures (CTMP).
Chemical consumption	The consumption of chemicals in the process expressed as precent of oven dry wood.
Kappa number	The consumption of a 0.1 N potassium permanganate solution by 1 g of pulp, under specified conditions and expressed as the consumption in ml corresponding to 50% consumption of the volume of solution added. It is a direct measure of the content of residual lignin in the pulp.
Yield (unscreened)	The yield of pulp in the process, expressed in percent of oven dry wood.

Screenings — The amount of shives and knots in the pulp retained by a screen and expressed in percent of oven dry wood.

Brightness — The brightness of a sheet of pulp, measured under specified conditions with a blue filter (457 nm) and expressed as reflection factor with smoked magnesium oxide as 100.

Freeness — Also called "wetness" or "degree of beating" it expresses how extensive the beating or refining treatment has been. Two scales are applied in this context:
a) the Canadian Standard Freeness (CSF) with a graduation from 1 000 to 0 and
b) the Sohopper Riegler (SR) value with a graduation from 0 to 100. They are not linearly related. The following table gives a rough comparison of the two scales:

CSF	SR
700	15
600	20
500	25
400	32
300	40
200	52
100	68

Tensile index — A measure of the tensile strength of the paper under standard conditions (conversion factor from breaking length in m to tensile index in $N.m/g \approx 0.01$).

Burst index — A measure of the pressure at which the paper will burst as determined under standard conditions (conversion factor from burst factor to burst index in $kPa.m^2/g \simeq 0.1$).

Tear index — A measure of the tearing resistance of the paper under standard conditions of test (conversion factor from tear factor to tear index in $mN.m^2/g \simeq 0.1$).

II.2 Bleached

Sequence — A description of the stages of bleaching applied to the pulp. The following abbreviations are used:

	C	Chlorination
	E	Extraction with sodium hydroxide
	H	Hypochlorite treatment
	D	Chlorine dioxide treatment
	P	Peroxide treatment
	HS	Hydrosulphite (dithionite) treatment
Yield on bleaching		The yield on bleaching expressed in percent of unbleached pulp.
Total yield on bleaching		The total yield of pulp after bleaching, expressed in percent of oven dry wood.
Brightness		See "Unbleached"
Freeness		See "Unbleached"
Tensile index		See "Unbleached"
Burst index		See "Unbleached"
Tear index		See "Unbleached"

Appendix III

LIST OF SPECIES EVALUATED FOR PULPING CHARACTERISTICS

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