臺灣省林業試驗所 林務局 合作試驗報告

第一六號

CO-OPERATIVE BULLETIN
of
TAIWAN FORESTRY RESEARCH INSTITUTE
in co-operation with
TAIWAN FORESTRY BUREAU
No. 16

濶葉樹材混合製漿造紙試驗

I 荖濃事業區

谷雲川 邱俊雄

Pulping and Papermaking Experiments on Conversion Hardwood Mixtures

I. Lao Nung Working Cycle

by
Y. C. Ku C. H. Chiou

中華民國六十一年十月
臺灣省林業試驗所印行
臺灣 臺北

Published by
TAIWAN FORESTRY RESEARCH INSTITUTE
Taipei, Taiwan, China
Oct. 1972

目　　次 (Contents)

本計劃承國家科學委員會及林務局之補助謹此致謝。

濶葉樹材混合製漿造紙試驗

I �englishi濃事業區

谷 雲 川　　邱 俊 雄

提　　要

本試驗乃是探討林相改良濶葉樹材混合製漿之可能性，以提高其經濟利用價值。報告中曾分別就木材各種性質，單一樹種製漿及混合樹種製漿之結果，以及混合樹種造紙之性質加以討論。單一樹種不論收率及品質均以南投黃肉楠、木荷、豬腳楠及杜英為最好，混合樹種製漿之收率比一般針濶葉樹高，其品質略低於針葉樹，但與一般濶葉樹相比較，則不僅不差，且撕力比較高。抄製包裝紙可代替一部份進口牛皮漿，另外抄製印書紙品質甚好。由本試驗證明，林相改良濶葉樹材可以成功的大量用做製漿造紙之用。

一、緒　言 (Introduction)

本省近年來林務局進行大面積之林相改良，所變更之地區幾乎全為單位面積蓄積量非常低之濶葉樹材。其所伐採之木材除一小部份經濟價值較高可供為家具俱建築材料外，其他則多為利用價值低之所謂雜木，而這些木材在本省嚴重缺少造紙原料狀況下，正是造紙纖維工業所需要之最好原料。

臺灣開始利用濶葉樹為原料來造紙，不過為近幾年來的事，而且由於種類複雜，單一利用某些樹種大量製漿時根本不可能，因而必需就現有之樹種混合製漿，並且以硫酸鹽法最為適宜。本計劃乃是配合本所顧問聯合國林產專家徐倫本博士 (Dr. H. F. Schlumbom) 所建議，為了多目標利用林相改良之濶葉樹材，所伐採之試材下端部份將用作乾燥及强度試驗用，而本試驗所用之木材多為上端及枝稍材。

本試驗之目的，乃是配合造紙業之需要，利用本省林相改良所伐採之濶葉樹材，找出其最適宜之蒸煮條件及紙漿之性質，並混合其它紙漿抄製各種紙張，使濶葉樹材能達到最高利用價值，其所得之結果，各紙廠可以直接加以參考利用。

本試驗分五年完成，但除試材分別來自本省各不同林相改良地區外，其它一切實施方法均完全相同。因而各有其獨立性，而本期之資料並可供以後相互對照之用，使資料更為完整。文中謬誤之處難免；尚希先進不吝指教是幸。

二、試驗材料 (Raw Material)

本試驗之試材，乃是由臺灣南部�englishi濃事業區第57及58林班，海拔高度自1550至1650公尺，其傾斜度由西至東南，利用逢機取樣法，沿林道上方經調查鑑定之樹種計有30株，其胸高直徑均在35至60公分之間，實際伐採18株（17種不同樹種）以供本試驗之用。

試材名稱及一些特性見下表：

第一表　樹種之名稱、年齡、胸高、直徑及樹高

Table 1. Name、Age、DBH Diameter、and Height of Trees

樹種編號 Tree Numbers	科名 Family Names	種名 Species Names	樹齡(年) Tree Age year	胸高直徑 (cm) D.B.H.	樹高 (m) Tree Height
13	八角茴香科 Illiciaceae	紅花八角 Illicium arborescens Hay.	(146)	42	18
14	八角茴香科 Illiciaceae	紅花八角 Illicium arborescens Hay.	(169)	48	18
5	樟科 Lauraceae	南投黃肉楠 Actinodaphne nantoensis Hay.	(113)	51	17.5
18	樟科 Lauraceae	瓊楠 Beilschmiedia erythrophloia Hay.	(137)	48	26
22	樟科 Lauraceae	尖葉楠 Machilus acuminatissima Kaneh.	(120)	54	24
17	樟科 Lauraceae	假長葉楠 Machilus Pseudo—longifolia Hay.	63	31	12
24	樟科 Lauraceae	猪脚楠 Machilus thunbergii Sieb. et Zucc.	64	46	16
11	樟科 Lauraceae	變葉新木薑子 Neolitsea Variabillima Ka. et Sa.	82	39	16
27	樺木科 Betulaceae	臺灣赤楊 Alnus formosana Makino.	60	52	17
10	殼斗科 Fagaceae	長尾柯 Castanopsis carlesii Hay.	54	49	24
6	殼斗科 Fagaceae	錐果櫟 Cyclobalanopsis longinux Schott.	(118)	35	20
25	殼斗科 Fagaceae	狹葉櫟 Cyclobalanopsis stenophylloides Kudo.	89	48	20
1	殼斗科 Fagaceae	鬼櫟 Lithocarpus lepidocarpa Hay.	(85)	45	19
4	殼斗科 Fagaceae	油葉杜 Pasania brevicaudata Schott.	87	52	16
21	殼斗科 Fagaceae	大葉校栗 Pasania kawakamii Schott.	97	44	20
2	膽八樹科 Elaeocarpaceae	杜英 Elaeocarpus sylvestris Poiret.	74	43	20
9	山茶科 Theaceae	木荷 Shima superba Gard. et Champ.	(160)	42	22
12	山茶科 Theaceae	厚皮香 Ternstroemia gymnanthera Sprague	(206)	42	19

註：附有（　）號之樹齡，不甚準確。

Tree ages in brackets (　) could not clearly be measured.

運回之試材均先剝皮再鋸成2吋× 2.5吋×6呎之角材，經氣乾後再以人工切成大小約爲1×½×⅛吋之切片，分別測定其含水量，然後置於塑膠袋內備用。混合蒸煮之試材，乃是根據調查時樹種出現之頻率乘以該樹種之比重，然後測得該樹種所佔之百分比，以百分比混合各試材木片，置於塑膠袋內備用。

三、試驗程序 (Experimental Procedures)

依照 TAPPI Standard Methods 測定各試材灰分、熱水抽出物、百分之一燒碱抽出物、苯醇抽出物、乙醚抽出物、戊醣含量及木質素含量，另外用 Wise Methods 測定全纖維素及阿爾發纖維素含量。

單一蒸煮取 500克絕乾重之試材，放入3公升不銹鋼之蒸煮釜內，用電間接加熱，溫度由變壓器控制可達到 ±2°C，開始蒸煮時打開排氣管直到蒸煮液噴出時再關閉，以排出蒸煮釜內之空氣。蒸煮條件爲總鹼 15%算爲 Na_2O、硫化度25%、液比4：1、溫度 170 °C、蒸煮上升時間爲一小時半、保持時間爲一小時半。混合蒸煮除總鹼爲13%、15%、17%及19%，溫度爲 165°C 及 170°C 外，其它條件均與單一蒸煮相同。所有紙漿，均經洗滌乾淨打散，並測定其收率及高錳酸鉀價。打漿是在 Niagara 型標準打漿機中進行，打漿濃度爲1.57%，所有紙漿均分別打至自由度 500 ml 及 300 ml (加拿大標準) 左右。按照 Tappi 規定抄製手抄紙，各種强度之測定均在相對濕度爲65%，溫度爲 20°C 新建之恆溫恆濕之物理實驗室中進行。

由上面所得之最佳條件紙漿，再配合其它紙漿，利用實驗用長網造紙機抄製不同比例之紙張，並在恆溫恆濕之物理實驗室中進行各種强度之測定。

四、結果與討論 (Results and Discussion)

1. 纖維形態及化學組成 (Fiber Morphology and Chemical Composition)

第二表 木材纖維長寬度

Table 2. The Fiber Dimension of Hardwoods

種名 Species Names	纖維長度 Fiber Length (mm)			纖維寬度 Fiber Width (μ)			細胞壁厚度 (μ) Thickness of Cell Wall			長寬比 Length Width Ratio
	最大 Max.	最小 Min.	平均 Av.	最大 Max.	最小 Min.	平均 Av.	最大 Max.	最小 Min.	平均 Av.	
紅花八角 Illicium arborescens	2.2	0.3	1.13	37	17	24	8.8	2.2	5.5	48
南投黃肉楠 Actinodaphne nantoensis	3.25	1.0	2.25	30	17	23	6.5	2.2	3.6	98
瓊楠 Beilschmiedia erythrophloia	1.8	0.8	1.35	35	13	22	8.7	2.2	4.5	61
尖葉楠 Machilus acuminatissima	1.5	0.7	1.11	30	13	24	8.7	2.2	4.1	47
假長葉楠 Machilus pseudo—longifolia	1.6	0.6	1.18	30	15	23	10.9	6.5	8.7	50
猪脚楠 Machilus thunbergii	1.6	0.5	1.12	28	17	23	8.7	2.2	6.3	48
變葉新木薑子 Neolitsea variabillima	1.8	0.5	1.19	28	13	28	8.8	2.2	3.7	43

臺灣赤楊 Alnus formosana	1.8	0.5	1.25	37	15	26	8.8	2.2	5.1	49
長尾柯 Castanopsis carlesii	1.9	0.7	1.18	28	13	21	8.7	2.2	5.5	55
錐果櫟 Cyclobalanopsis longinux	2.0	0.7	1.38	28	13	22	10.9	2.2	6.4	61
狹葉櫟 Cyclobalanopsis stenophylloides	2.1	0.9	1.37	26	13	21	8.7	2.2	4.9	66
鬼櫟 Lithocarpus lepidocarpa	1.9	0.8	1.24	37	13	21	8.7	2.2	4.9	59
油葉杜 Pasania brevicaudata	1.8	0.8	1.22	24	13	20	8.7	2.2	4.7	62
大葉校栗 Pasania kawakamii	2.1	0.7	1.30	28	13	21	10.9	4.3	7.0	62
杜英 Elaeocarpus sylvestris	1.6	0.5	0.99	28	15	21	6.6	2.2	3.9	47
木荷 Schima superba	2.0	1.0	1.53	26	13	19	11.0	2.2	4.9	81
厚皮香 Ternstroemia gymnanthera	3.3	1.3	2.06	35	17	27	8.7	2.2	6.6	76

由上表可以看出南投黃肉楠及厚皮香之纖維長度最長，另外木荷及殼斗科內之六種樹種亦較其它樹種爲長，纖維寬度與細胞壁厚與一般濶葉樹相似，一般來說濶葉樹之纖維比針葉樹及竹材短，因而所得之紙其撕力比較低。

第三表　木材化學組成

Table 3. Chemical Composition of Hardwoods

種名 Species Names	水分 Moisture Content %	灰分 Ash %	抽出物 Extratives % 乙醚 Ether	抽出物 Extratives % 熱水 Hot Water	抽出物 Extratives % 百分之一燒碱 1% NaOH	抽出物 Extratives % 苯醇 Alcohol-Benzene	戊醣 Pentosan %	木質素 Lignin %	全纖*維素 Holocellulose %	阿而發纖維素* α-Cellulose %	比重** Specific Gravity
紅花八角 Illicium arborescens	9.35	0.31	0.79	2.66	16.36	2.72	17.87	30.30	86.31	48.56	0.49
南投黃肉楠 Actinodaphne nantoensis	8.98	0.65	1.53	2.93	20.79	2.86	17.33	25.60	86.81	50.67	0.50
瓊楠 Beilschmiedia erythrophloia	11.40	1.63	1.59	3.20	20.12	1.31	16.32	23.15	84.75	46.36	0.53
尖葉楠 Machilus acuminatissima	11.20	0.56	2.07	3.66	14.60	4.97	19.07	24.40	84.15	59.17	0.52
假長葉楠 Machilus pseudolongifolia	8.75	1.11	1.37	9.39	22.28	3.92	17.93	27.09	80.64	47.00	0.50
猪脚楠 Machilus thunbergii	15.63	0.97	1.45	4.40	21.06	4.71	20.26	18.70	81.48	52.95	0.61
變葉新木薑子 Neolitsea variabillima	13.20	0.59	1.62	3.18	14.54	2.99	15.40	22.92	85.47	52.03	0.53

臺灣赤楊 Alnus formosana	12.13	0.61	1.68	2.48	16.58	2.06	23.72	23.95	86.12	44.73	0.51
長尾柯 Castanopsis carlesii	12.35	0.60	1.54	11.37	22.49	2.94	13.78	22.79	78.27	47.88	0.52
錐果櫟 Cyclobalanopsis longinux	11.57	0.51	1.59	5.06	23.05	3.10	15.93	22.15	83.77	53.02	0.75
狹葉櫟 Cyclobalanopsis stenophylloides	12.87	0.62	1.70	5.87	22.21	3.06	16.47	20.61	83.28	51.01	0.71
鬼櫟 Lithocarpus lepidocarpa	12.45	0.53	1.67	2.80	15.08	3.19	15.90	22.90	86.74	54.09	0.70
油葉杜 Pasania brevicaudata	11.75	0.58	1.56	2.17	18.43	3.08	16.51	25.99	82.48	5575	0.63
大葉校栗 Pasania kawakamii	11.68	1.00	0.89	4.12	18.20	3.07	20.47	23.03	86.96	57.49	0.60
杜英 Elaeocarpus sylvestris	9.57	0.45	1.53	4.54	18.40	3.38	21.35	22.98	79.47	42.06	0.59
木荷 Schima superba	9.27	0.49	1.49	2.57	19.23	2.48	14.42	28.78	86.09	47.46	0.54
厚皮香 Ternstroemia gymnanthera	8.10	0.46	1.44	5.92	20.94	6.15	18.09	30.47	76.15	41.55	0.58

* 灰分及木質素未改水 Ash and lignin uncorrected.

** 生材體積爐乾重量 Green Volume. Ovendry Weight.

由上表可以看出，灰分除瓊楠較高外其它均與一般濶葉樹相似，抽出物則以猪脚楠及尖葉楠，厚皮香比較高，木質素則以紅花八角及厚皮香較高，而纖維素以厚皮香特別低，此兩種均會使紙漿收率降低，比重則以殼斗科比較高。

2. 蒸煮試驗 (Pulping Experiment)

(一) 單一樹種蒸煮 (Single Species Cooking)

第四表 單一樹種蒸煮之結果

Table 4. Kraft Pulping Results of Individual Species

編號 No.	種名 Species Names	蒸解收率 Screened yield %	未蒸解部份 Screen rejects %	未漂白度 Pulp brightness % Elrepho	高錳酸鉀價 Permanganate no. ml.
13	紅花八角 Illicium arborescens	41.1	0.3	16.2	26
14	紅花八角 Illicium arborescens	40.1	0.4	13.5	32
5	南投黃肉楠 Actinodaphne nantoensis	48.5	—	25.1	16
18	瓊楠 Beilschmiedia erythrophloia	41.6	0.4	24.4	17

22	尖葉楠 Machilus acuminatissima	47.1	—	23.3	11
17a	假長葉楠 Machilus pseudolongifolia	54.6	—	23.9	10
17b	假長葉楠 Machilus pseudolongifolia	55.7	—	21.5	13
24	猪脚楠 Machilus thunbergii	47.8	0.1	17.8	15
11	變葉新木薑子 Neolitsea variabillima	50.7	—	22.0	14
27	臺灣赤楊 Alnus formosana	45.2	0.1	19.8	19
10	長尾柯 Castanopsis carlesii	50.3	0.1	16.3	19
6	錐果櫟 Cyclobalanopsis longinux	46.6	0.2	20.0	16
25	狹葉櫟 Cyclobalanopsis stenophylloides	43.3	0.4	15.5	24
1	鬼櫟 Lithocarpus lepidocarpa	49.2	0.1	25.0	9
4	油葉杜 Pasania brevicaudata	43.1	1.9	20.9	19
21	大葉校栗 Pasania kawakamii	48.1	—	23.1	15
2	杜英 Elaeocarpus sylvestris	46.1	—	26.5	12
9	木荷 Shima superba	48.3	0.4	22.1	13
12a	厚皮香 Ternstroemia gymnanthera	38.2	0.2	18.9	14
12b	厚皮香 Ternstroemia gymnanthra	41.5	—	18.6	13

註：蒸煮條件相同見「試驗程序」

Cooking Conditions are the Same, See "Experimental Procedures"

由上表可以看出收率以紅花八角、瓊楠、狹葉櫟、油葉杜及厚皮香較低，且其中油葉杜不易蒸解，而以假長葉楠爲最高，高達百分之五十五，高錳酸鉀價則以紅花八角及狹葉櫟最高，另外油葉杜，臺灣赤楊及長尾柯亦較高，而這些高錳酸鉀價高之樹種，其紙漿未漂白度也比較低，而顯示出不易漂白。

第五表 單一樹種紙漿之性質

Table 5. Kraft Pulp Properties of Individual Species

編 號 No.	種 名 Species Names	打漿時間 Beating Time min.	自由度 Pulp Freeness c.s.f. ml	裂斷長 Breaking Length km.	撕力比 Tear Factor	破裂比 Burst Factor	耐摺力 Folding Endurance M.I.T. double folds
13	紅花八角 Illicium arborescens	9	490	6.17	123	41.4	126
14	紅花八角 Inllicium arboescens	10	500	5.06	121	27.1	23
5	南投黃肉楠 Actinodaphne nantoensis	12	500	6.84	144	39.0	36
18	瓊楠 Beilschmiedia erythrophloia	8	500	5.52	117	36.8	35
22	尖葉楠 Machilus acuminatissima	6	505	5.73	101	35.8	22
17a	假長葉楠 Machilus pseudo—longifolia	12	500	4.54	104	24.4	11
17b	假長葉楠 Machilus pseudo—longifolia	15	500	5.23	80	30.5	31
24	猪脚楠 Machilus thunbergii	7	500	7.03	111	42.9	75
11	變葉新木薑子 Neolitsea variabjllima	11	500	5.78	101	32.1	31
27	臺灣赤楊 Alnus formosana	8	490	6.08	71	35.9	88
10	長尾柯 Castanopsis carlesii	13	495	5.96	121	33.0	35
6	錐果櫟 Cyclobalanopsis longinux	11	490	5.08	121	27.7	15
25	狹葉櫟 Cyclobalanopsis stenophylloides	11	500	4.78	120	27.0	12
1	鬼櫟 Lithocarpus lepidocarpa	12	500	4.84	112	24.1	9
4	油葉杜 Pasania brevicaudata	7	500	4.37	109	26.7	11
21	大葉校栗 Pasania kawakamii	10	500	5.36	111	30.2	26
2	杜英 Elaeocarpus sylvestris	8	500	7.00	119	36.0	35
9	木荷 Shima superba	9	485	7.22	139	44.4	68
12a	厚皮香 Ternstroemia gymnanthera	7	500	6.81	140	45.0	119
12b	厚皮香 Ternstroemia gymnanthera	10	490	6.38	116	36.0	42

第五表　單一樹種紙漿之性質（續一）

Table 5. Kraft Pulp Properties of Individual Species

編號 No.	種名 Species Names	打漿時間 Beating Time min.	自由度 Pulp Freeness c.s.f. ml	裂斷長 Breaking Length km.	撕力比 Tear Factor	破裂比 Burst Factor	耐摺力 Folding Endurance M.I.T. double folds
13	紅花八角 Illicium arborescens	16	300	7.15	108	48.8	431
14	紅花八角 Illicium arborescens	16	285	6.35	99	34.2	57
6	南投黃肉楠 Actinodaphne nantoensis	24	300	7.85	123	52.3	302
18	瓊楠 Beilschmiedia erythrophloia	18	310	7.57	95	51.2	158
22	尖葉楠 Machilus acuminatissima	16	295	7.63	86	50.6	294
17a	假長葉楠 Machilus pseudo—longifolia	23	305	6.14	72	40.5	68
17b	假長葉楠 Machilus pseudo—longifolia	24	295	5.88	74	37.1	38
24	豬腳楠 Machilus thunbergii	15	300	8.38	84	53.6	542
11	變葉新木薑子 Neolitsea variabillima	17	300	6.83	81	43.2	172
27	臺灣赤楊 Alnus formosana	12	300	7.01	62	38.9	184
10	長尾柯 Castanopsis carlesii	21	300	7.17	102	44.9	216
6	錐果櫟 Cyclobalanopsis longinux	17	300	5.70	112	36.6	45
25	狹葉櫟 Cyclobalanopsis stenophylloides	17	305	5.93	107	40.9	95
1	鬼櫟 Lithocarpus lepidocarpa	19	295	6.51	109	36.3	44
4	油葉杜 Pasania brevicaudata	16	305	6.08	84	41.5	106
21	大葉校粟 Pasania kawakamii	17	300	7.60	92	49.3	385
2	杜英 Elaeocarpus sylvestris	16	300	8.11	105	57.8	632
9	木荷 Shima superba	14	300	7.86	118	46.7	422
12a	厚皮香 Ternstroemia gymnanthera	12	305	7.95	119	53.6	616
12b	厚皮香 Ternstroemia gymnanthera	14	300	6.54	104	40.3	156

由上表可以看出，南投黃肉楠、猪脚楠、杜英、木荷及厚皮香各種强度均較好，其中南投黃肉楠、木荷及厚皮香撕力特別好，此乃其纖維較其它樹種長之關係，另外殼斗科各樹種紙漿性質相近似，而且撕力比較高，此乃因其纖維比較長之關係。

（二）混合蒸煮 (Mixture Cooking)

第六表　混樹種蒸煮之結果

Table 6. Kraft Pulping Results of Species Mixtures

編號 No.	種名 Species Names	用碱量 Active alkali %	最高溫度 Max. temp. °C	蒸解收率 Screened yield %	未蒸解部份 Screen rejects %	未漂白度 Pulp brightness Elrepho %	高錳酸鉀價 Permanganate no. ml.
31	混合濶葉樹材 Mixture	13	170	50.1	2.7	16.6	26
30	混合濶葉樹材 Mixture	15	170	49.4	0.1	19.4	20
32	混合濶葉樹材 Mixture	17	170	47.9	—	20.0	18
33	混合濶葉樹材 Mixture	19	170	45.4	—	23.8	13
37	混合濶葉樹材 Mixture	13	165	51.1	1.6	17.3	26
36	混合濶葉樹材 Mixture	15	165	48.9	0.4	19.1	24
35	混合濶葉樹材 Mixture	17	165	48.5	—	21.6	17
34	混合濶葉樹材 Mixture	19	165	47.0	—	21.8	16
	中美巴拿馬混合濶葉樹 * Panama Hardwood Mixture	17	178	41.2	2.5	17.0	24
	美國南部松 ** Southern Pine (U.S.A.)	24	170	43.1	0.3	—	23
	美國濶葉樹 *** Hardwoods (U.S.A.)	16	170	47.0	—	—	19

*其他蒸煮條件爲：硫化度26%，液比7.5：1，升達最高時間120分，保持最高時間60分。

Other cooking conditions are : Sulfidity 26%. Liquor ratio 7.5 : 1. Time to max. temp. 120 min. Time at max. temp. 60min.

**其他蒸煮條件爲：硫化度25%，液比6.5：1，升達最高時間110分，保持最高時間50分。

Other cooking conditions are : Sulfidity 25%. Liquor ratio 6.5 : 1. Time to max. temp. 110 min. Time at max. temp. 50 min.

***其他蒸煮條件爲：硫化度25%，升達最高時間60分，保持最高時間90分。

Other cooking conditions are : Sulfidity 25%. Time to max. temp. 60 min. Time at max. temp. 90min.

由上表可以看出，收率隨溫度及用碱量增加而減少，高錳酸鉀價亦隨用碱量及溫度增加而減少，紙漿白度則隨用碱量增加而增加。

由表中可以看出，本省之混合濶葉樹材收率高出中美洲、巴拿馬混合濶葉樹及美國南部松，而與美國一般濶葉樹相近似，其高錳酸鉀價亦比巴拿馬混合濶葉樹及美國南部松爲低。

第七表　混合樹種紙漿之性質

Table 7.　Kraft Pulp Properties of Species Mixtures

編號 No.	種名 Species Names	打漿時間 Beating Time min.	自由度 Pulp Freeness c.s.f.ml.	裂斷長 Breaking Length km.	撕力比 Tear Factor	破裂比 Burst Factor	耐摺力 Folding Endurance M.I.T. double folds
31	混合濶葉樹材 Mixture	13	500	5.60	110	32.4	27
30	混合濶葉樹材 Mixture	11	495	5.61	104	32.3	33
32	混合濶葉樹材 Mixture	13	500	5.38	111	21.1	17
33	混合濶葉樹材 Mixture	13	505	5.72	107	31.5	18
37	混合濶葉樹材 Mixture	13	505	5.09	101	59.3	38
36	混合濶葉樹材 Mixture	13	500	5.15	127	55.4	43
35	混合濶葉樹材 Mixture	12	500	5.46	120	52.4	26
34	混合濶葉樹材 Mixture	13	495	5.85	120	53.4	44
	中美巴拿馬混合濶葉樹 Panama Hardwood Mixture	21	500	10.00	125	58.0	—
	美國南部松 Southern Pine (U. S. A.)	34	500	10.50	148	78.0	—
	美國濶葉樹 Hardwoods (U. S. A.)	—	450	7.50	90	55.0	—

第七表　混合樹種紙漿之性質（續一）

Table 7.　Kraft Pulp Properties of Species Mixtures

編號 No.	種名 Species Names	打漿時間 Beating Time min.	自由度 Pulp Freeness c.s.f.ml.	裂斷長 Breaking Length km.	撕力比 Tear Factor	破裂比 Burst Factor	耐摺力 Folding Endurance M.I.T. double folds
31	混合濶葉樹材 Mixture	21	305	7.38	90	45.1	96
30	混合濶葉樹材 Mixture	17	300	6.88	91	43.6	107
32	混合濶葉樹材 Mixture	22	300	6.84	97	44.6	104
33	混合濶葉樹材 Mixture	23	300	7.10	86	43.4	121

37	混合濶葉樹材 Mixture	19	305	7.11	84	70.4	293
36	混合濶葉樹材 Mixture	21	300	7.07	94	69.5	192
35	混合濶葉樹材 Mixture	22	300	6.83	126	70.3	298
34	混合濶葉樹材 Mixture	22	300	6.79	110	67.1	181
	中美巴拿馬混合濶葉樹 Panama Hardwood Mixture	35	300	11.60	112	76.0	—
	美國南部松 Southern Pine (U.S.A.)	46	300	10.80	123	81.0	—
	美國濶葉樹 Hardwoods (U.S.A.)	—	—	—	—	—	—

由上表可以看出，裂斷長及撕力比均隨用礆量增加而略有增加但不顯著，破裂比及撕力比均以溫度在 165°C 時爲佳。

由表中可以看出，林相改良混合濶葉樹材之裂斷長要比巴拿馬混合濶葉樹材及美國南部松爲低，而與美國一般濶葉樹材接近，撕力比則與巴拿馬混合濶葉樹材相似，而低於美國南部松，不過比美國一般濶葉樹材來得高，破裂比則略低於美國南部松而與巴拿馬濶及美國一般濶葉樹材相似。

3.造紙試驗 (Papermaking Experiment)

本試驗所用之混合濶葉樹木漿蒸煮條件爲用藥量 15%，最高溫度爲 170 °C，其它條件均與上面相同。混合竹漿蒸煮條件爲用藥量 15%，最高溫度 160 °C，保持時間爲 2 小時。針葉樹及濶葉樹木漿來自中華紙漿廠，而蔗漿則來自臺灣紙業公司新營廠。稻草漿則來自宏康紙廠。

第八表　混合濶葉樹材所抄紙張之性質

Table 8. Data on Some Papers Made From The Mixture of Conversion Hardwoods

編號 Run No.	紙之種類 Kind of Paper	紙漿種類 Pulp Furnish % 混合濶葉樹 Mixed Hardwoods	紙漿種類 Pulp Furnish % 其他紙漿 Other Pulps	自由度 Freeness c.s.f. ml.	基重 Basis Weight g/m²	厚度 Thickness mm	密度 Density g/cc	裂斷長 Breaking Length km 縱向 MD	裂斷長 Breaking Length km 橫向 CD
66	印書紙及包裝紙 Printing and Wrapping	100	—	290	52	0.074	0.70	8.30	4.0
67	印書紙及包裝紙 Printing and Wrapping	70	針葉樹漿 Softwood Pulp 30	280	55	0.078	0.71	8.25	3.6
25	印書紙及包裝紙 Printing and Wrapping	—	濶葉樹漿 Hardwood Pulp 100	285	89	0.124	0.72	4.65	2.3
23	印書紙及包裝紙 Printing and Wrapping	—	蔗漿 Bagasse Pulp 100	230	94	0.118	0.80	5.59	3.3
55	印書紙及包裝紙 Printing and Wrapping	—	竹漿 Bamboo Pulp 100	350	58	0.079	0.73	8.04	4.0
38	印書紙及包裝紙 Printing and Wrapping	—	稻草漿 Straw Pulpa 90 針葉樹漿 Softwood P. 10	320	53	0.062	0.85	5.38	3.0

第八表　混合濶葉樹材所抄紙張之性質（續一）

Table 8. Data on Some Papers Made From The Mixture of Conversion Hardwoods

編號 Run No.	紙之種類 Kind of Paper	紙漿種類 Pulp Furnish: 混合濶葉樹 Mixed Mardwoods	紙漿種類 Pulp Furnish: 其他紙漿 Other Pulps	撕力比 Tear Factor: 縱向 MD	撕力比 Tear Factor: 橫向 CD	破裂比 Burst Factor	耐摺力 Folding Endurance MIT double-folds: 縱向 MD	耐摺力 Folding Endurance MIT double-folds: 橫向 CD	白度 Brightnesss Elrepho %
66	印書紙及包裝紙 Printing and Wrapping	100	—	68	60	35.7	328	88	15.4
67	印書紙及包裝紙 Printing and Wrapping	70	針葉樹漿 Softwood Pulp 30	80	65	34.3	317	70	15.9
25	印書紙及包裝紙 Printing and Wrapping	—	濶葉樹漿 Hardwood Pulp 100	72	84	21.4	36	10	74.5
23	印書紙及包裝紙 Printing and Wrapping	—	蔗漿 Bagasse Pulp 100	45	49	24.5	32	11	73.7
55	印書紙及包裝紙 Printing and Wrapping	—	竹漿 Bamboo Pulp 100	97	142	53.1	234	54	26.0
38	印書紙及包裝紙 Printing and Wrapping	—	稻草漿 Straw Pulp 90 針葉樹漿 Softwood P. 10	50	52	30.9	656	182	71.0

由上表可以看出，利用未漂混合濶葉樹漿所抄紙張之強度，除撕力及頂破力不如竹材外，其它強度均與竹材相似，與蔗漿及稻草漿相比，則各種強度均以混合濶葉樹漿所抄之紙張爲好。因而混合濶葉樹漿可以抄製品質甚好之包裝紙及印書紙。如果再配合長纖維針葉樹漿及竹漿，則更可以抄製高級印書紙及強度好之包裝紙。

五、結　　論 (Conclusions)

1. 根據纖維形態及化學組成，以南投黃肉楠，木荷及殼斗科內六種木材較好。厚皮香雖然纖維較長，但其化學組成顯示不好。
2. 單一製漿以南投黃肉楠、木荷、豬脚楠及杜英爲最好。
3. 混合製漿品質與一般濶葉樹相似，且撕力較高。
4. 利用小型長網造紙機抄製包裝紙及印書紙，品質甚好。且各種強度均比蔗漿及稻草漿爲好。
5. 由本試驗證明，利用林相改良濶葉樹材，可以成功的大量用做製漿造紙之用。

六、參考文獻 (Literature Cited)

1. 趙順中等：臺灣濶葉樹混合製漿造紙之研究　林試所農復會合作報告第三號　1962
2. 趙順中等：臺灣濶葉樹材纖維觀測及化學組成分析林試所林務局合作報告第十四號　1971
3. 谷雲川：臺灣主要樹材纖維形態及化學組成試驗（二）　林試所報告第一四二號　1966
4. TAPPI STANDARDS　1963
5. Chidester G.H. and Schafer E.R. : Pulping and Papermaking Experiments on Colombian Woods U.S. FPL No.2117　1965

6. Chidester G. H. and Schafer E. R. : Pulping of Asia and Australasian Wood and Plant Fibers U. S. FPL No .2211 1961
7. Jackson A. and Parkinson J. R. : Kraft Pulps from Central American Hardwoods Tappi October 1968
8. Nicolas P. M. Navarro J. R. and Ynalvez L. A. : Kraft Pulping of Some Philippine Hardwoods Tappi May 1967
9. Schlumbom H. F. : Forest Products Research in Taiwan (Final Report) UNFFIDP 1969

English Summary

The purpose of this experiment is to investigate the possibility of using conversion hardwood mixtures to make pulp and paper with kraft pulping and paper making on the 8—inch experimental paper machine. The prpoperties of unbleached kraft pulps produced from these woods as individual species or as species mixtures together with the properties of the woods and paper qualities from the mixtures, are discussed. Comparisons are made with kraft pulps from other countries. Actinodaphne nantoensis. Shima superba. Machilus thunbergii and Elaeocrpus sylvestris were found to be the best species for pulp and paper making in this Lao Nung Working Cycle. pulps produced from the conversion hardwoods were a little lower in quality to softwood pulps but it was similar in quality to hardwood pulps and even better in tearing resistance. A goodquality kraft pulp prepared from a mixture of these woods was demonstrated to be suitable for making good quality printing and wrapping papers This experiment shows that conversion hardwood can be converted into commercially acceptable paper products.

1. Introduction

A large area of hardwood forest conversion has been carried out by Taiwan Forestry Bureau every year since 1965. Almost all the species in the conversion area are low value hardwoods, and these woods can be utilized to provide raw material for Taiwan pulp and paper industry.

Because of the species in these conversion forests are so intermixed that an economical utilization of them for papermaking virtually requires that they be used without selection, and the best pulping process is sulphate (or kraft).

Under FAO—UNDP Technical Assistance assignment, the forest products expert, Dr. H.F. Schlumbom, recommended that for better utilization of these hardwoods, three projects were carried out to investigate the same raw material, the other two projects are "Mixed Hardwood Kiln Drying Experiment" and "Abridged Tests on 20 Hardwood Species". Only the upper parts and main branches were used in this project.

The purpoes of this experiment is to investigate the possibility of using conversion hardwood mixtures to make pulp and paper with kraft pulping and papermaking on the 8—inch laboratory Fourdrinier paper machine. This project is planning to be finished in five years, all the procedures are same except the raw material comes from the different conversion area.

Special acknowledgments are made to the National Science Council and the Taiwan Forestry Bureau for the financial support of this project.

2. Raw Material

A special random sampling method was used for this experiment, all trees were collected from the Lao Nung Working Cycle, Compartments 57 and 58. The elevation was from about 1550 m. to 1650 m. The forest was a typical natural, mixed hardwood stand of the temperate rain forest of southern Taiwan. 30 trees were marked and identified, while 18 trees (17 different species) were actually cut and used in this experiment. The kinds of wood and its description are given in Table 1.

Hand—made chips of approximattely $1 \times \frac{1}{2} \times \frac{1}{8}$ inch were used for all pulping, the chips were stored in polyethylene bags until required. Hardwood mixtures were prepared according to the frequency of each specieslin the forest times its specific gravity to get the proportions in the mixtures.

3. Experimental Procedures

All ash content, hot water extractives,one percent caustic soda extractives, alcohol-benzene extractives, pentosans and lignin were determined by TAPPI Stnadard Methods. Holo-cellulose and alpha-cellulose were determined by Wise Methods.

Sulphate pulps of single species were produced in a stainless steel autoclave with electric heater of 3 L. capacity. Liquor ratio 4 : 1, Sulphidity 25%, and active alkali (Calculated as Na_2O) 15% were used. Temperature was raised to 170°C in 90 min. and maintained at this level for another 90 min.

Sulphate pulps of hardwood mixtures were prepared in the same conditions as single species except that total alkali were 13%, 15%, 17%, 19% and max. temperature were 165°C, 170 °C.

After cooking, the pulps were washed and screened, The pulp yields and permanganate numbers were also measured.

All beatings were carried out in a standard Niagara beater, and a freeness of 500 ml. (c. s. f.) and 300 ml. were obtained for all the pulps. Handsheets with a basis weight of $60 g/m^2$ were prepared on the TAPPI Standard Sheet Machine according to the TAPPI Standard Method T 205 m—58.

The handsheets and papers were conditioned at relative humidity of 65% and a temperature of 21°C before testing physical properties. All sheet properties mentioned in this paper were measured according to the TAPPI Standard Methods.

Different grades of bleached and unbleached papers were made with fiber furnishes that consisted either entirely of conversion hardwood pulps or of blends of the conversion hardwood pulps and other pulps. The pulps were processed in a 5-pound-capacity beater and made into papers on the 8—inch laboratory Fourdrinier paper machine.

4. Results and Discussion

A. Fiber Morphology and Chemical Composition

From table 2 shows that the fiber length of Actinodaphne nantoensis and Ternstroemia gymnanthera are much longer than all other species, and Shima superba and six species in Fagaceae are also better than others. Fiber length hsa a very close relation to the tearing resistance of paper, that is why softwood pulps are usually better than hardwood pulps, expecially the tearing resistance.

From table 3 shows that Beilschmiedia erythrophloia has a high ash content than the other species. Machilus thunbergii, Machilus acuminatissima and Ternstroemia gymnanthera are in the group of high extractive content. Illicium arborescens and Ternstroemia gymnanthera have a higher lignin content, and we also found that Ternstroemia gymnanthera was in low cellulose content.

Wood species in Fagaceae have higher specific gravity.

B. Pulping Experiment

1). Single Species Cooking

From table 4 we can see that the Pulp yields of Illicium arborescens, Beilschmiedia erythrophloia, Cyclobalanopsis stenophylloides, Pasania brevicaudata and Ternstroemia gymnanthera are lower than the other species, and Pasania brevicaudata is hard for cooking. Illicium arborescens and Cyclobalanopsis stenophylloides have the higher permanganate numbers, and the values of other species are all within the normal limits for bleachable hardwood pulps.

From table 5 shows that kraft pulps produced from Actinodaphne nantoensis, Machilus thunbergii, Elaeocarpus sylvestris, Shima superba and Ternstroemia gymnanthera are better than the other species. Due to the longer fiber length, the pulps of Actinodaphne nantoensis, Shima superba and Ternstroemia gymnanthera have a higher tearing resisitance. Pulps prepared from Fagaceae are also good.

2). Mixture Cooking

From table 6 shows that the pulp yields and permanganate numbers of hardwood mixtures are reduced by increasing chemicals and temperature,and increasing chemicals will add pulp brightness. The pulp yields of conversion hardwood mixtures are higher than the pulps produced from Panama hardwood mixtures and U. S. southern pines, the pulp permanganate numbers are lower than the pulps of other countries.

From table 7 shows that the pulp breaking length and tear factor are increased by increasing chemicals, but it is not very much. Pulps produced from a temperature of 165°C are better than those of 170°C. From the comparison we can see the breaking length are found lower than the length of Panama tropical hardwoods and U. S. southern pines, but equal to breaking length of U. S. hardwoods. Tear factors observed for the conversion hardwoods are higher than those of U.S. hardwoods, but lower than those for U. S. s outhern pine.

C. Papermaking Experiment

Cooking conditions of coversion hardwoods are just same as single species cooking, and the bamboo mixtures are : active alkali 15%,max. temperature 160°C and the maintaining time 90 minutes. The softwood and hardwood Pulps came from Chung—Hwa Pulp mill, and the bagasse Pulps were from Hsin—Ying Pulp mill. The rice straw Pulps came from Hung—Kang paper mill.

From table 8 shows that the paper properties made from the conversion hardwoods are lower to those of bamboo mixtures in tearing and bursting strengths but same in other strengths. Compared to the strength of papers produced from bagasse and rice straw pulps, the papers from conversion hardwoods are much better. This can be proved that good wrapping and printing papers can be made with or without adding long fiber Pulps.

5. Conclusions

A. According to the properties of woods, Actinodaphne nantoensis and Shima superba are the best species, and the species in Fagaceae are also better than others.

B. Kraft Pulps produced from Actinodaphne nantoensis, Shima superba, Machilus thunbergii and Elaeocarpus sylvestris were found to be the best species for paper-making in this Lao Nung Working Cycle.

C. Kraft Pulps produced from conversion hardwood mixtures were similar to the conventional hardwoods, but with higher tearing resistance.

D. A good—quality kraft pulp prepared from a mixture of these woods, was demonstrated to be suitable for making good quality printing and wrapping papers.

E. This experiment confirms that conversion hardwood can be converted into commercially acceptable paper products.