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桑條製漿造紙之研究

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Studies on Pulping and Papermaking
of Mulberry Branches

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趙順中

谷雲川

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一、緒 言 (Introduction)

養蠶為中國人發明，中國綢緞自古聞名世界，自從人造纖維發明以後，蠶絲業受到嚴重打擊，養蠶事業因之衰落。臺灣天然條件很適宜於養蠶，但因市場狹小，利潤太低，未能發展。

民國五十三年八月，美國一家專門經營蠶絲業務的吉利公司董事長喬利先生來臺考察蠶絲生產情形，結果對於本省蠶絲極其稱贊，認為本省農家環境及技術很適宜於發展蠶絲事業，他說蠶絲有其特殊優點，非人造纖維所能代替，例如降落傘要用蠶絲製造，可在太空中不起化學變化，人造纖維則不能代用，他分析目前蠶絲業市場的概況說，目前世界生絲產量不够供應，蠶絲業務極有前途，他希望在臺灣收購三十萬公斤生絲並願意成為臺灣生絲業永久性的主顧。

經此鼓勵，臺灣的養蠶事業突然為之大振，政府將養蠶業列入「四年經建計劃」，農林廳，農復會，經合會等機關擬向全省作有計劃的推廣，國軍退除役官兵輔導委員會決定在東部大規模種桑養蠶，安置榮民生活，看來養蠶事業在臺灣將成為一種最新的最有希望的農村家庭副業。

隨着養蠶事業的發展，必將產生一種大量的副產物，就是桑條。桑條為配合養蠶季節並促進桑葉生長每半年要收割一次，每次將產生大量的桑條，其最佳的利用方式，可能是製漿造紙。

關於桑條造紙，本所以往未曾作過有系統之試驗，其他紙業文獻中亦未能找到此類之資料，究竟桑條用作製漿造紙情形如何，在目前正值本省造紙原料缺乏之際，實有研究之必要，惟因參考資料較少，文中難免有不當之處，敬祈先進專家指教是幸。

本試驗開始之時曾向我國蠶桑專家尹良瑩先生請教，多蒙指正至為感謝。試驗期間承農復會森林組楊組長志偉暨潘技正長弼賜予協助，所用之桑條係蠶桑改良場栽桑課謝課長重智免費供應，於此一併敬申謝忱。

二、生長調查 (Investigation of Growth)

桑條為配合養蠶，每年割取兩次，一次約在五月，一次約在十一月，平均大約半年一次。在此兩次中，一次由根部割取，僅餘二三寸高，令其再發生枝條，另一次為部份剪割，僅將上端枝稍剪去少許。

本試驗所用之桑條係採自蠶桑改良場所屬之臺北公館地區，該地區種植桑條約十餘公頃，品種有臺桑一號及觀察五號兩種，本試驗所用之試材為臺桑一號，係於本年（五十六年）四月二十六日採集，上次全部割伐日期為五十五年五月四日，生長期間為一年，其間於五十五年十一月曾將枝稍剪割一次。

此次試驗係選擇一公頃生長比較平均之地區，在此一公頃內選出十個適當之單位面積作為代表，每一單位面積為百分之一公頃。將此十個單位面積之桑條由根部全部割取，（去年十一月僅割取上端枝稍），割取後立刻先稱其重量，然後剪去其葉子，再稱其全部條枝重量，同時抽取樣品，測定其水分，由於部位之不同，其所含水分亦不同，故分別測定其葉，細枝及粗枝三部之水分。粗枝與細枝之規格係自己規定，

直徑大約在 2 至 10mm 中間者稱為細枝，10mm 以上者稱為粗枝。直徑在 2mm 以下者因過於幼嫩故隨葉子一併棄除，此次割伐之桑條直徑最大者為 25mm。

茲將以上調查結果分述如下：

1. 在此 10 個單位面積內，去年（五十五年）十一月僅剪割上端細枝條之記錄如下：
 - A. 枝葉總重量為 883 公斤（水分在內），其中葉子重量為 607 公斤，純枝條重量為 276 公斤。
 - B. 桑葉重量佔總重量 68.7%，枝條佔 31.3%。
 - C. 葉子水分為 74.08%，枝條水分為 83.34%，照此水分計算，每公頃純桑條之絕乾重量為 460 公斤。
 - D. 枝條直徑為 2mm—10mm（此次剪割均為細枝條）。
 - E. 枝條長度為 40cm—120cm。
2. 在此 10 個單位面積內，本年（五十六年）四月由根部全部割伐之記錄如下：
 - A. 枝葉總重量為 1656 公斤（水分在內），其中葉子重量為 705 公斤，純枝條之重量為 951 公斤。
 - B. 桑葉重量佔總重量 42.6%，純枝條佔 57.4%。
 - C. 葉子水分為 74.08%，粗枝之水分為 58.5%，細枝條之水分最高為 83.34%。
 - D. 枝條中，細枝重量佔 18%，粗枝佔 82%，照此比例計算，每公頃純枝條之絕乾重量為 3520 公斤。
 - E. 桑條皮重量佔枝條重量 22.4%，木質部分佔 77.6%。
 - F. 桑條皮水份為 69%，木質部分之水分為 54%。
3. 每一單位面積（1% 公頃），平均種 60 株，照此計算，每公頃種植 6000 株。每公頃純枝條之絕乾重量為 3980 公斤（460+3520=3980）。

三、纖維形態 (Fiber Morphology of Mulberry Branches)

將桑條之韌皮部份及粗細桑條之木質部份，分別先用沸水處理，再經 Jeffreys 氏液處理，然後置於顯微鏡下測定其纖維長度觀察五號桑條亦作同樣處理及觀測茲將結果列表如下：

第一表 桑條纖維長寬度

Table 1. Dimensions of Mulberry Branch Fibers

類 別 Specises	長 度 Length (mm)			寬 度 Width (μ)			長 度 寬 度 Length Width
	最 大 (Max.)	最 小 (Min.)	平 均 (Av.)	最 大 (Max.)	最 小 (Min.)	平 均 (Av.)	
臺桑一號 (細枝)	0.90	0.40	0.583	26	9	41.5	14.0
臺桑一號 (粗枝)	1.10	0.40	0.785	22	9	36.8	21.3
臺桑一號 (韌皮)	11.25	0.45	4.530	31	11	18.2	249.0
觀察五號 (細枝)	1.00	0.40	0.625	26	13	47.1	13.3
觀察五號 (粗枝)	1.20	0.50	0.805	26	11	42.9	18.8

由上表結果得知，桑條之韌皮纖維細而長，超過針葉樹材，而木質部之纖維甚短，不如潤葉樹材，亦不如稻草及蔗渣。

四、化學組成分析 (Analysis of Chemical Composition)

茲將臺桑一號及觀察五號之粗細枝條之化學成分分別分析，其結果如下：

第二表 桑條之化學組成分析

Table 2. Analysis of Chemical Composition of Mulberry Branches

樹種 Species	水 Moisture Content (%)	灰 Ash (%)	抽出物 Extractives				戊 醣 Pentosan (%)	木 質 Lignin (%)	全 纖 維 素 Total Cellulose (%)	α- 纖 維 素 α-Cellulose (%)	β+ γ 纖 維 素 β+γ Cellulose (%)
			熱水 Hot Water (%)	燒 碱 1% NaOH 碱 (%)	醇 苯 混 合 液 Benzene Alcohol (%)	乙 醚 Ether (%)					
臺桑 1 號 木質	6.26	1.47	5.87	6.06	4.23	0.18	15.28	19.92	62.36	31.27	31.09
臺桑 1 號 韌皮	8.58	5.95	13.78	4.26	12.26	0.55	13.25	11.92	66.29	32.85	33.44
觀察 5 號 木質	8.63	1.07	7.95	6.40	4.22	0.17	19.16	22.23	62.56	30.77	31.79
觀察 5 號 韌皮	8.00	5.61	5.66	3.78	8.03	0.55	11.84	13.95	67.12	33.17	33.95

由上表結果可知，桑皮之灰份較高，桑條之全纖維素含量高於一般潤葉樹，但其中α纖維素較低，其木質素均低於針葉樹及潤葉樹甚多。

五、試材與方法 (Raw Materials and Methods)

1. 試材處理 (Treatment of Raw Materials)

將採集之桑條，剪去其葉子及直徑在 2mm. 以下之枝條捨棄不要，次將細枝與粗枝分開，然後分別用鐵錘打碎，目的在於蒸煮時藥品容易吸收，容易風乾。皮與木質部不易分開，故混合試驗。在蒸煮或製漿之前先測定其水分，如混合製漿，則按照 18% 細枝與 82% 粗枝之比例混合作為試材。

2. 製漿方法 (Pulping Methods)

利用一般木材試驗造紙，不須將粗細木材分開，但桑條略有不同，因細桑條組織幼嫩，皮多，水分高故認為有單獨試驗之必要，本試驗先將細枝條單獨蒸煮製漿試驗，然後與粗枝條混合試驗。

本試驗所用之製漿方法有下列三種：

A. 硫黃燒碱法 (Sulphur Caustic Soda Process) 蒸煮藥液之製法係將硫黃溶解於燒碱液中。

B. 中性亞硫酸鈉法 (Neutral Sodium Sulfito Process) 蒸煮藥液係用固體亞硫酸鈉及固體碳酸鈉配製。

C. 冷碱法 (Cold Caustic Soda Process) 在室溫及普通氣壓下用燒碱溶液浸漬原料。

本試驗所用之蒸煮設備係 1 呎之不銹鋼製蒸煮鍋，原料經過蒸煮或浸漬後，分別用藍平球磨機 (Lampen Ball Mill) 或盤式精練機 (Disc-Refiner) 使紙漿分散至適當游離度，經過篩選，然後抄成紙

張。抄紙設備係使用加拿大標準規格手抄機，依照 TAPPI 規定方法抄製。紙張物理性質試驗時，相對濕度保持65%。

六、試驗過程 (Experimental Procedure)

1、粗細桑條之比較 (Comparison of Big and Small Mulberry Branches)

A. 細桑條蒸煮及製漿試驗 Experiments on Cooking and Pulping of Small Mulberry Branches)

取細桑條 180 克 (絕乾重) 裝入 1 呎蒸鍋內，用硫黃燒鹼法依照下列條件蒸煮，所用之條件為過去試驗瀾葉樹混合蒸煮最適當之條件，目的為便於比較。

- | | | |
|---------------|---|-------------|
| (a) 藥品用量 | 21 ~23 %
2.5~2.8% | } 均為對絕乾原料重量 |
| (b) 最高溫度及保持時間 | 165°C 2 小時至 4 小時
170°C 2 小時 | |
| (c) 到達最高溫度時間 | 1 ¹ / ₃ ~1 ² / ₃ 小時 | |
| (d) 液比 | 4:1 | |

蒸煮完畢，經過洗滌篩選然後用藍平球磨機打漿，游離度儘量使之接近以便比較，最後抄成紙張試驗其物理性質，茲將所得結果列表如下：

第三表 細桑條蒸煮製漿試驗結果

Table 3. Results of Cooking and Pulping of Small Mulberry Branches

燒鹼 NaOH (%)	硫黃 S (%)	最高溫度 Max. Temp. °C	保持時間 Time at Max. Temp. hr	紙漿收率 Pulp Yield (%)	乾基重 Basis Weight (Moisture Free) (g/m ²)	游離度 Freeness ml	抗張力 Tensile Strength (kg/15mm)	裂斷長 Breaking Length	頂破力 Bursting Strength (kg/cm)	破裂比 Relative Bursting Strength	撕力 Tearing Strength (g)	撕力比 Relative Tearing Strength	白度 Brightness (% G E)
21	2.5	165	2	37.0	63.9	180	8.4	8.75	4.08	63.77	61.70	96.50	16
21	2.5	165	4	35.5	63.7	180	7.1	7.46	3.37	52.94	68.10	106.90	17
21	2.5	170	2	35.0	64.1	155	7.6	7.98	3.68	57.48	71.30	111.36	18
23	2.8	165	2	34.0	61.5	160	7.8	8.45	3.30	53.6	62.40	101.40	20
23	2.8	165	4	31.0	60.1	175	7.1	7.87	3.10	51.89	52.16	86.75	21
23	2.8	170	2	28.0	64.4	170	7.9	8.18	3.25	50.44	58.50	90.89	20

B. 粗桑條蒸煮製漿試驗 (Experiments on Cooking and Pulping of big Mulberry Branches)
用相同條件改用粗桑條試驗，其結果如下：

第四表 粗桑條蒸煮試驗結果

Table 4. Results of Experiment on Cooking of Big Mulberry Branches

燒 碱	NaOH (%)	硫 黃 S (%)	最 高 溫 度 Max. temp. °C	保 持 時 間 Time at Max. temp. hr	紙 漿 收 率 Pulp yield (%)	乾 基 重 Basis Weight (Mois- ture free) (g/m ²)	游 離 度 Freeness ml	抗 張 力 Tensile Strength (kg/15mm)	裂 斷 長 Breaking length	頂 破 力 Bursting Strength (kg/cm ²)	破 裂 比 Relative Bursting Strength	撕 力 Tearing Strength g	撕 力 比 Relative Tearing Strength	白 度 Brightness (%GE)
21	2.5	165	2	38.0	63.9	180	8.4	8.75	4.08	63.77	61.7	96.5	22	
21	2.5	165	4	36.0	61.4	180	8.3	9.06	3.78	61.52	48.0	78.1	24	
21	2.5	170	2	36.0	61.7	180	8.1	8.83	3.94	63.86	54.0	87.5	22	
23	2.8	165	2	37.0	60.8	160	8.0	8.81	3.90	65.28	52.8	86.8	24	
23	2.8	165	4	35.0	61.3	170	7.3	7.88	2.72	44.32	41.9	68.3	25	
23	2.8	170	2	35.0	58.9	180	7.8	8.83	3.30	59.29	47.3	80.4	24	

由以上記錄可知粗細桑條之性質略有不同。

茲將其結果比較如下：

- A. 紙漿強度 細桑條之撕力略高，其他抗張力，頂破力及耐摺力則不如粗枝條，兩者相差約10%左右。
- B. 紙漿收率 粗桑條高於細桑條約2~4%。
- C. 紙漿白度 粗桑條高於細桑條約4%GE。

2. 粗細桑條混合蒸煮製漿試驗 (Mixed Cookig and Pulping from Big and Little Mulberry Branches)。

將粗細桑條以82%與18%之百分比混合為試料，分別用硫黃燒碱法，中性亞硫酸鈉法及冷碱法作蒸煮製漿及抄紙試驗，所用之蒸煮製漿條件均為過去試驗潤葉樹較適當之條件，為明瞭桑條與其他潤葉樹品質比較情形，並將以往所試驗潤葉樹之資料，選擇有關係者列入以下各表，以資參考。

A. 硫黃燒碱法 (Sulphur-Caustic Soda Process)

蒸煮製漿條件與以上粗細桑條所用者相同，茲將試驗結果列表如下：

第五表 硫黃燒碱法試驗結果

Table 5. Results of Experiment on Sulphur-Caustic Soda Process

樹種	燒碱 NaOH (%)	硫黃 S (%)	最高溫度 Max. temp. °C	保潔時間 Time at Max. temp. (hr.)	紙漿收率 Pulp yield (%)	乾基 Basis Weight (Moisture free) (g/m ²)	游離度 Freeness ml	抗張力 Tensile Strength kg/15mm	裂斷長 Breaking length	頂破力 Bursting Strength (kg/cm ²)	破裂比 Relative Bursting Strength	撕力 Tearing Strength (g)	撕力比 Relative Tearing Strength	白度 Brightness (% G.E.)
桑條混合	21	2.5	135	2	38.0	64.29	170	9.5	9.85	4.3	66.25	58.2	90.58	23
桑條混合	21	2.5	165	4	37.0	60.70	205	8.8	9.65	3.8	63.68	49.0	81.09	24
桑條混合	21	2.5	170	2	35.0	62.10	210	8.6	9.56	3.9	63.50	49.6	72.00	23
潤葉樹材	21	2.5	165	2	49.0	60.70	210		9.49		64.51		81.71	28

(潤葉樹混合紙漿係由黃麻，臺灣赤楊，江某，白飽子，九芎及大葉楠等六種木材混合製成) 由以上之結果觀察，粗細桑條混合紙漿之各項強度均高於此六種潤葉樹混合漿，紙漿收率僅有 37%，低於潤葉樹材甚多，白度雖不高，但呈淡咖啡色，與牛皮木漿顏色很接近。

B. 中性亞硫酸鈉法 (Neutral Sodium Sulfito Process)

蒸煮藥液配製及製漿條件如下：

- (a) 藥品配製
- | | | |
|--------------------------|----------|-------------|
| Na_2SO_3 | 12.5~20% | } 均為對絕乾原料重量 |
| Na_2CO_3 | 2.5~4% | |
- (b) 最高溫度及保持時間 165°C 3小時
- (c) 到達最高溫度所需時間 1 $\frac{1}{3}$ 。1 $\frac{1}{2}$ 小時
- (d) 液比 4:1

蒸煮完畢，洗滌清潔，用盤式精鍊機磨漿，調節盤距及紙漿濃度，使游離度均能控制在300ml 左右，以便比較。最後抄成紙張並試驗其物理性質，茲將其結果列表如下：

第六表 中性亞硫酸鈉法試驗結果

Table 6. Results of Experiment on Neutral Sodium Sulfito Process

原料	粗細桑條混合				八種潤葉樹混合			
Na_2SO_3 %	12.5	5.01	17.5	20.0	12.5	15.0	17.5	20.0
Na_2CO_3 %	2.5	3.0	3.5	4.0	2.5	3.0	3.5	4.0
液比	4	4	4	4	6	6	6	6
最高溫度°C	165	165	165	165	170	170	170	170

最高溫度 保持時間(時)	3		3		3		3		3		3		3	
黑液 PH	5.8		6.1		7.4		7.5		7.4		7.7		7.8 8.0	
紙漿收率%	59		59		58		56		69		68		68 66	
乾基重g/m ³	61.02	61.66	60.42	60.58	60.76	62.08	60.04	63.18	62.5	61.6	59.8	60.7		
游離度 ml	500	290	490	310	500	305	510	310	490	500	505	510		
抗張力 kg/15mm	4.26	5.46	4.18	4.48	4.50	6.78	6.48	8.36						
裂斷長 km	4.65	5.90	4.61	4.92	4.93	7.28	7.19	8.82	2.24	3.04	2.94	3.34		
撕力 g	58.56	43.84	53.76	50.56	52.16	46.08	51.84	38.72						
撕力比	95.96	71.09	88.97	83.45	85.84	74.22	86.34	61.28	68.6	70.3	81.9	82.6		
頂破力 kg/cm ²	1.20	1.23	1.42	1.55	1.90	2.62	2.27	3.36						
破裂比	19.81	19.94	23.61	25.63	31.35	42.34	37.80	53.29	24.0	27.6	26.8	28.0		
白度%GE	27	26	28	27	33	28	34	28	41	40	40	36		

(八種潤葉樹名稱爲白柏、土楠、山桐、血桐、黃櫨、水黃皮、無患子及沙朴)

由以上試驗結果可知：

- (a) 桑條之紙漿强度高於此八種潤葉樹之混合漿，尤其抗張力，幾乎高出一倍。
- (b) 桑條之紙漿收率較低，最高不到60%，此八種混合漿均超過66%以上。
- (c) 桑條紙漿之白度較低，但接近淺咖啡色，頗爲美觀。

C. 冷碱法 (Cold Caustic Soda Process)

將試料浸漬於燒碱溶液中，其條件如下：

- (a) 燒碱濃度 3%。
- (b) 浸漬時間 3小時 (在室溫及普通大氣壓下)

浸漬完畢後，不經洗滌，立即裝入精鍊機磨漿，調節磨盤距離，紙漿濃度及送漿量，磨成五種不同之游離度 (495ml 390ml 310ml 200ml 及 115ml) 以資比較。茲將試驗結果列表如下：
(另外將其他潤葉樹冷碱法試驗結果列入表內，以作參考)。

第七表 冷碱法試驗結果

Table 7. Results of Experiment on Cold Caustic Soda Process

原 料	粗 細 桑 條 混 合 紙 漿					大葉按	江 某	白飽子	重陽木	山黃麻
碱液濃度%	3	3	3	3	3	3.5	3.5	3.5	3.5	3.5
浸漬時間小(時)	3	3	3	3	3	2	2	2	2	2
紙漿收率%	69	69	69	69	69	82	84	84	82	82
乾基重 g/m ²	59.8	57.5	58.1	62.7	61.6	59.9	61.7	65.7	62.1	55.8
游離度 ml	495	390	310	200	115	200	210	200	200	215

抗張力 kg/15mm	3.05	3.72	4.12	4.68	4.78					
裂斷長 km	5.07	4.81	4.55	4.19	3.31	1.42	2.31	3.60	1.11	3.56
撕力 g	34.96	35.52	31.04	27.84	22.18					
撕力比	58.46	61.77	53.42	44.40	36.00	25.0	34.0	51.8	22.5	46.6
頂破力 kg/cm ²	2.24	2.05	1.26	1.00	0.94					
破裂比	35.67	31.59	20.86	16.88	15.28	13.40	14.60	22.80	14.5	25.10
白度 %GE	39	40	41	42	44	46	52	50		37

由以上結果可以看出：

- (a) 冷碱法桑條紙漿之各種強度均超過潤葉樹紙漿。
- (b) 收率及白度均低於一般潤葉樹。

七、結論 (Conclusion)

桑條為配合養蠶，每年割伐兩次，一次全部割伐，保留地面上二三寸高，令其發生新枝，約半年後，第二次割伐，此次僅割去其上端細枝，又半年後再全部割伐。一公頃一年內兩次割伐所得之桑條（葉子除去不計）共計3980公斤（絕乾重）。每公頃桑條種植數目約為6000株。

第一次全部割伐時，所獲枝條較多，佔枝葉總重量 57.4%，葉子佔 42.6%。第二次僅割伐細枝時，葉子較多，佔枝葉總重量68.2%，枝條佔31.3%。在此兩次割伐中，細枝條（直徑在 10mm 以下者），佔總重量（細枝及粗枝之和）四分之一，粗枝（直徑在10mm 以上者）佔四分之三，最粗之枝條，直徑為 25mm。

桑條韌皮部分之纖維長度平均為 4.53mm，長寬比為249，超過潤葉樹，稻草及蔗渣甚多。韌皮佔枝條總重量 22.4%，其他為木質。木質部分之纖維較短，粗桑條平均為 0.78mm，細桑條平均為0.58mm，較潤葉樹，稻草及蔗渣為低。

桑條之纖維素含量均高，韌皮部分含66.29%木質部分含62.6%。其木質素含量特別少，木質部分含 19.92%，韌皮部分含11.92%。韌皮部之灰分為5.95%，水分為69%，均甚高。

本試驗用三種製漿方法，即硫黃燒碱法，亞硫酸鈉法及冷碱法，根據試驗結果，可得以下結論：

- (1) 在備料方面，桑條比較其他木材容易，不須使用製材及切片設備，僅壓碎切斷即可。小型紙廠使用方便。
- (2) 桑條紙漿之顏色呈淺咖啡色，近於牛皮木漿，適宜於製造包裝紙及沖牛皮紙。
- (3) 粗桑條紙漿之強度，收率及白度均略高於細桑條。粗細桑條混合紙漿之強度。均超過其單獨製得之強度。並超過一般潤葉樹紙漿，硫黃燒碱法紙漿抗張力可達9kg/15mm以上，亞硫酸鈉法紙漿可達 8kg/15mm 以上，冷碱法紙漿可達 5.5kg/15mm 以上，紙張基重均為 60g/m²。
- (4) 由於桑條生長期間不超過一年，組織幼嫩，故其紙漿收率較其他一般潤葉樹略低，硫黃燒碱法化學紙漿收率在40%以下。亞硫酸鈉半化學紙漿在60%左右，冷碱法半化學紙漿為70%左右。
- (5) 本省過去桑條產量不多，據聞除用作燃料外，並無其他用途，將來數量大增，如交通運輸方便，售價低廉，必為紙廠所歡迎，養蠶事業亦必因之而日趨發展。

八、英文摘要 (English Summary)

I Investigation of growth

The mulberry branch is cut twice each year, in May and in November, in order to supply the needs of the sericultur industry. The interval is about six months. In May it is cut two or three inches above from the roots, new branches will sprout from the cutting place. In November it is cut a slightly under the top of the branches. The mulberry branches used in this experiment were supplied gratis by the Institute of Silkworm Mulberry Improvement Station, Kung-Kuan, Taipei. Ten or more hectares of land are planted with mulberry branches. There are two species of mulberry, the Taiwan Mulberry No. 1 and the Obsevation Mulberry No. 5. The T. M. No. 1 used in this experiment was cut in April 26 this year (1967).

The cutting before this was in May 4 last year (1966). They had about one year for growing. There was an intermediate cutting in November last year. (It was cut slightly under the top of the branches last year).

In this experiment we selected an area of one hectare that was considered an average mulberry branch growth for testing. We also selected ten representative units, the area of each unit was one hundredth of one hectare. We cut the mulberry branches two or three inches from the root, and weighed them immediately. After the leaves of mulberry branches were removed we weighed the bare mulberry branches again. At the same time test for the moisture content were also made. The moisture content were different from part to part. The moisture content of leaves, small and big branches were determined separately. The standard we used to separate the small branches from the big branches was optional. Branches with diameters of 2 to 10 mm. were called small branches and those with diameters of over 10 mm. were called big once. The biggest banches were found to be 25 mm. in diameter. Those branches with diameters below 2 mm. were discarded. The results of above investigation were listed as follows:

1. Data related to the branches cut from the top in this 10 units November last year (1966) were shown below:
 - (A). The total weight of leaves and branches was 883 kg(including moisture content), of which the weight of the leaves was 607 kg, and that of the branches was 276 kg..
 - (B). The weight of mulberry leaves constituted 68.7% of the total weight of the plant. The weight of branches was 31.3%.
 - (C). The moisture contents of the leaves and branches were 74.08% and 83.34% respectively. The calculated dry weight of branches was 460 kg..
 - (D). The diameters of the branches were ranged from 2 to 10 mm., and their length from 40 to 120 cm..
2. Data related to the mulberry branches cut from the root in this 10 units April this year (1967) were shown below:
 - (A). The total weight of the leaves and branches was 1656 Kg (including moisture

content) of which the weights of the leaves and branches were 705 Kg and 951 Kg respectively.

- (B). The weights of the leaves and branches were 42.6% and 57.4% respectively of the total weight of the branches.
 - (C). The moisture contents of the leaves, big and small branches were 74.08%, 58.5% and 83.34% respectively, The moisture content of the leaves was the highest of the three.
 - (D). The weights of the small and big branches were 18% and 82% respectively of the total weight of the branches (Without leaves). the calculated total weight of the small and big branches in one hectare was 3520 Kg (moisture free).
 - (E). The percentages of the barks and woods of the mulberry branches in weight were 22.4% and 77.6% respectively.
 - (F). The percentages of the moisture content of the barks and woods of the mulberry branches in weight were 69% and 54% respectively.
3. The average number of the mulberry plants that were planted in one unit of area (1% of the hectare) was 60. Accordingly, there were 60000 in one hectare, and the oven dry weight of the mulberry branches (without leaves) in one hectare in one year was 3980 Kg (460+3520).

II. Raw materials and Methods

1. Treatment of Raw Materials

Mulberry leaves and branches with diameter below 2mm were discarded. The small and big branches were separated and broken into small pieces with hammer, because the small pieces absorbed chemicals more easily in cooking and it was more easily dried for air seasoning. It was hard to peel the barks from the mulberry branches, so the branches was cooked with the barks on. The moisture content was determined before cooking or pulping. If the mixed cooking processes were adopted the small and big branches would be mixed at 18% and 82% as raw materials.

2. Pulping Methods

Ordinarily, it is unnecessary to separate the small and big woods into two parts for experiment of papermaking, but the mulberry branches are different from other woods. The tissue of small mulberry branches is tender, and the percentage of barks and the moisture content are higher. We consider that it is necessary to make individual test for pulping with the small branches. In this experiment we tested firstly the small branches only, then the combination of the big and small branches. In this experiment the pulping processes and cooking conditions were as follows:

(1) Sulphur caustic soda process

The cooking liquor was prepared by dissolving sulphur in caustic soda solution. The cooking conditions were as follows:

A. Chemical requirements

NaOH 21—23% } (on the weight of oven dry raw materials)
S 2.5—2.8%

B. Max. temp. and time at Max. temp.

165°C 2 to 4 hrs

170°C 2 hrs

C. Time to max. temp.

1¹/₃ to 1²/₃ hrs.

D. Liquor ratio 4:1

(2) Neutral sodium sulfite process

The cooking liquor was prepared by dissolving sodium sulfite power and sodium carbonate powder in water. The cooking conditions were as follows:

A. Chemical requirements

Na₂SO₃ 12.5—20% } (on the weight of oven dry raw materials)
Na₂CO₃ 2.5—4%

B. Max. temp. and time at max. temp.

165°C 3 hrs.

C. Time to max. temp.

1¹/₃—1²/₃ hrs.

D. Liquor ratio 4:1

(3) Cold caustic soda process

The raw materials were soaked in the caustic soda solution. The soaking conditions were as follows:

(A) Concentration of caustic soda solution 3%

(B) Time of soaking 3 hrs. (under room temp. and ordinary atmospheric pressure.)

In this experiment, the apparatus of cooking was a autoclave with a volume of 1 liter. After cooking the pulp was taken from the autoclave, washed through 80 mesh wire, defibered by using disintegrator and sifted through screen in order to remove the coarse particles. At the end the pulp yield was measured. Before papermaking we treated the pulp with Lampen ball mill or Disc refiner to the proper freeness. The type of the machine that was used in papermaking was the Canadian standard hand-sheet machine. The method for papermaking was the Tappi standard method.

According to the results of the above experiments we reached the following conclusions:

- a. The fiber lengths of the bark of the mulberry branches averaged 4.53 mm. It was as good as the fiber of soft woods.
- b. The fiber length of the wood of mulberry branch was shorter, the big branches averaged 0.78mm, the small branches averaged only 0.58mm. For comparison the hardwood fiber average over 1.0mm..
- c. The ash content of the bark of mulberry branch (5.95%) was rather high, while that of hardwoods was below 2%.

- d. The lignin content of mulberry branch was rather low, only 19.92% in the wood of mulberry branch and only 11.92% in the bark.
- e. The total cellulose content(62.36% in the wood and 66.29% in the bark) was rather high but its α -cellulose content was lower.
- f. The color of the mulberry branch pulp was light brown, it was similar to the color of kraft wood pulp. It can be used in making wrapping paper and similar kraft paper.
- g. It was easier to treat the mulberry branch than other woods. It did not need the equipment for wood sawing. It could be processed with the limited facilities of the small paper mills.
- h. The pulp strength, yield and brightness of the big mulberry branch were better than that of the small mulberry branch.
- i. The strength of the mixed pulp of big and small mulberry branch was better than that of the individual big and small mulberry branch pulp.
- j. The strength of the mixed pulp of big and small mulberry branches was better than most hardwoods that we had tested in the past. The tensile strength of the sulphur caustic soda pulp was over 9Kg/15mm., the neutral sodium sulfite pulp was over 8Kg/15mm., the cold caustic soda pulp was over 5.5Kg/15mm., (Basis Weight (moisture free) 60g/m²).
- k. Because the mulberry branch was tender, its pulp yield was rather low. It was similar to the rice straw and bagasse. The yield of the mulberry branch pulp in sulphur-caustic soda process was only 38%, it was not over 60% in neutral sodium sulfite semichemical pulping process, it was below 70% in cold caustic soda process.

九、參考文獻 (Literature Cited)

- 1 Rydholm: Pulping Processes 1965
- 2 Casey: Pulp and Paper Vol. 1. 1960
- 3 FAO: New Materials For More Paper 1953
- 4 加藤晴治: 桑のバルプの化學 1954。
- 5 趙順中、谷雲川、黃麗炎、林澤南、林勝傑: 臺灣葉澗樹混合製漿造紙之研究。五十一年五月
- 6 趙順中、谷雲川、黃麗炎、林澤南、潘登灶: 冷鹼法澗葉樹製漿造紙之研究。五十一年十一月