The Properties of Tropical Woods. 5
Studies on the utilization of Cambodian woods. (3)

Kraft Pulping and Papermaking Characteristics of Some Cambodian Woods.*

By

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I Introduction

A large quantity of timber species, which could be considered significantly abundant raw material for pulp and paper manufacture, grow in the tropical countries bordering the Pacific Ocean. Hardwoods predominate in this region, and these timber species are found intermixed in the forests. With the rising demand for pulp and paper products throughout the world, the establishment of pulping industries in the developing countries is assuming greater importance. Emphasis is being directed to the utilization of indigenous forests. Likewise, the logging residue, sawmill slabs, edgings and trimmings, and plywood mill waste from these species are also abundant potential sources of pulping material. As an instance of demand, in 1965 about 77 million cubic meters of wood were consumed in Japan. The use of approximately one-fourth of the total demand was imported, of which 55% was tropical wood. It was roughly estimated that accumulated sawmill wastes amounted to more than one million cubic meters of wood.

There is a wide range of differences in the chemical components of wood and morphological and physical properties of fibre among these species, therefore, it is important that the pulping and papermaking studies of individual species be carried out, and that they be classified into groups as large as possible, according to a certain "papermaking classification".

Pulping and papermaking laboratory investigations of these tropical woods have been carried out at the Government Forest Experiment Station, Tokyo, Japan, in order to gather relevant data applying to the tropical forests. This paper presents results on the kraft pulping and papermaking of some Cambodian woods (1 coniferous, 7 broad-leaved species).

II Wood Samples

The samples were collected from the coastal area of the Gulf of Thailand. The forests in this area consist mainly of Chhoeuteal, Phdiek, Komnhan, with lower proportions of Ro yong, Rong leang, Srol kraham and Koki khsach[11].

Following is the species used:

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Table 1.　Wood samples.

Common name	Botanical name	Log No.
Chhoeuteal bangkuoi	*Dipterocarpus insularis* Hance	ⅡA—1～ⅡA—8
Chhoeuteal sar	*Dipterocarpus alatus* Boxb.	Ⅱ(A)—1～Ⅱ(A)—6
Komnhan	*Shorea hypochra* Hance	ⅡB—1～ⅡB—14
Phdiek	*Anisoptera glabra* Kurz	ⅡC—1～ⅡC—4
Ro yong	*Parkia streptocarpa* Hance	ⅡD—1
Koki khsach	*Hopea pierrei* Hance	ⅡE—1
Srol kraham	*Dacrydium elatum* (Boxb.) Wall	ⅡF—1
Rong leang	*Tristania* sp.	ⅡG—1

The logs had approximately 4 m length and 50 to 65 cm diameter. No information on the ages of the trees was available for any species and could not be determined because these had no distinct growth zones.

III **Experimental**

(a) **Sample Preparation**

Disks, 20 mm thick, were cut from each of the logs of the eight species investigated. Most of the disks were hand cut into chips (20 by 10～15 by 2～3 mm) for pulping studies. The pulping tests were carried out on composite samples of each species containing an equal weight of chips from each of the logs of that species.

Representative samples from each of the eight batches of chips were ground in the Wiley mill so as to pass a 40 mesh sieve; this wood meal was used for chemical analyses.

One disk from each species was selected for morphological investigations.

(b) **Chemical Examination of Wood and Pulp Samples**

All analyses were made according to JIS (Japanese Industrial Standard) methods. The holocellulose was determined according to Wise[8]. Alpha-cellulose was determined with isolated holocellulose according to the ordinary method using 17.5% aqueous sodium hydroxide. Chlorine consumption of pulp(Roe number)was determined according to TAPPI standard method T 202 os-61.

(c) **Morphological Examination**

The following morphological examinations have been carried out on the wood samples: determination of fibre length and diameter; determination of the thickness of the fibre wall; basic density.

(d) **Pulping Procedure**

Sulphate pulps were prepared in 4 *l* stainless steel autoclave heated to a temperature of 170°C by a controlled-temperature electrical heater. The pulps, after washing, were screened on an 8-cut (8/1000 in. slot openings) screen plate. Pulping conditions are shown in the appropriate table. Yield determination and subsequent evaluations were made on screened pulp.

(e) **Bleaching**

The pulps were bleached by a five-stage process. The bleaching conditions used are shown in Table 5. The brightness of the bleached pulps was measured according to the appropriate JIS method. The ether-extractives of unbleached and bleached pulps were determined, and were investigated by thin layer chromatography. Trials were also carried out to show the effect of extractives in the pulps for colour reversion of bleached pulps.

(f) Evaluation of Pulps

The Lampen mill charged with pulp (equivalent to 24 g O. D.) at 3% consistency was used for beating the pulps. Sheet making and testing were carried out according to the appropriate JIS methods.

IV Results and Discussion

(a) Chemical Characteristics

The results of the chemical analysis of representative samples of the wood for investigation from these eight species are shown in Table 2.

Table 2. Chemical components of representative wood samples.
All results are based on O. D. wood.

Sample	Ash	Solubility in				Holo-cellulose*1	α-cellu-lose*2	Lignin
		Cold water	Hot water	1% NaOH	Et·OH-Benzene			
Chhoeuteal bangkuoi	0.39	2.9	5.2	28.3	5.2	64.0	43.5	36.4
Chhoeuteal sar	0.91	1.9	3.1	24.2	2.8	72.8	48.8	32.8
Komnhan	1.30	3.7	6.1	20.9	6.1	68.9	47.3	32.4
Phdiek	0.91	2.2	4.7	21.3	4.5	75.0	50.2	29.2
Ro yong	0.94	2.2	2.8	14.6	1.0	77.5	50.5	29.6
Koki khsach	0.19	7.9	10.6	30.1	11.8	69.3	49.1	26.5
Srol kraham	0.42	2.4	3.3	14.8	2.8	70.3	51.0	35.4
Rong leang	0.47	1.4	2.7	19.8	1.1	71.9	47.6	36.3
Beech	0.30	1.6	2.4	16.9	1.0	85.0	49.1	21.4

*1 Ash, Lignin free *2 Lignin free

The hardwood samples were distinguished from beech wood by being relatively high in lignin and low in holocellulose. The alpha-cellululose contents of these hardwood samples, except Chhoeuteal bangkuoi, were very similar to that of beech wood. Similar results concerning the chemical analysis of some tropical woods have been reported by WISE[8]. Chhoeuteal bangkuoi differed from the six other hardwoods by containing less holocellulose and alpha-cellulose. There were considerable variations in ash contents (0.19 to 1.30%), alcohol-benzene solubles (1.0 to 11.8%) and 1% sodium hydroxide solubles (14.6 to 30.1%). The chemical composition of the wood of Srol kraham was broadly similar to that of the average for a number of Japanese softwoods[5]. These chemical characteristics should affect the yield and properties of pulps.

(b) Morphological Properties of Wood

Morphological properties of wood samples are given in Table 3.

Table 3. Morphologicai properties of wood samples.

Sample	Fibre lenghth (mm)	Fibre diameter (mm)	Cell wall thick-ness (μ)	Basic density (g/ml)
Chhoeuteal bangkuoi	1.47	0.025	6.5	0.65
Chhoeuteal sar	1.52	0.024	6.5	0.62
Komnhan	1.31	0.021	4.5	0.59
Phdiek	1.68	0.025	5.0	0.56
Ro yong	1.06	0.030	2.5	0.43
Koki khsach	1.32	0.017	4.0	0.70
Srol kraham	2.91	0.046	3.5	0.42
Rong leang	1.06	0.017	7.0	0.90
Beech	1.13	0.020	3.5	0.48

These hardwoods ranged in fibre length from 1.06 to 1.68 mm, in diameter from 17 to 30 μ and in fibre wall thickness from 2.5 to 7.0 μ. The fibre length and fibre wall thickness of the wood of Chhoeuteal, Komnhan and Phdiek, predominant species in Cambodian forests, were all higher than the average for the hardwoods used in Japan for pulping[10]. There was considerable variation in the basic density of the eight species examined, that of the wood of Rong leang being particularly high.

(c) **Pulping**

The conditions used for pulping and the properties of the pulps are shown in Table 4.

Table 4. Pulping conditions and properties of sulphate pulps.
Pulping conditions: sulphidity, 25% (based on active alkali); liquor to wood ratio, 5 : 1; schedule, 1 hr. 40 min. to 170°C, and 1 hr. 30 min. at 170°C.

Cook No.	Total alkali (as Na_2O) %	Yield (%)			Roe number	Brightneess (unbleached)
		screened	screenings	total		
Chhoeuteal bangkuoi						
II A—a	20	37.9	0	37.9	3.19	12.4
II A—b	18	40.4	0	40.4	4.60	14.6
Chhoeuteal sar.						
II Ⓐ—a	20	44.3	0	44.3	2.07	15.8
Komnhan						
II B—a	20	43.2	0	43.2	3.64	21.3
Phdiek						
II C—a	20	43.9	0.1	44.0	3.20	22.4
Ro yong						
II D—a	20	47.5	0	47.5	3.12	21.1
II D—b	18	49.9	0	49.9	3.86	30.9
Koki khsach						
II E—a	20	42.5	0.1	42.6	3.27	21.6
II E—b	18	43.8	0.6	44.4	4.00	28.1
Srol kraham						
II F—a	20	40.5	0.1	40.6	6.99	17.3
Rong leang						
II G—a	20	40.4	0.2	40.6	3.65	15.1
Beech*	15	49.7	0	49.7	2.19	25.8

* Pulping condition: liquor to wood ratio, 4 : 1.

Pulp was prepared from each of the woods with 20% total alkali and a cooking time of 1 hr. 30 mins. at 170°C : these conditions were previously found satisfactory for the production of bleachable sulphate pulp from certain tropical wood species[1)7)6)]. One other condition (18% total alkali) was investigated to determine the effect of varying the total alkali.

Total pulp yield ranged from 37.9% (Chhoeuteal bangkuoi IIA-a) to 49.9% (Ro yong IID-b). The Roe numbers were within the range desirable for bleachable pulps in all cases. The yield seemed to be correlated with the species extractive and lignin contents. Pulp yield decreased with increasing extractive and lignin contents. Chhoeuteal bangkuoi gave low pulp yield owing to low alpha-cellulose content.

(d) Bleaching

The bleaching conditions and the properties of the bleached pulps are given in Table 5.

Table 5. Bleaching conditions and properties of bleached sulphate pulps.

Bleaching conditions.

Treatment	Pulp consistency (%)	Temperature (°C)	Reaction time (hr.)	Chemicals (%)
First stage (Chlorination)	4	room temperature	1	120% of Roe number
Second stage (NaOH extraction)	6	70	1	2.5*
Third stage (ClO_2 bleaching)	6	70	2	1.0*
Fourth stage (NaOH extraction)	6	70	1	1.5*
Fifth stage (ClO_2 bleaching)	6	70	2	1.0*
Sixth stage (SO_2 treatment)	3	room temperature	0.5	0.5*

* Pulp basis

Properties of bleached sulphate pulps.

Pulp No.	Brightness		Yield (%)	
	unbleached	bleached	unbleached pulp basis	O. D wood basis
Chhoeuteal bangkuoi				
II A—aB	12.4	82.5	96.4	36.5
II A—bB	14.6	85.9	94.7	38.3
Chhoeuteal sar				
II Ⓐ—aB	15.8	82.0	98.1	43.5
Komnhan				
II B—aB	21.3	87.4	98.0	42.3
Phdiek				
II C—aB	22.4	88.2	98.0	42.3
Ro yong				
II D—aB	21.1	86.6	95.5	45.4
II D—bB	30.9	87.6	96.1	47.9
Koki khsach				
II E—aB	21.6	89.8	96.0	40.8
II E—bB	28.1	88.0	98.1	43.0
Srol kraham				
II F—aB	17.3	87.1	97.5	39.4
Rong leang				
II F—aB	15.1	87.6	96.3	38.9
Beech*	25.8	90.4	98.8	49.1

* Third stage (Ca-hypo. bleaching) 2% (pulp basis); other bleaching conditions are the same as for the other samples.

All pulps produced clear and white pulps; however, the pulps from Chhoeuteal cooked with 20% total alkali showed relatively low brightness (approximately 82). In the case of the pulps cooked with 18% total alkali the brightness of bleached pulps was improved, although the pulps required a little more chlorine consumption than the pulps cooked with 20% total alkali.

It is considered that printing troubles are caused by the residual resin (extractives) in bleached hardwood sulphate pulps, and the colour reversion is also influenced by them. Be that as it may, it is very difficult to remove such resin from the pulps in the pulping and bleaching process, because they are stable for chemical reaction[7)2)].

A large number of pitch flecks were shown on the pulp sheets from Chhoeuteal according to the ultraviolet light radiation method which was suggested to determine pitch flecks by Kondo *et al.*[7)]. It would be expected, therefore, that the colour reversion would appear on the pulp sheets from Chhoeuteal.

Data on the effect of extractives in the pulps for colour reversion of bleached pulps are shown in Table 6. The reversion is expressed as the post colour number, as defined by Giertz[4)].

Table 6. Effect of ether-extractives for colour reversion of bleached sulphate pulps.

Pulp No.	Untreated			Treated		
	Brightness		PC No.*	Brightness		PC No.*
	before ageing	after ageing		before ageing	after ageing	
ⅡA—bB	85.9	70.2	4.17	84.6	78.4	1.58
ⅡD—bB	87.6	77.2	2.49	88.1	81.0	1.43
ⅡE—bB	88.0	80.6	1.54	86.7	81.2	1.16

Ageing condition: 120°C, 18 hrs.

* PC No. = (k/s after heating − k/s before heating) × 100

where $k/s=(1-R\alpha)^2/2R\alpha$

and k = the absorption coefficient of the sheet.

s = the scattering coefficient of the sheet.

$R\alpha$ = brightness.

The residual resin appeared as brown spots on the pulp sheets after ageing procedure, although these resin spots were indistinguishable owing to their white colour before ageing procedure. The pulp from Chhoeuteal bangkuoi showed highest colour reversion, however, this reversion was improved remarkably by ether extraction of bleached pulp. By the facts presented above it was confirmed that the extractives remaining in the bleached pulp from Chhoeuteal bangkuoi adversely affected the colour reversion. Croon *et al.* reported that sterols were one of the extractive components influencing colour reversion of birch sulphate pulp[2)]. Beta-phytosterol was found in the ether-extractives of unbleached pulp from Chhoeuteal bangkuoi by thin layer chromatographic techniques.

In another experiment the ether extractives of unbleached and bleached pulp from Chhoeuteal bangkuoi were determined. The results are as follows:

Pulp sample	Resin content
Unbleached pulp (ⅡA-b)	1.39% (unbleached pulp basis)
Bleached pulp (ⅡA-bB)	1.31% (unbleached pulp basis)

The data show a significant difficulty of removing residual resins in the pulp by bleaching procedures.

(e) Pulp Evaluation

Evaluation data for the unbleached and bleached pulps are shown in Table 7.

Table 7. Evaluation of sulphate pulps.

	Pulp No.	Basis weight g/m²	Thickness mm	Density g/ml	Breaking length km	Burst factor	Tear factor	Folding endurance	Freeness (C.S.F.)
Unbleached	II A—a	59.94	0.078	0.77	6.5	3.7	120.1	30	210
	II A—b	62.95	0.086	0.73	5.9	4.0	117.6	39	205
	II Ⓐ—a	60.41	0.079	0.77	6.8	3.6	127.1	49	205
	II B—a	62.61	0.081	0.77	6.0	3.4	117.6	28	210
	II C—a	61.20	0.083	0.74	5.7	3.1	137.6	25	205
	II D—a	60.97	0.072	0.85	7.9	4.6	125.0	66	230
	II D—b	60.72	0.073	0.83	8.3	5.4	108.5	100	205
	II E—a	59.80	0.080	0.75	6.4	3.8	127.4	34	230
	II E—b	62.33	0.084	0.74	6.7	4.3	107.8	43	205
	II F—a	60.91	0.071	0.86	9.5	6.9	123.5	1,300	225
	II G—a	60.27	0.080	0.74	6.3	3.8	127.4	29	220
	Beech	60.29	0.070	0.86	10.7	7.3	94.9	590	220
Bleached	II A—aB	60.02	0.078	0.77	4.4	2.0	108.3	10	210
	II A—bB	62.81	0.079	0.80	5.3	3.3	110.8	20	205
	II Ⓐ—aB	62.84	0.076	0.83	4.8	2.5	106.9	16	205
	II B—aB	58.43	0.075	0.78	5.1	2.7	101.3	14	210
	II C—aB	61.00	0.075	0.81	5.4	2.8	114.4	18	225
	II D—aB	60.21	0.067	0.90	7.4	4.3	109.9	58	230
	II D—bB	62.35	0.072	0.87	6.8	4.3	92.9	29	205
	II E—aB	59.13	0.077	0.77	5.4	3.0	118.0	17	220
	II E—bB	61.08	0.083	0.73	4.9	2.8	93.3	13	230
	II F—aB	62.08	0.068	0.91	6.1	6.1	107.3	1,200	225
	II G—aB	60.89	0.078	0.78	3.1	3.1	120.9	14	220
	Beech	62.07	0.074	0.83	8.0	4.4	57.4	31	230

The pulps from the hardwood samples had higher tearing resistance and lower tensile strength, bursting strength and folding endurance than the pulp from beech wood. These pulps also gave lower hand sheet density than that of the pulp from beech wood. The strength properties and the hand sheet density of the pulps from Ro yong and Srol kraham were similar that of the pulps from beech and pine wood respectively.

It is considered that the principal fibre properties influencing tearing resistance are fibre length, fibre wall thickness and probably also fibre strength, and other pulp strength properties, such as bursting and tensile strength, are dependent on fibre bonding rather than on fibre length. The thickness of the fibre wall has an important bearing on most paper properties. Dadswell and Watson[3] found that thick-walled fibres give bulky, open sheets with rather rough surface, whereas thin-walled fibres give dense, well-formed sheets. Pulp strength properties such as burst, tensile, and folding endurance are adversely affected by an increase in fibre wall thickness. These thick-walled fibres do not collapse readily when formed into sheets and thus present less opportunity for fibre bonding.

It seems that higher tearing resistance and lower tensile strength, bursting strength and folding endurance of the pulps from Chhoeuteal, Komnhan, Phdiek and Koki khsach are caused by the longer fibre and thicker fibre wall of these hardwoods than that of beech wood. The pulp from Rong leang developed relatively high tearing resistance in spite of its shorter fibre length than that of the other hardwoods and beech, which, may be attributed to the extremely thick-walled fibre of this species. The pulp from Ro yong gave similar properties compared with the pulp from beech wood owing to the similarity of the morphological and chemical properties between these two species.

In conclusion, it should be emphasized that all pulps from the wood samples investigated, with the exception of Chhoeuteal, are suitable for production of sulphate pulp for papermaking, although they have relatively low pulp yield and strength properties than those of beech and pine. It is necessary to develop a residual resin removing method of the pulps from Chhoeuteal for papermaking purposes, because these pulps contain residual extractives which would be a cause of various pitch troubles.

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南洋材の性質 5
カンボジア産材の性質（3）
カンボジア産材8樹種のパルプ化
（摘　　要）

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紙パルプ産業は近年著しい発展をとげ，世界的な傾向として原木に対する要求度はますます高まりつつある。したがって，従来パルプ原料として，ほとんど利用されていない南洋材は潜在資源として脚光を浴びつつあり，これらの材の輸出国である低開発国においても，また輸入国である先進国においても，パルプ材としてこれらを使用しうるか否かについて大きな関心が向けられている。

しかし，南洋材は森林中において多くの樹種が混在して生育しており，またこれらの材は化学的性質，物理的性質，木部繊維の形態的性質等に広範囲な変化がみられるので，パルプ材としての適否を判定するためには個々の樹種についてパルプ化適性を検討するのはもちろんのこと，製紙上の見地から，これらの樹種をできるだけ大きな群に分類し，群としてのパルプ化適性を検討することはきわめて重要なことである。

上記の目的を達成するために，林産化学部，木材部共同研究“南洋材の性質”の一部として南洋材のパルプ化に関する研究を，林産化学部パルプ研究室で行なっている。

この報告は，カンボジア産材8樹種（針葉樹1種，広葉樹7種）のクラフト法によるパルプ化試験の結果について述べたものである。

1. 供　試　材

供試材の詳細については，林業試験場研究報告第190号，“南洋材の性質(1)”[11)]に述べられている。

2. 実　　験

a）試料調整

厚さ 20 mm の円板を各樹種の各丸太から採取し， 20×10～15×2～3 mm の手割りチップを作製し，パルプ化試験に供した。各樹種のチップの一部を採りウイリイミルで粉砕し 40 mesh 通過部分をとり，木材分析（化学成分分析）用試料とした。各樹種の円板のなかから1枚ずつを選び，形態的性質測定用試料とした。

b）材およびパルプの化学的試験

木材分析はＪＩＳにより行なった。ホロセルロースは Wise 法により測定した[8)]。α-セルロースは分離

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ホロセルロースについて，常法により測定した。未漂白パルプの塩素吸収量（Roe 価）は TAPPI 標準法 T 202 os-61 により測定した。

c）形態的性質測定

材の形態的性質については，木部繊維の長さおよび直径，繊維壁の厚さ，材の比重（容積密度数）の測定を行なった。

d）パルプ化

蒸解は 4 l 容電熱式オートクレーブで行ない，得られたパルプは洗浄後，8-カットスクリーンにより選別した。パルプ収量およびその他の試験は精選パルプについて行なった。

e）漂　白

パルプは5段法により漂白した。漂白条件は Table 5 のとおりである。漂白パルプの白色度は JIS によって測定した。パルプのエーテル抽出物について，漂白パルプの色もどり現象に与える影響を検討した。

f）パルプの強度試験

パルプの叩解は Lampen mill で行ない，試験紙葉の調製および諸試験は JIS によって行なった。

3.　結果および考察

a）化学的性質

材の化学分析の結果は Table 2 のとおりである。

供試広葉樹材は，いずれもブナ材と比較してリグニン含有量が高く，ホロセルロース含有量が低かった。また α-セルロース含有量は，チュテール　バンコイを除き，いずれもブナ材とほぼ似かよった値を与えた。チュテール　バンコイは，他の供試広葉樹材と比較してホロセルロース，α-セルロースの含有量が低かった。灰分含有量（0.19～1.30%），アルコール・ベンゼン可溶分（1.0～11.8%），および 1% 水酸化ナトリウム可溶分（14.6～30.1%）は，樹種によりかなりの変化が認められた。スロール　クラハムの化学組成は，多くの日本産針葉樹の化学組成平均値と大体似たものであった[5]。

b）材の形態的性質

材の形態的性質は Table 3 のとおりである。

供試広葉樹材の繊維長は 1.06～1.68 mm，繊維直径は 17～30 μ，繊維壁の厚さは 2.5～7.0 μ の範囲であった。カンボジアの森林構成の優勢樹種であるチュテール，コムニヤン，プジックの繊維長，繊維の膜壁厚は，いずれもパルプ材として使用されている日本産広葉樹材の平均値より高い値を示した。供試材の比重（容積密度数）の変異は大きく，ロン　リアンの比重は特に高かった。

c）パルプ化

パルプ化の条件および得られたパルプの性質は Table 4 のとおりである。

パルプ収率は 37.9%（チュテール　バンコイ　II A—a）から 49.9%（ロヨン　II D—b）の範囲でかなりの差が認められた。ローエ価はすべての場合，漂白用パルプとして適当な値の範囲内にあった。パルプ収率は材の抽出成分およびリグニン含有量に関係があると思われ，これらの組成分含有量の多い材のパルプ収率は低かった。チュテール　バンコイは，α-セルロースの含有量も低いので，パルプ収率は特に低かった。

d）漂　白

条件および漂白パルプの性質は Table 5 のとおりである。

供試パルプはいずれも漂白後製紙用漂白パルプとして十分な白色度を示した。しかし 20% 有効アルカリで蒸解したチュテール材のパルプの白色度はやや低い値を示した（白色度，約 82)。18%有効アルカリで蒸解したパルプの場合，20%有効アルカリで蒸解したパルプの漂白の場合よりやや多量の漂白薬品を消費したが，漂白パルプの白色度は多少改善された。

漂白パルプの残留樹脂分は，印刷障害や色戻りの原因となり，しかもこれらの樹脂分の除去はきわめて困難であるといわれている[7)2)]。

紫外線照射法[7)]によりチュテールの漂白パルプに多数の樹脂斑点が認められたので，このパルプの色戻り現象が予想された。

漂白パルプの色戻りに対する抽出成分の影響についての試験結果を Table 6 に示す。

加熱処理前のパルプシート中の残留樹脂分は，樹脂分が白色のため判別しにくいが，加熱処理を行なうとシート中の樹脂分は褐色の斑点として認められた。チュテール　バンコイのパルプは最高の色戻りを示した。しかしこの色戻りは漂白パルプをエーテル抽出処理し，抽出分を除くことにより，著しく改善された。上記の事実から，チュテール　バンコイ材の漂白パルプに残留する樹脂分は色戻りに悪影響をおよぼしていることが確かめられた。クローンらは，ステロールはバーチの硫酸塩パルプの色戻りに悪影響をおよぼす抽出成分の一つであることを報告している[2)]。薄層クロマトグラフィーにより，チュテール　バンコイ材の未漂白パルプのエーテル抽出分中に β-フィトステロールの存在を認めた。

チュテール　バンコイ材の未漂白，漂白パルプのエーテル抽出分を定量し，次の結果を得た。

II A—b	未漂白パルプエーテル抽出分	1.39%（対未漂白パルプ）
II A-bB	漂白パルプ　〃	1.31%（　〃　）

上記の結果から，パルプ中の残留樹脂分は，漂白処理により除去することは非常に困難であることが認められた。

e）パルプの物理的性質

供試材パルプ（未漂白および漂白）の物理的性質は Table 7 のとおりである。

供試広葉樹材パルプはいずれもブナ材パルプと比較して，引裂強度が高く，引張り，破裂，耐折強度が低かった。またパルプシートの密度はいずれもブナパルプより低い値を示した。ロ　ヨンおよびスロールクラハム材のパルプの強度的性質およびパルプシートの密度は，それぞれブナおよびアカマツパルプと類似の結果を与えた。

チュテール，コムニヤン，ブジック，コキー　クサイのパルプがブナパルプと比較して引裂強度が高く，引張り強度，破裂強度，耐折強度が低いのは，これらの材がブナ材よりも木部繊維の繊維長が長く，繊維の膜壁厚が厚いためと考えられる。ロン　リアンのパルプは，材の繊維長がブナやその他の供試広葉樹材のそれよりも短いにもかかわらず比較的高い引裂強度を示した。これはロン　リアンの繊維膜壁厚が特に厚いためと思われる。ロ　ヨン材のパルプはブナパルプと比較して類似の性質を示した。これは両者の材の形態的性質，化学的性質が似ているためと考えられる。

以上諸試験の結論として，供試材はいずれもパルプ収量，強度性質等がブナやアカマツ材と比較してや

や劣るが，チュテール材を除き，製紙用硫酸塩パルプの製造に適当であるといえよう。チュテール材のパルプは種々のピッチトラブルの原因となる残留樹脂分を含有しているので，製紙用原料とするためにはこの樹脂分の除去法を開発する必要がある。