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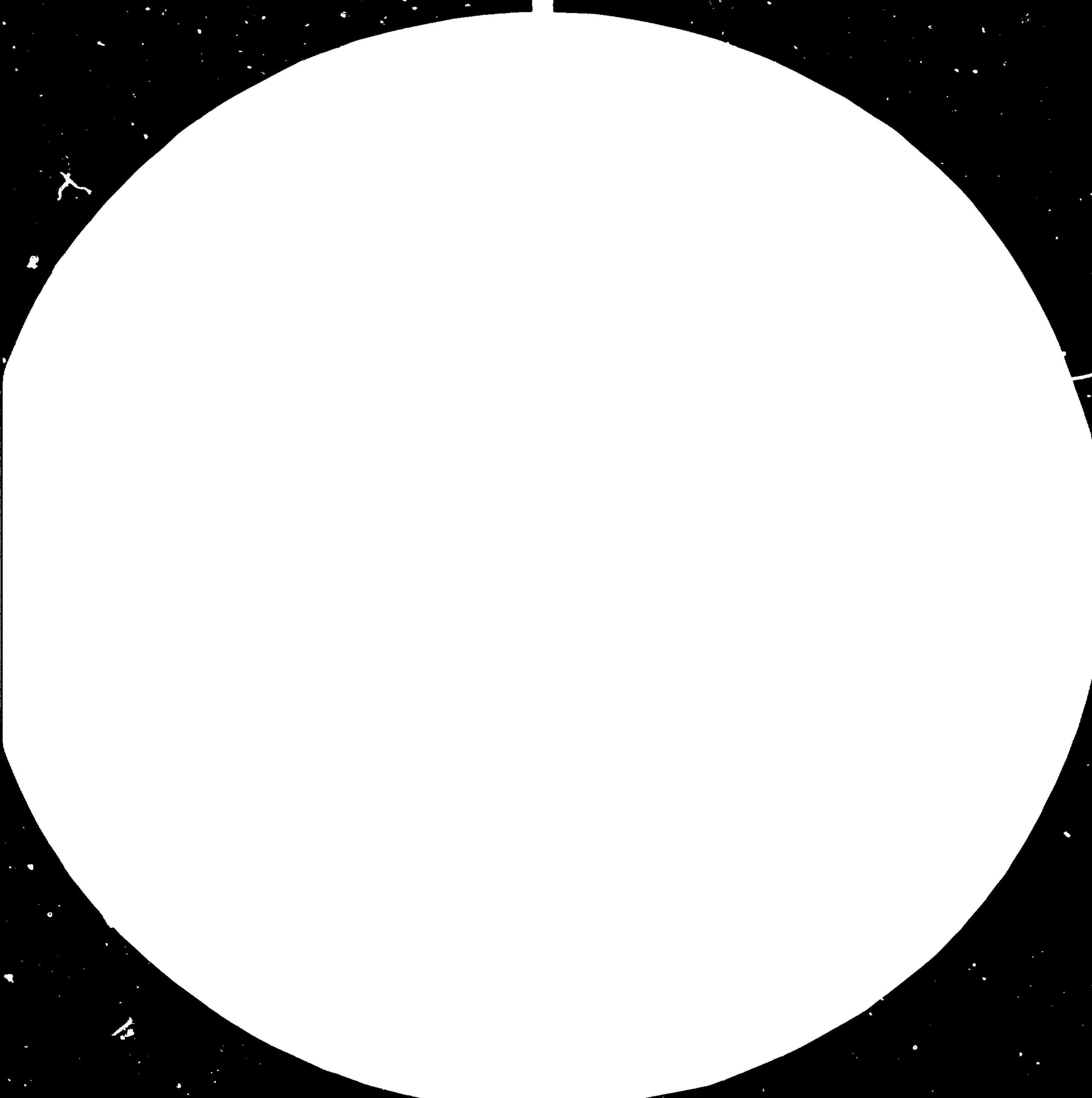

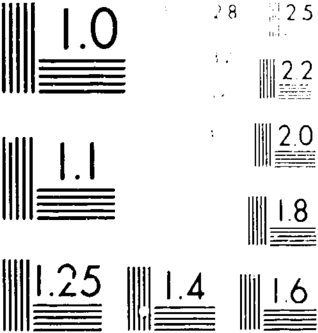
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ABACA AS A SOURCE OF PAPER-MAKING PULP*

by

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INTRODUCTION

For many years, fibres such as those from abaca and sisal have been used in paper-making, but originally, paper-making was a secondary use, the main use being cordage. When synthetic fibres were used for cordage, papermakers who had been using old ropes as a source of fibre turned to the original fibre as their raw material.

Abaca fibre has an important place in paper-making although the volume used will always be small. In 1978, some 20,000 tonnes of abaca pulp was used; a very small quantity when compared with wood pulp consumption at around 125 million tonnes. Since the world production of abaca in 1976 was about 93,000 tonnes, even if all abaca produced was used in pulp making, it would always be a small proportion of the total market for pulp.

The Tropical Products Institute (TPI) has been examining abaca as a pulpmaking material for more than 20 years. Originally, we were asked to find a reason why abaca from one source was preferred by pulpmakers, and the results of this investigation were published in "Causes and Prevention of Knots in Tissues Made from Decorticated Abaca" (Jarman, et al. 1970). In the course of this work, we realized that different grades of abaca and different methods of preparing the fibre could yield different qualities of pulp. It was found also, that such information, as is available, was widely dispersed in the technical literature. My colleague, C.B. Tabb, who has now retired, was encouraged by the FAO Hard Fibres Committee to start a project with the objectives of collecting together in one publication as much published information as possible and filling some of the gaps by research work in TPI, where he was commissioned with some consultants. This paper is a report on some of that work.

THE EFFECT OF GRADES OF FIBRE

In the Philippines, abaca fibre is divided into many grades depending on the cleanliness of the fibres and the part of the leaf sheath from which it was taken. The main grades produced are shown in Table 1.

The grading system in Ecuador is more simple, possibly because most of the production is for pulp and paper. All of the fibre is well cleaned (Hanick, et al., 1975) and grading is by diameter of fibre and colour. It is summarized in Table 2.

The fact that grading of fibre is likely to affect pulp quality has been indicated by a number of workers studying fibre morphology, including P. C. Tabora (1976). They have shown that fibres tend to be longer, narrower and thinner-walled from outermost to innermost parts of the leaf sheath. They found also that the lignin content was highest in the outermost part of the sheath.

In Table 3, the results of chemical analysis of three grades of Philippine abaca are given, showing small but significant differences in cellulose and lignin content between grades. Work in the Philippines has shown that cellulose content decreases and lignin content increases with decreasing efficiency of cleaning (E. J. Escolano, 1971).

In Table 4, the results of two soda and two alkali sulphite cooks on different grades of abaca are given. These results indicate that the less cleaned grades give lower yields of less free pulp with higher bursting strength and tensile strength and lower tearing strength. The results reported draw attention to the main advantages of abaca pulp: generally high strength when unbeaten and very porous and a particularly high tearing strength. The results are not conclusive because the varieties of fibres were not known and there was insufficient fibre available to pulp all grades separately. However, there is a firm indication that any changes in fibre preparation must give attention to freeing the fibre from parenchyma cells.

THE EFFECT OF VARIETY

In our investigations, it was not possible to investigate the effect of variety. The results of a Philippine work, shown in Table 5, indicate considerable differences due to variety (Franco, 1975). Mature-and-about-to-mature leaves from 7 varieties of abaca grown in three different regions were examined.

Other workers have obtained similar results. In our own work, we have found differences in pulp obtained from the same grade of fibre from different regions. Unfortunately, there was not sufficient information about the fibre to be certain whether this was an effect of variety or growing conditions.

EFFECT OF AGE WHEN HARVESTING

Morphological studies have shown that fibre length increases with the age of the leaf sheath when harvested. There is a tendency for the cell wall and the cell wall thickness also to increase but this effect is marked only in the cell wall thickness between the 4th and 8th month (Tabora, 1975).

It might be expected that these morphological changes would affect pulp quality. However, Franco (1975) examined seven varieties of abaca harvested when about to mature (pongpong stage) and mature (after the appearance of the flag leaf or influorescence). The results were inclusive for tear factor: the stronger pulp was obtained from four about-to-mature and three mature samples; for breaking strength: the difference was significant in only three trials, one favouring about-to-mature and two mature samples.

THE EFFECT OF DIGESTION CONDITIONS

The effect of different pulping processes was investigated using a sample made up of equal parts of abaca grades S-I, G, and JK. Details of some of the digestions made are in Table 6. The pulp obtained with the least severe soda cook included a large proportion of material that did not pass a screen with 0.15 mm slits. The least severe sulphate cook yielded a pulp with a smaller proportion of screening rejects. In both cases, the screening rejects were soft and could have been dispersed in a breaker but since an objective was to produce a porous pulp, this was undesirable. Both the soda and sulphate processes yielded pulps with few screening rejects when the alkali was 15% expressed as sodium oxide.

Once sufficient alkali had been applied to allow the fibre strands to be readily resolved into ultimate fibres, the addition of more alkali had little effect on either the residual lignin in the pulp or the brightness of the pulp although the total yield was reduced.

In all of the alkaline sulphite digestions, a well-resolved pulp was obtained although the pulps had a dirty appearance. A single digestion on a higher grade of abaca yielded a brighter pulp. It was, therefore, concluded that the poor colour of pulp reflected the poor colour of the mixed abaca sample. However, all of the pulps made by the alkaline sulphite process were brighter than those produced by either the soda or sulphate processes and would have the advantage of being suitable for many purposes without bleaching.

The strength characteristics of some pulps are given in Table 7 (for unbeaten pulps) and Table 8 (for those beaten for one hour in a Lampen mill). The unbeaten soda and sulphate pulps were more free than the alkaline sulphite pulps. There was little difference in the tensile or bursting strengths. The tearing strength was highest in the sulphate pulps and lowest in the alkaline sulphite pulps. After beating for one hour in the Lampen mill there was an increase in tensile strength of about 10%, in bursting strength of about 7% and a decrease in tearing strength of about 10%.

The results of these trials indicated that for high strength where colour is unimportant, a sulphate cook with the minimum alkaline to resolve the fibres is preferred, but where colour is important, the alkaline sulphite process using a high grade of fibre is preferred.

FRACTIONATION OF PULP

One of the differences between higher and lower grades of abaca fibre is that the lower grades include more parenchyma tissue. The presence of these "fines" has a major effect in increasing the air resistance of the sheet of paper. Experiments were made to see if by removing the "fines" from pulp after digestion, sheets could be formed from pulps from low grades of abaca with the same low air resistance as is usual from pulps made from high grade fibre. By fractionating pulps to remove fines, a more porous sheet was made. Unfortunately, it also reduced the tensile and bursting strength of unbeaten pulps to the level of wood pulp. Consequently, it would seem that a certain proportion of "fines," approximately that normally present in well-cleaned fibre, is desirable in maintaining the very high strength of unbeaten abaca pulp.

CONCLUSIONS

The results presented indicate that there are many factors such as growing conditions, variety, fibre preparation and pulping process which affect the quality of pulp made from abaca. If the user is to get the best value from a rather expensive pulp, much more information is required about the effect of these factors.

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TABLE 1

MAIN GRADES OF PHILIPPINE ABACA

GRADE	CLEANING	LAYER OF LEAF SHEATH	SHARE OF TOTAL BALING %
S2	Excellent	Next to outside	20.9
I	Good	Innermost and middle	7.4
G	Good	Next to outside	25.8
JK	Fair	All except outside	17.9
Y2	Damaged	All	7.0

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TABLE 2

GRADES OF ECUADOR ABACA

GRADE	LAYER OF LEAF SHEATH
1	Inner and Middle
2	Inner and Middle
3	Next to outside
4	Next to outside
5	Outside
6	All damaged and tow

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TABLE 3

CHEMICAL COMPOSITION OF PHILIPPINE ABACA

GRADE	S-I	G	JK
Alcohol-Benzene solubility	0.6	0.9	1.1
Hot water solubility	4.9	9.1	9.5
Holocellulose	90	85	85
Lignin	9.6	12.0	12.2
Pentosans	16.9	16.6	17.0
Ash	1.4	3.8	4.2
Ash insoluble in HCI	0.09	0.45	0.50

All expressed as % on oven dry abaca

TABLE 4

PULPING DIFFERENT GRADES OF ABACA

PULPING PROCESS	SODA		ALKALINE SULPHITE	
NaOH % o.d. abaca	19.4		2.5	
Na_2 % o.d. abaca			25	
Max. temperature °C	170		170	
Total digestion time, min.	157		270	
Grade of abaca	S-I	Mixed	S-S2	Mixed
Yield of unbleached pulp, %				
Total	70.1	61.1	77.5	65.2
Screened	70.0	60.9	77.4	65.1
Kappa number	6.9	7.9	3.6	6.6
Unbeaten Pulp Evaluation				
Canadian Standard Freeness	663	525	683	468
Burst Factor	59	107	72	104
Breaking Length km	7.4	10.8	8.4	10.6
Tear Factor	450	495	610	405
Air Resistance Gurley	0.3	4.1	0.5	12
Beaten 30 mins. Lampen Mill				
Canadian Standard Freeness	530	410	510	306
Burst Factor	76	110	100	106
Breaking Length km	9.0	12.3	10.4	12.6
Tear Factor	495	350	420	265
Air Resistance Gurley	1.2	20	9.5	62

Testing conditions 20+ 1°C 65% Relative Humidity
Mixed = Equal parts of S-I, G and JK

TABLE 5

PULPING OF SEVEN VARIETIES OF ABACA

REGION	VARIETY	YIELD O.D. PULP % FRESH STALKS	BURST FACTOR	TEAR FACTOR	BREAKING LENGTH KM
Visayas	Linawaan	3.37	76.8	269	8.1
	Minenonga	3.24	79.6	182	8.0
Bicol	Tinauagan Pula	2.82	68.5	175	7.3
	Tinauagan Puti	2.95	57.4	177	6.9
Mindanao	Tangongon	2.90	73.0	287	8.5
	Bangalanon	2.89	66.0	224	8.2
	Baguisanon Puti	2.51	71.4	159	8.6

Digestion conditions 18% NaOH on dry crushed stalks
$170^{\circ}C$ 3 hours
Strength properties are averages of values at 500,400 and 300 CSF
Testing Atmosphere $21 \pm 1^{\circ}C$ and 50% Relative Humidity

TABLE 6

ABACA - DIFFERENT PULPING PROCESSES

PROCESS IDENTIFICATION	SODA A	SODA B	SODA C	SULPHATE D	SULPHATE E	SULPHATE F	ALKALINE SULPHITE G	ALKALINE SULPHITE H
NaOH as Na_2O on o.d. fibre	9	15	18					
Active Alkali as Na_2O on o.d. fibre				9	15	18		
Sulphidity				25	25	25		
Na_2SO_3 on o.d. fibre							18	25
NaOH on o.d. fibre							3.0	2.5
Maximum temperature °C	170	170	167	170	170	167	170	170
Total digestion time min.	150	157	154	156	160	146	270	270
Pulp yield % o.d. fibre								
Total	69.1	61.1	62.8	67.2	63.5	60.9	66.7	65.2
Screened	55.6	61.0	62.7	66.0	63.4	60.8	66.6	65.1
Kappa Number	25	7.9	7.6	24	7.5	7.5	7.6	6.6
Brightness (Photovolt)	21	40	41	20	39	40	57	67

TABLE 7

EVALUATION OF PULPS FROM DIFFERENT PROCESSES (UNBEATEN)

PULP	SODA AVERAGE B+C	SULPHATE AVERAGE E+F	ALKALINE SULPHITE G	H
CSF	543	536	478	468
Breaking Length km	10.5	11.8	11.5	10.6
Burst Factor	101	104	111	104
Tear Factor	348	371	315	263

Testing Atmosphere 20± 1°C 65 ± 2% Relative Humidity

TABLE 8

EVALUATION OF PULPS FROM DIFFERENT PROCESSES
BEATEN 60 MIN. LAMPEN

PULP	SODA AVERAGE B+C	SULPHATE AVERAGE E+F	ALKALINE SULPHITE G	H
CSF	318	313	293	236
Breaking Length km	12.3	12.3	12.7	11.8
Burst Factor	112	113	116	108
Tear Factor	331	320	287	248

Testing Atmosphere 20±1°C 65± 2% Relative Humidity

COMPARISON OF ECUADOR AND PHILIPPINE GRADES

ECUADOR GRADE	PHILIPPINE GRADE
1	EF
2	J
3	S2
4	G
5	S3

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