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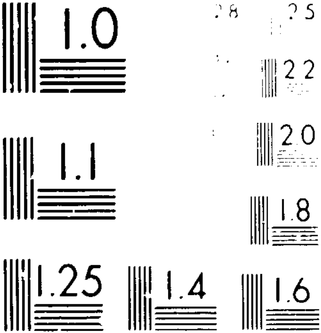
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A STUDY OF GRASSES FOR PULP AND PAPER IN INDONESIA *

by

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INTRODUCTION

Even if wood has been considered as the most suitable raw material for pulp and paper in the world, in most developing countries non-wood fibres in the form of grasses have been used as the only indigenous raw material for paper for many years. Grasses are easier to pulp than wood, due to their physical structure and chemical compostion, so that the processing could be carried out by using less energy and chemicals, in smaller mills and by using less skilled labour.

The study of grasses for papermaking has been neglected for many years due to the advent of wood as a raw material for the paper industry. With the steady increase in cost of fuel for energy and the need of developing countries to establish their own production capacities using their own raw material, the study of grasses is gaining in importance.

This paper deals with grasses found in abundance in Indonesia: rice straw which is the main agricultural waste, and alang-alang which is regarded as a noxious weed.

THE GRASSES

Rice Straw

Indonesia is an agricultural country, with 138 million inhabitants who mostly live on rice. Rice fields occupy more than 8 million hectares of Indonesia's land area, of which 4.4 million hectares are found on the island of Java. Even if Java's area is only seven percent of the whole of Indonesia, more than 70 percent of its people live there and more than 50 per cent of its rice fields are found there too. Rice straw, therefore, has been used as a raw material for papermaking for more than 50 years in Java. Padalarang Paper Mill, the first paper mill in Indonesia, was established in 1923 and was based on "merang," (part of the rice straw) as its raw material. The rice straw formerly used in the paper mills is in fact not the whole straw, but only the upper part of the rice stalk which contains the grain. This part, which is cut by hand one by one during harvesting consists of culms and rachises, and is called "merang" after the grains are removed. Research has shown that this part is the best part of the rice straw from the papermaking point of view.

Efforts to increase rice production have initiated the introduction of new high-yielding varieties of rice which are shorter. These varieties are harvested by cutting the whole plant so that what is left for the paper mill to process is the whole rice straw consisting not only of culms and rachises but also of a large amount of leafy material. This leafy material contains mainly parenchymatous cells which are undesirable for papermaking. The whole straw has to be utilized for papermaking, since separation of culms and rachises will be uneconomic.

As more and more new high-yielding varieties (PB 5, PB 20 IR 26, C 4,etc.) are cultivàted, less and less "merang" is available. This has caused severe problems for the paper and board mills using merang as their raw material.

Alang-Alang

Agricultural land outside Java is limited, since the soils are,on the average,less fertile. Even if there are more than 170 million hectares of land, only 4 million hectares are used for rice cultivation. There are, however, large areas, estimated to be more than 16 million hectares, covered with the grass Imperata cylindrica or alang-alang. The alang-alang fields outside Java which increase annually are the result of shifting cultivation practices.

Alang-alang is regarded as a noxious weed since it frequently appears in cultivated plots and usually suppresses the growth of the main crop. In Indonesia,alang-alang is found almost anywhere at sea level up to a height of 2700 m. The eradication of alang-alang as a weed is a very difficult problem. Symposia and seminars have been held for some years to discuss the problem of eradicating alang-alang. Herbicides have been developed, mechanical methods with the use of heavy equipment were tried, and other methods proposed. Effective and ecologically acceptable methods to eliminate this weed, however, are not yet clearly established.

From the point of view of agriculture, alang-alang is a weed. Since it is so hard to eradicate,it will probably be better to look upon it as a cellulosic resource which could be utilized for pulp and paper. With the search for new fibrous resources, the extensive areas covered with alang-alang may be a good alternative.

Physical Structure and Chemical Composition

The physical constitution of grasses alters from species to species and from variety to variety. Alang-alang consists only of leaf blades and leaf sheaths, while "merang" due to traditional harvesting methods consists of only culms and rachises. Straw of high-yielding rice varieties, on the other hand, consists of culms and rachises as well as leaf blades and leaf sheaths. The physical analysis of alang-alang, merang and some of the first high-yielding rice varieties grown in Indonesia are shown on the following table.

TABLE 1. PHYSICAL CONSTITUTION OF SOME GRASSES (%)

Parts	Alang-alang	Merang	PB 5	PB 20	C_4 - 63
Culms	-	54.1	31.0	25.9	25.75
Rachises	-	45.9	57.4	19.9	7.8
Leaf sheaths	18.8	-	5.4	35.9	39.0
Leaf blades	81.2	-	6.2	18.3	27.5

The table shows that of the high yielding rice varieties, C_4 - 63 consists mostly of leafy material, while PB 5, of culms and rachises. When examined under the microscope, it is shown that the various parts of the grasses have different average fiber lengths as shown on table 2.

TABLE 2. FIBER LENGTH, mm

Parts	Alang-alang	Merang	PB 5	PB 20	C_4 - 63
Culms	-	1.25	0.95	0.89	0.79
Rachises	-	1.20	0.86	1.05	1.04
Leaf sheaths	1.11	-	0.79	2.27	1.96
Leaf blades	1.09	-	0.79	1.52	1.14

The leaf sheaths of PB 20 have the longest fibers, and those of PB 5, the shortest. Even if the grass fibers are short, they are, however, slender. When the length to diameter ratios were measured, values of 130 up to 170 for alang-alang and the rice straws respectively were obtained. This would give good felting characteristics.

The chemical compositions of the grasses differ from each other as shown on table 3. Compared to rice straw, alang-alang has a much lower ash content. Rice straw is known for its high ash and silica content. This, however, depends also on the varieties, place of growth and the part of the plant analyzed. Ash of alang-alang is around 5 - 6 percent, while that of the whole rice straw around 20 percent. Rice straw, however, has a low lignin content.

TABLE 3. CHEMICAL COMPOSITION OF GRASSES (%)

	Alang-alang	Rice Straw	Merang	Bagasse
Ash	5.42	20.16	13.70	3.77
Silica	3.67	18.49	10.24	2.82
Lignin	21.42	11.49	8.28	25.45
Cross & Bevan Cellulose	63.34	56.85	64.08	62.82
Alfa Cellulose	44.78	35.44	47.57	40.94
Pentosans	28.58	21.62	-	26.63
Alcohol-benzene extract	3.75	7.27	4.26	3.04
Hot water solubility	8.59	15.60	12.02	10.84

It seems that alang-alang is chemically more related to bagasse than to rice straw.

When an analysis for ash is made on the different parts of the rice plant of one of the high yielding varieties, the following results were obtained:

TABLE 4. ASH CONTENTS OF PARTS OF THE RICE PLANT

	Rachises	Culms	Leaf sheaths	Leaf blades
Ash (%)	10.16	14.15	23.55	26.76
Silica (%)	8.48	9.60	18.01	23.38

This shows that the leaves have the highest ash content and the rachises, the lowest. The leaves also contain most of the parenchymatous cells which are of no value as a papermkaing material and cause drainage problems during washing and screening. The old traditional method of harvesting of local rice varieties in former days in which the culms and spikes were picked one by one and separated from the rest of the plant seem very approoriate from the point of view of papermaking, so that the small paper and board mills have been happy using this agricultural residue as their raw material for many years. It is also understandable that they are not too happy with the residue of the new high yielding varieties. The high ash content impedes strength development.

Pulping

Pulping experiments were performed on the grasses after they were cut to 3-4 cm length. The alkaline process was applied with varying alkali concentrations and cooking temperatures. The experiments were made in laboratory digesters of 3 liters capacity on alang-alang obtained from abandoned rubber plantations in West Java and on rice straw of one of the high yielding varieties.

To remove some of the parenchymatous cells, part of the samples were run through a disk refiner and screened. Material removed from alang-alang was 12 percent and from rice straw, 16 percent.

Previous work has shown that alang-alang was harder to delignify than rice straw, but was able to give pulp of better strength properties. This must be due to its higher lignin content and lower ash content.

In order to improve the rate of delignification, higher cooking temperatures were applied. When using 14% soda based on grass and increasing the cooking temperature from 135°C to 150°C and 170°C and keeping other cooking variables constant (4 hours cooking time and 1 1/2 hours to cooking temperature, but two hours to 170°C), the following results were obtained:

TABLE 5. SODA PULPING OF ALANG-ALANG

	Temperature °C	Total yield, %	Screened yield, %	Permanganate number
Alang-alang (depithed)	135	42.5	40.1	14.7
	150	43.5	42.8	17.6
	170	43.2	41.8	24.6
Alang-alang (undepitched)	[illegible]	43.1	39.76	20.0
	[illegible]0	41.6	40.5	16.4
	170	41.6	40.6	21.9

Increasing the cooking temperature during soda pulping of alang-alang does not always result in a bleachable pulp. At 170°C the pulp obtained has a higher permanganate number than pulps cooked at lower temperature. Similar trends were observed during pilot plant studies in which an 8 m^3 digester was used and 14% soda based on grass. An increase in cooking temperature from 135°C to 165°C did not improve the bleachability. The retention time at those temperatures was two hours. A higher lignin content as well as higher silica of the pulp cooked at the higher temperature was observed as shown on the following table.

TABLE 7. RESULTS FROM PILOT PLANT STUDIES

Cooking temperature		135°C	165°C
Screened yield	%	43.5	43.2
Screenings	%	1.8	2.3
Permanganate number		16.7	16.8
Klason lignin	%	5.43	7.08
Ash	%	5.36	5.93
Silica	%	2.94	3.96

The above phenomena were probably caused by the condensation of the grass lignins especially when a relatively low alkali concentration was used and a too long retention time.

Efforts to improve delignification were continued by adding 0.15% anthraquinone. When going from 135°C to 150°C, a lower permanganate number was obtained and the yield was also improved. This method seems to be promising and should be explored further.

Soda pulping experiments at various cooking temperatures were also performed on rice straw. Rice straw has low lignin content so that the effect is not that pronounced as on alang-alang pulp, as shown on the following tables. The retention time at cooking temperature was 2 hours except for that at 170°C which was 1 1/2 hours and the total cooking time 3 1/2 hours.

TABLE 8. SODA PULPING OF RICE STRAW

NaOH %	Cooking temperature °C	Total yield %	Screened yield %	Permanganate number
10	135	50.4	48.3	10.4
	150	51.7	49.0	9.7
	170	52.0	51.1	9.9
12	150	49.7	48.4	8.0
	170	48.9	43.4	7.1

When the cooking time is prolonged while alkaline concentration is relatively low and cooking temperature high, a pulp with much screenings is obtained. Working at 175°C using 8% alkali and increasing the retention time from one hour to three hours gave an increase in screenings of the pulps from 2.3 percent to 10.5 percent. The total yield as well as the permanganate number did not differ much.

The best parts of the rice straw from the papermaking point of view are the culms and rachises which are found in merang. Soda pulping experiments on merang using 8% and 10% alkali based on grass with two hours retention time at cooking temperature gave the following results.

TABLE 9. SODA PULPING OF MERANG

Cooking chemical	Cooking temperature °C	Total yield %	Screened yield %	Permanganate number
8% NaOH	135	55.5	55.3	7.5
	170	54.8	54.5	6.3
10% NaOH	135	55.1	54.9	6.1
	170	51.5	51.0	5.9

The merang pulps showed high yields and low permanganate numbers.

When the pulps were evaluated for their strength development, it was shown that the physical properties of the alang-alang soda pulps were not much affected by the increased cooking temperature. At 50 - 60°SR, tear factors were around 50, burst factors around 35, and breaking lengths around 5600 m for alang-alang pulps which were undepithed. A slight increase in strength was observed when the alang-alang was depithed.

The rice straw soda pulps evaluation, on the other hand, showed that the high temperatures affect the physical properties markedly. Burst factor and breaking length, when going up from 135°C to 170°C, decreased from 31 to 18 and from 4400 m to 2300 m respectively at 60°SR.

The superior properties of merang as a papermaking material were also shown when the pulps were evaluated for their physical properties. Even if a decrease in properties was observed when increasing the cooking temperature, the strength properties were much superior to alang-alang and rice straw. At 50°SR, tear factors decreased from 63 to 52, burst factors from 72 to 60, and breaking lengths from 9000 m to 8500 m when the cooking temperature was increased from 135°C to 170°C.

CONCLUSION

The grasses which are still unutilized as well as rice straw which form agricultural residue scattered over all the villages in Indonesia could be used as a papermaking raw material. Further studies, fundamental as well as practical and economical, are necessary in order to enlarge our knowledge about these grasses so that their utilization can be performed optimally.

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