JARQ 25, 283–288 (1992)

Chemical Characteristics and Utilization of Oil Palm Trunks

Yoichi TOMIMURA
Department of Wood Chemistry, Forestry and Forest Products Research Institute
(Tsukuba, Ibaraki, 305 Japan)

Abstract
Chemical characteristics of oil palm trunks were investigated to find out the best utilization way. Oil palm trunk tissue consists mainly of vascular bundles and parenchyma cells, which are separated easily and discriminately from each other by mechanical crush. Starch content was remarkably high in parenchyma cells. Xylose and glucose were the main sugar components in both tissue, indicating that the polysaccharide consists of xylan, starch, and cellulose. Lignin contents was less than 20% in both fractions. The lignin of oil palm contained *p-hydroxybenzoic* acid as an ester group which could easily be removed by alkaline treatment.
Oil pal, trunks have a high potential for food and cattle feed production due to the high contents of xylan and starch in addition to cellulose and lignin. The *p-hydroxybenoic* acid could be used as a raw material for engineering plastics. Oil palm trunks have a great potential for its utilization in the course of processing for cattle feed production.

Discipline: Forestry and forest products
Additional key words: lignin, parenchyma, p-hydroxybenzoic acid, starch, vascular bundles

Introduction

Oil palm, being a native species to West Africa, has been introduced to various parts of the tropics to obtain palm oil from its fruits. The production of palm oil has tremendously increased since the 1970s, especially in Malaysia and Indonesia[13]. The total plantation area in the world is expected to be 5 million ha by the year 2000[13]. Since it is difficult to harvest fruits from a tree grown too tall, oil palm trees are usually replanted in every about 25 years of its economic life span, though they can still produce fruits with high yields[9]. It is estimated that the amount of trunks available is at the rate of 84 t/ha[8]. But the trunks are normally left in the field without any utilization thereafter. They are usually cut into pieces and burnt down to avoid insect and disease incidences[9].

Thus, an enormous quantity of lignocellulosic materials are discarded in vain, while destruction of the rain forests has been expanding in the same tropical areas by excess cutting of trees. The shortage of log supplies in these areas is increasingly a serious problem. Therefore, research on the utilization of oil palm trunks is now getting more urgent than ever. There are some merits in utilizing oil palm trunks. Since they are systematically planted on a large scale, steady and stable supplies of trunks can be expected. In addition, since palm estates are usually located in a flat land, it is easy to collect and transport trunks to industrial sites.

Oil palm belongs to monocotyledon and its trunks consist of vascular bundles and parenchymas. Oil palm trunks have such special characteristics as high moisture content (1.5 to 2.5 times the weight of the dry matter), low cellulose and lignin content and high content of water solubles and NaOH solubles in comparison with rubberwood and bagasse[9]. Physical properties of trunks show heterogeneity and vary depending on both radial and vertical directions[7]. Some difficulties in utilizing oil palm trunks also lie in extremely tough outer bark and high content of decayable parenchyma cells. This paper attempts

Table 1. Analyses of vascular bundles and parenchyma

(%)

Plant part	Ash	Starch	Lignin (Acid soluble)	Sugar composition				
				Man	Ara	Gal	Xyl	Glu
Vascular bundles	2.2	2.4	15.7 (3.9)	2.0	+	+	34.8	63.2
Parenchyma	2.9	55.5	20.0 (4.5)	1.3	6.5	1.9	34.8	55.5

Table 2. Yield of nitrobenzene oxidation products

(%)

Origin	Vanillin	*p*-Hydroxybenzoic acid	Syringaldehyde
Milled wood lignin from vascular bundles	4.1	9.8	11.0
Milled wood lignin from parenchyma	3.6	14.9	8.0

to review the results of the studies on chemical compositions of oil palm trunks for the purpose of developing their effective end use.

Chemical composition of oil palm trunks

Wood samples located at a breast height of 25-year-old oil palm trunks (*Elaeis guineensis* Jacq.) were used for chemical analyses. Samples were debarked, cut into small chips, and then crushed to separate vascular bundles from parenchyma. It was easy to separate distinctly these fractions. Vascular bundles and parenchyma accounted for 71–76% and 24–29% of the whole chips, respectively. Table 1 shows the results of chemical analyses of vascular bundles and parenchymas. Oil palm chips contained a few percent of ash, which might be crystalline silica. Starch content was extremely high in parenchymas. This is the reason why fungi grow so fast on the surface of the cross section of oil palm trunks. This starch can be used as food materials or a raw material for alcohol fermentation[4]. Sugar compositions of trunks consisted mainly of glucose and xylose as is the case with Gramineae. Xylan can be used as a raw material of food and pharmaceutical industries for xylose or xylitol production. Lignin content was low in comparison with ordinary wood. Low lignin content and relatively high carbohydrate content of oil palm trunks imply that this wood would be useful for cattle feed production[7]. Treatment of trunks with sodium hydroxide for cattle feed production was reported by Oshio et al.[15].

Several attempts to utilize oil palm trunks as building materials have been also reported[1]. Long shape vascular bundles themselves could be used as a raw material for wood-based panels such as cement board, fiberboard and strandboard[16]. The outer region near bark is rich in vascular bundles and the density of this area is high. Therefore, the outer region might be appropriate for manufacturing building materials. But the inner region with low lignin content and high content of parenchymas in tissue structure is not suited for building materials which need strength to a greater extent. Several workers[10–12] have reported that it would not be also proper for pulp and paper manufacture since fiber content of oil palm trunks is low and high content of starch would consume pulping chemicals in vain.

Chemical characteristics of oil palm lignin

Table 2 shows the results of nitrobenzene oxidation of milled wood lignin. Both milled wood lignins from vascular bundles and parenchyma produced vanillin, *p*-hydroxybenzoic acid, syringaldehyde and a small amount of phenolic acids such as vanillic acid and syringic acid, but *p*-hydroxybenzaldehyde was not observed in the degradation products. This means that both milled wood lignins do not contain *p*-coumaric acid ester structure. Many monocotyledons such as bamboo, wheat straw, bagasse and corn stalk have *p*-coumaric acid ester structure in their lignin component.

Fig. 1 shows the gas chromatogram and mass spectra of alkaline hydrolysis products of parenchyma milled wood lignin. The main peak was attributed to *p*-hydroxybenzoic acid from retention time and mass pattern and there were small peaks attributed

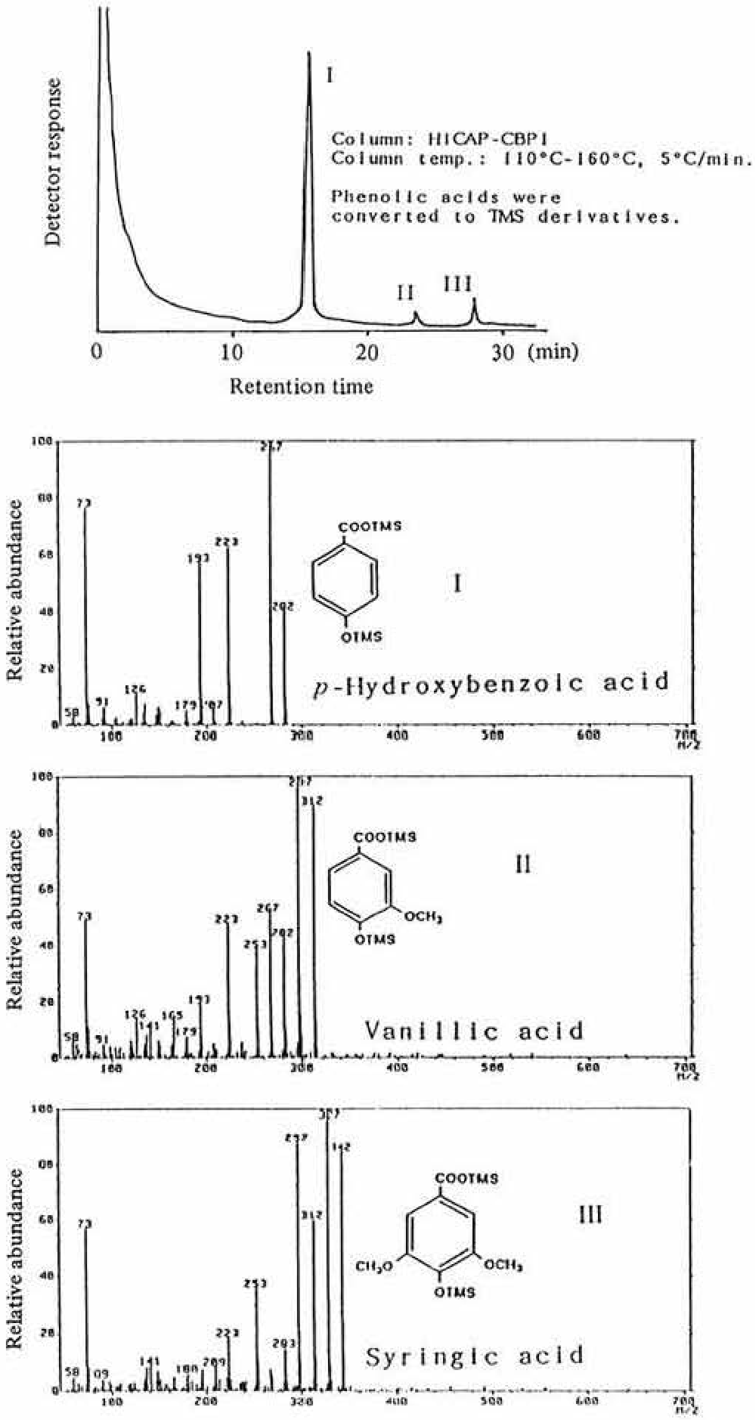

Fig. 1. Gas chromatogram and mass spectra of phenolic acids produced by alkaline hydrolysis of oil palm lignin

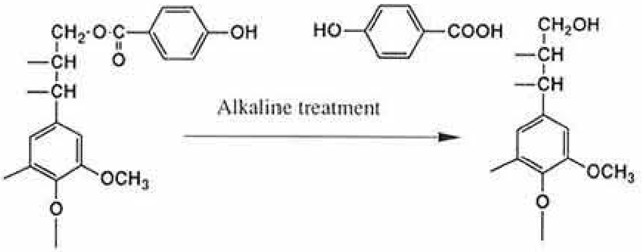

Fig. 2. Ester structure in oil palm lignin

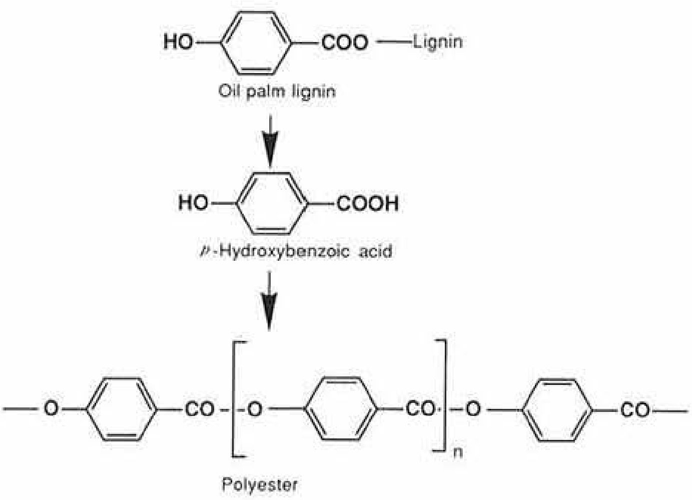

Fig. 3. Synthesis of polyester from oil palm lignin

to vanillic acid and syringic acid. Therefore, the phenolic acid ester structure consisted of C_6–C_1 type (Fig. 2). But phenolic acids of C_6–C_3 type such as *p*-coumaric acid, ferulic acid and sinapic acid were not observed in alkaline hydrolysis products. The vascular bundle lignin also gave the same reaction products. This means that the oil palm lignin is different from the Gramineae one. Phenolic acid ester, especially *p*-hydroxybenzoic acid ester structure, is characteristic to poplar lignin[14]. It is interesting to see that the oil palm lignin has the same structure as poplar lignin. The content of *p*-hydroxybenzoic acid was higher in parenchyma than in vascular bundles (Table 2). Since ester linkage is labile under an alkaline treatment, this phenolic acid can be easily recovered by an alkaline treatment, followed by an extraction with organic solvent. Phenolic acid such as *p*-hydroxybenzoic acid can be used as a raw material for manufacturing engineering plastics[2,3] (Fig. 3).

It is very difficult to find the end use of lignin. The structure of lignin, being heterogeneous, requires high temperature and high pressure to degrade lignin. Moreover, the degradation product of lignin is not a single compound but mixtures of various phenols. But in this case, there is no need to use drastic conditions with the pressure and high temperature to produce *p*-hydroxybenzoic acid. One-day soak of chips into dilute sodium hydroxide solution at room temperature may be enough.

Total utilization of oil palm trunks

For the utilization of oil palm trunks, at first, bark

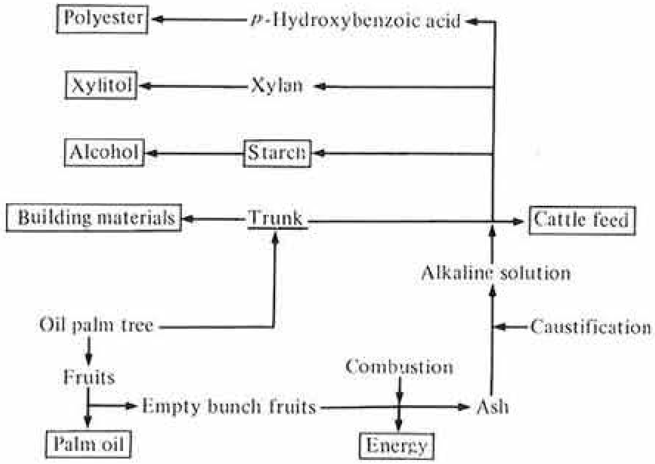

Fig. 4. Total utilization of oil palm trunks

and outer region near bark with high density must be removed. These parts can be used as building materials. The chemical composition of oil palm trunks suggests that their conversion to cattle feed be the best way to utilize the trunks totally. Because, an alkaline treatment[15] for increasing digestibility can also produce useful materials for cattle feeding. About 10% sodium hydroxide is used for the treatment[6]. This alkaline solution can extract starch, xylan and *p*-hydroxybenzoic acid. The starch extracted might be used in food industry or it is fermented to alcohol[4]. The xylan extracted is converted to xylitol which is used as a noncaloric sweetener for diabetes. Polyester can be made from the *p*-hydroxybenzoic acid extracted by polymerization and can be used as engineering plastics. Higashi et al.[2,3] made high molecular weight copolyesters from hydroxybenzoic acids. Finally, the alkaline solution can be provided from palm oil industry. Since the empty fruit bunches contain high percentage of potassium carbonate, the ash of those bunches can be converted to potassium hydroxide by caustification[5]. Hosokawa et al. estimate that 3 *l* of 1.5 N potassium hydroxide solution can be obtained from 1 kg ash[5]. The possibility of total utilization of oil palm trunks is shown in Fig. 4.

References

1) Chew, L. T. et al. (1991): Panel products. *Research Pamphlet*, **107**, 35–50.

2) Higashi, F., Yamada, Y. & Hoshio, A. (1984): Direct polymerization of hydroxybenzoic acids by use of diphenyl chlorophosphate in the presence of N,N-dimethylformamide. *J. Polym. Sci., Polym. Chem. Ed.*, **22**, 2181–2187.

3) Higashi, F., Takahashi, I. & Akiyama, N. (1984): Further study of the direct polycondensation reaction of hydroxybenzoic acids with tosyl chloride and N,N-dimethylformamide. *J. Polym. Sci., Polym. Chem. Ed.*, **22**, 3607–3610.

4) Hoi, W. K. & Putri F. Akmar (1991): Solid and liquid fuels. *Research Pamphlet*, **107**, 87–97.

5) Hosokawa, J. et al. (1989): *In* Proceedings of 39th annual meeting of Japan Wood Research Society, 138 [In Japanese].

6) Ismail, Abd. Rahman & Hoi, W. K. (1991): Animal food. *Research Pamphlet*, **107**, 67–73.

7) Killman, W. & Lim, S. C. (1985): Anatomy and properties of oil palm stem. *Proceed. nat. symp. on oil palm by-products for agro-based industries, Kuala Lumpur. Palm Oil Res. Inst. Malaysia Bull.*, **11**, 18–42.

8) Megat Ayub, M. J. (1985): *Proceed. nat. symp. on oil palm by-products for agro-based industries, Kuala Lumpur. Palm Oil Res. Inst. Malaysia Bull.*, **11**, 1.

9) Mohamad Husin et al. (1985): Potentials of oil palm by-products as raw materials for agro-based industries. *Proceed. nat. symp. on oil palm by-products for agro-based industries, Kuala Lumpur. Palm Oil Res. Inst. Malaysia Bull.*, **11**, 7–15.

10) Mohd. Nor Mohd. Yusoff et al. (1984): Preliminary characterization of oil palm stem as raw materials for pulp and paper. *Malaysian Forester*, **47**, 28–42.

11) Mohd. Nor Mohd. Yusoff (1985): Neutral sulphite semichemical pulping of oil palm trunk. *Proceed. nat. symp. on oil palm by-products for agro-based industries, Kuala Lumpur. Palm Oil Res. Inst. Malaysia*

Bull., **11**, 79–94.
12) Mohd. Nor Mohd. Yusoff, Khoo, K. C. & Lee, T. W. (1989): Properties of sulphate and soda-anthraquinone pulps from oil palm trunk. *J. Trop. For. Sci.*, **2**, 25–31.
13) Nishino, T. (1988): *Monthly Bull. Overseas Agr. Develop. News*, **3**, 1–22 [In Japanese].
14) Okabe, J. & Kratzl, K. (1965): On the origin of bonds between *p*-hydroxybenzoic acid and lignin. *Tappi*, **48**, 347–354.
15) Oshio, S. et al. (1989): Nutritive value of oil palm trunk for ruminants. *In* Proceedings of 12th MSAP annual conference, 52–57.
16) Tomimura, Y. (1990): Manufacture of medium density fiberboards from Malaysian rubberwood and oil palm. *Bull. For. & For. Prod. Res. Inst.*, **57**, 157–160 [In Japanese].

(Received for publication, Sept. 3, 1991)