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ENZYMATIC SACCHARIFICATION OF OIL PALM TRUNKS

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ISHIHARA, T., PUTRI F. AKMAR, ISMAIL AB. RAMAN & KHOO, K.C. 1991. Enzymatic saccharification of oil palm trunks. Treatment with cellulolytic enzyme on different portions of two oil palm trunks yielded appreciable amounts of solubilized matter. Sugars produced by this enzymatic hydrolysis comprised principally glucose and constituted 32 to 79% of the solubilized matter. The ratio of sugars to the amount of solubilized matter, as given by the weight loss, increased with a decrease in the amount of solubilized matter radially towards the periphery of the trunks. Except for the outer zone of one tree, this ratio did not show wide differences along the height although the amount of solubilized matter distinctly increased with the height of the palms.

Key words: Oil palm trunks - enzymatic saccharification - solubilized matter - glucose

Introduction

At present there are about 1.7 million *ha* of land cultivated with oil palm in Malaysia (Anonymous 1988). It is estimated that the total planted area will be increased to about 1.8 million *ha* by the year 1990 (Khalid *et al.* 1983).

During oil palm replanting, about 209.7 to 270.3 m^3 ha^1 of oil palm trunks are generated (Khali Hamzah personal communication). Many studies have been carried out to use this abundant new source of raw material. This includes pulp and paper making (Khoo & Lee 1985), production of wood cementboard (Rahim & Abdul Razak 1987), particleboard (Chew & Ong 1985), animal feed (Oshio *et al.* 1989) and enzymatic hydrolysis (Tomimura *et al.* 1989).

Unlike other common timbers, the oil palm trunk is a heterogenous material. Previous studies have shown that its physical and chemical composition varies with height and width (Lim & Khoo 1986). The alpha cellulose content, for example, increases from the pith towards the outer region. A greater quantity of short-chain carbohydrates is found in the inner portion of the trunk which is richer in parenchymatous tissue. Hence, in any attempt to use the oil palm trunk (OPT) as a substrate in fermentation, different portions of the trunk would show different susceptibility. This forms the basis of the present study.

Materials and methods

Two 30-y-old palms from the Sungai Tinggi Estate were felled for study. The trunks were divided into billets of 1.5 *m* each, starting from 1.5 *m* above the ground and labelled A,B,C,D (Figure 1). Cross-sectional discs of 15 *cm* thickness were obtained at a palm height of 3.0, 4.5, 6.0 and 7.5 *m*. Each billet was further divided into three concentric zones of 7 cm labelled O,C,I (bark removed, Figure 1).

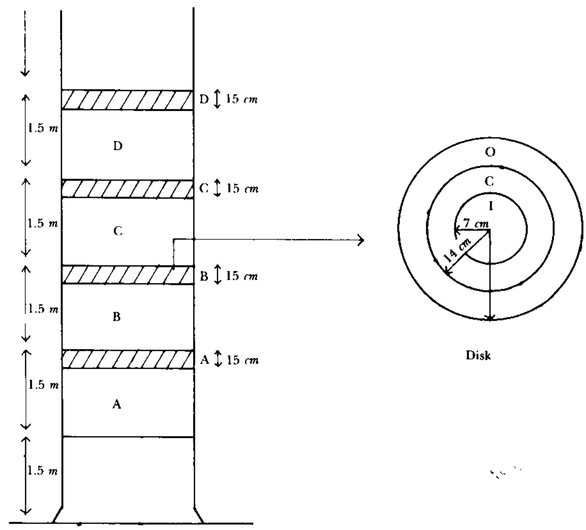

Figure 1. Sampling of oil palm trunk

The discs were then chipped into smaller pieces manually and air dried. They were later ground in a Wiley mill to 200 mesh size. Ground samples (wood meal) were stored in plastic containers at room temperature.

Incubation

Wood meal (200 *mg)* was shaken in a L-test tube with 5 *ml* of buffer solution (0.1 *N* acetate, pH 5.0) containing 50 *mg* of Meicelase (CEP-6130, Meiji Seika Co. Ltd.) and one drop of toluene at 40°C for 48 *h*. The same experiment was carried out with buffer solution containing no enzyme in order to know the amount of water soluble matter and for comparison. After incubation, the reaction mixture was filtered with a sintered glass crucible of porosity 2. The residue was dried at 105°C for 2 *h*.

Analysis

Weight loss or solubilized matter was determined by substracting the weight of the oven dry (O.D.) residue from the bone dry weight of the starting material. Sugars were determined using HPLC Model HP 1084B with column Bio-Rad Aminex HPX-87P and a refractive index detector; 10 to 20 u.*I* were injected and double distilled water was used as the mobile phase.

Results and discussion

The amount of water soluble matter of the oil palm trunks with and without enzymatic treatment generally increased along the height and across the width towards the centre as shown in Table 1. A comparison of specimens obtained from different positions reveals that the higher the position the more is the solubilized matter (D>C>B>A). The innermost part gave the highest value while the outer part the least (I>C>O). This may be due to the greater amount of soft parenchymatous tissue in the centre than in the harder outer portions which contain more vascular bundles (Lim & Khoo 1986). It is also noted that there existed an appreciable difference between two different palms of the same age and location.

Table 1 shows that the amount of enzymatically solubilized matter is two to three times higher than the non-enzymatically solubilized matter. It also shows that the enzymatically solubilized matter increases also with height. This supports the above presumption and therefore it can be concluded that the inner and higher position of the stem are more susceptible to enzymatic attack.

Table 2 shows results of sugar determination of the hydrolyzate by HPLC together with weight loss on incubation. HPLC chromatogram of the hydrolyzate revealed the presence of glucose, xylose, galactose, rhamnose, arabinose, mannose and fructose and ethanol. However, glucose was most dominant (80-90%) while the other sugars were almost negligible (Table 3). Thus in Table 2, only the sum of these sugars obtained from 200 *mg* wood meal is shown.

Table 1. Amount of solubilized matter of oil palm trunk (percent of weight loss on incubation)*

Tree 1			Tree 2		
Sample	without enzyme	with enzyme	Sample	without enzyme	with enzyme
1AO	4.0	9.4	2AO	4.6	8.5
1AC	7.3	15.2	2AC	3.7	11.1
1AI	14.6	22.9	2AI	12.0	16.9
1BO	ND	ND	2BO	9.6	19.3
IBC;	9.5	20.1	2BC	13.5	21.6
1BI	11.2	24.5	2BI	ND	ND
1CO	6.5	21.1	2CO	8.1	21.8
1CC	9.8	29.9	2CC	17.4	28.9
1CI	18.9	39.6	2CI	26.1	32.1
1DO	8.0	23.3	2DO	8.3	21.6
1DC	14.0	40.5	2DC	17.3	32.7
1DI	ND	ND	2DI	21.7	35.3

*: average of three determinations; ND : not determined

Table 2. Weight loss on the enzymatic incubation and the amount of sugars in the hydrolysate (percent of the dry matter of the starting material)*

Tree 1				Tree 2			
Sample	Weight loss A	Sugars B	B/A	Sample	Weight loss A	Sugars B	B/A
1AO	9.4	4.2	0.44	2AO	8.5	3.2	0.38
1AC	15.2	5.4	0.35	2AC	11.1	4.2	0.38
1AI	22.9	6.1	0.27	2AI	16.9	5.4	0.32
1BO	ND	ND		2BO	19.2	15.2	0.79
1BC	20.1	8.7	0.43	2BC	21.6	10.3	0.47
1BI	24.5	#		2BI	ND	ND	
1CO	21.1	10.1	0.48	2CO	21.8	14.9	0.68
1CC	29.9	10.3	0.34	2CC	28.9	13.2	0.45
1CI	39.6	13.6	0.34	2CI	32.1	10.5	0.33
1DO	23.3	#		2DO	21.6	8.4	0.39
1DC	40.5	3.8		2DC	32.7	10.9	0.33
1DI	ND	ND		2DI	35.3	9.9	0.28

*: average of three determinations; ND : not determined; # : poor determination

Table 3. Sugar composition of the enzymatic saccharification from oil palm trunk

Sample	Total sugar	Sugar composition (%)					
	(mg)	cello,	gal.	ara.	fruc.	xyl.	glu.
2AO	5.8	-	-	„	11.5	-	90.0
2AC	7.3	-	-	4.0	-	10.4	84.0
2AI	9.5	-	2.7	2.9	14.6	2.0	78.6
2BO	27.2	1.9	-	-	8.2	5.6	84.2
2BC	18.2	-	-	2.8	5.5	-	91.7
2BI	ND	ND	ND	ND	ND	ND	ND
2CO	26.6	-	0.7	0.5	5.2	5.0	88.5
2CC	23.4	-	-	0.7	8.7	3.2	85.5
2CI	18.4	-	-	3.4	8.0	0.9	86.9
2DO	14.9	-	3.5	2.3	-	10.6	83.5
2DC	19.5	-	-	4.9	-	4.6	90.4
2DI	17.4	-	-	9.3	-	-	90.7

Note: cello. = cellobiose; gal. = galactose; ara. = arabinose; fruc. = fructose; xyl. = xylose; glu. = glucose; ND: not determined

Sugars are not the sole component of the solubilized matter. It is proved by the ratio of sugars and the solubilized matter, B/A in Table 2. The B/A ratio ranges from about 0.32 to 0.79. The outer part which contained rather smaller amounts of solubilized matter showed higher ratios (B/A) than the inner part which is richer in solubilized matter. This fact is also due to distribution of the vascular bundles which increase towards the peripheral zone. These bundles are not easy to be solubilized and the lower solubilized matter of the lower stem is due to the thickening of the older vascular bundles, the fibres of which are more lignified and have thicker cell walls (Lim & Khoo 1986). This is also consistent with decreasing B/A values with height increase which can be correlated with the distribution of the vascular bundles. While some differences were present in the amount of sugars produced by enzymatic saccharification of the oil palm trunks at different radial positions, these were not as great as the differences in the amount of solubilized matter.

Conclusion

The study showed that an appreciable amount of the oil palm trunk becomes solubilized by treatment with cellulolytic enzyme. However, the amount of sugars produced in the hydrolysis was found to be insufficient from the stand point of utilization of the oil palm trunk as a source of sugar under the conditions of the experiment. Further study should focus on the pretreatment of the material to enhance its susceptibility to enzymatic saccharification.

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