CARBOHYDRATES IN THE OIL PALM STEM AND THEIR POTENTIAL USE

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HALIMAHTON MANSOR & ABDUL RASHIH AHMAD. 1990. **Carbohydrates in the oil palm stem and their potential use.** The chemical composition of a 46-y-old oil palm stem, analysed at various heights and cross sections of the stem, indicated the amount of free sugars ranged from 2 to 10% in 75% aqueous methanol extracts and 50 to 60% in the acid hydrolysates. While the highest portion of the stem gave the most amount of free sugars there was no clear trend in the distribution of these components along the height. On the other hand, across the stem the core regions were distinctly richer in the free sugars than the peripheral regions. In all samples of the methanol extract, sucrose was the main free sugar while in the acid hydrolysates glucose was the main sugar component. The ash content was found to be evenly distributed, whilst the Klason lignin content was present more in the bottom part, decreasing with increasing tree height.

Key words: Oil palm stem - carbohydrate - glucose - xylose - acid hydrolysis

Introduction

The oil palm (*Elaeis guineensis* Jacq.) has been cultivated for its oil in Malaysia since the late 1950s. The disposal of palm stems during replanting has been one of the main concerns of the industry. This stem residue is one of Malaysia's rich sources of lignocellulosic material which is yet unused in many areas. In order to use this vast resource, many different applications have been studied. These include the production of wood-cement board (Rahim & Abdul Razak 1987) and particleboard (Chew & Ong 1985), pulp and papermaking (Khoo & Lee 1985) and the fermentation of the oil palm fibres to produce ethanol (Tomimura *et al.* 1989).

The objective of this work was to investigate the chemical composition, particularly the carbohydrate content of the oil palm stem with a view of using the material as a source of useful sugar products and their derivatives. These sugars are known to have many existing and potential uses (Szmant 1986). One possible outlet for these materials is conversion to the corresponding sugar alcohols, sorbitol and xylitol, respectively, by catalytic hydrogenation. These sugar alcohols and their derivatives are used in food, pharmaceutical, cosmetic, textile and polymer. For example, aqueous sorbitol solutions are hygroscopic and have been used as humectants, softeners and plasticisers in various formulations. Xylitol is found to be as sweet as sucrose while sorbitol is about 60% as sweet. Both substances had been found to be of advantage to the diabetics besides being non-cariogenic.

The determination of Klason lignin and ash contents was also included in this study. These chemical components have been shown to influence both the digestibility of lignocellulosic materials for ruminants and their *in vitro* susceptibility to enzymatic saccharification (Puls *et al.* 1983, Shimizu *et al.* 1983).

Materials and methods

Materials

A 46-y-old oil palm stem was collected from Palm Oil Research Institute Malaysia experimental station in Serdang, Selangor, Malaysia. The stem was divided into six billets namely A, B, C, D, E and F at 1.5 *m* intervals. Each billet was further divided into three to four concentric zones, 1, 2, 3 and 4 at 7 *cm* radius apart (Figure 1).

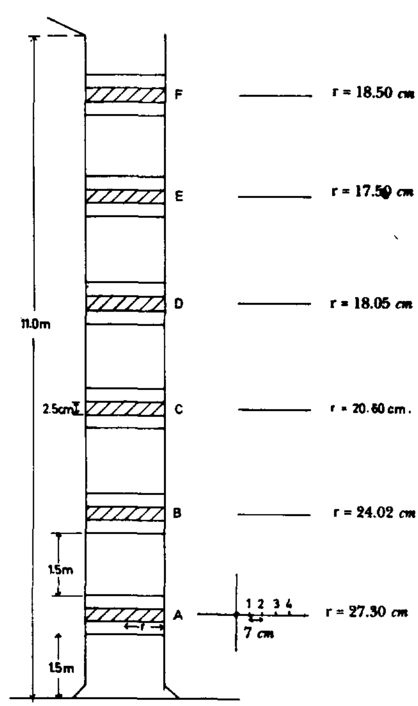

Figure 1. Sampling of oil palm trunk

The wood samples were dried at 40 to 45°*C* to a moisture content of 10%. They were then ground with a Wiley mill and passed through a 100 mesh size sieve. The wood meals were further dried in a vacuum oven at 40°*C* for about five days. The thoroughly dried samples were further ground to a very fine powder using a ball mill. The resulting powder was kept in a desiccator containing concentrated sulphuric acid as a drying agent for at least three days before chemical analyses were carried out.

Chemical analyses

Determination of free sugars (soluble sugars)

The wood meal (450 *mg*) was weighed into a 250 *ml* volumetric flask. Seventy-five percent aqueous methanol (200 *ml*) was then added and the mixture shaken at room temperature for 24 *h*. The flask was filled up to the mark with 75% methanol, shaken and filtered through a glass filter G-4. The residue was dried at 105°*C* overnight, cooled in a desiccator and weighed. From the filtrate, 15 *ml* of the solution was placed into a petri dish. The solution was evaporated by placing the dish on top of an oven. The resultant residue was dissolved in distilled water (3 *ml*), filtered through 0.2μm filter and analysed for free sugars by HPLC.

Determination of sugars by acid hydrolysis

Two hundred *mg* of the wood meal was weighed into a small glass tube. Seventy-two percent sulphuric acid (2 *ml*) was added with stirring. Then the mixture was incubated at 30°*C* for 1 *h*. Distilled water (56 *ml*) was added and the mixture was transferred to a 100 *ml* volumetric flask and autoclaved for 1 *h* at 120°*C* and 1.2 *atm*. After cooling, the flask was filled up to the mark with distilled water, and the contents filtered through a G-3 glass filter. The residue was rinsed three times with distilled water. For carbohydrate analysis, the filtrate was diluted, at one part of the sample to three parts of distilled water.

Determination of Klason lignin content

The determination was conducted according to TAPPI T222 (Anonymous 1978).

Determination of ash content

The method followed the standard procedure of TAPPI T15 (Anonymous 1978).

Results and discussion

Table 1 shows the chemical compositions determined at various heights and zones of the oil palm stem. The core regions were found to have the highest amount of free sugars as shown by the methanol-water extract while the peripheral sections had the lowest. The difference in the amount of this extract between these two regions was very large especially in the central part of the stem, C and D. This is probably due to the soft parenchymatous tissues being more in the central region where the food storage of the living tree is concentrated.

Table 1. Chemical composition at various heights and positions of the oil palm stem (percent moisture free basis)

Sample	Height (*m*)	75% methanol	Klason lignin	Acid hydrolysates	Ash
A1		18.7	20.3	47.9	4.1
A2		14.8	21.4	50.8	3.7
A3	1.5	9.5	22.2	55.3	2.3
A4		11.2	22.8	53.0	3.2
Average		13.6	21.7	51.8	3.3
B1		16.9	19.8	51.9	3.6
B2		13.1	20.5	53.4	3.2
B3	3.0	7.0	19.4	59.7	2.0
B4		9.3	22.6	55.3	4.0
Average		11.6	20.6	55.1	3.2
C1		20.1	18.4	47.0	4.0
C2	4.5	12.7	18.3	52.9	2.5
C3		8.0	21.3	55.0	2.4
Average		13.6	19.3	51.6	3.0
D1		18.0	19.8	49.6	3.9
D2	6.0	10.6	19.4	58.6	3.0
D3		3.0	23.0	56.8	2.4
Average		10.5	20.7	55.0	3.1
E1		15.0	11.8	64.3	3.6
E2	7.5	12.4	18.3	60.0	3.1
E3		8.8	23.3	57.1	2.8
Average		12.1	17.8	60.5	3.1
F1		16.0	8.2	69.5	3.2
F2	9.0	15.0	17.2	59.4	3.4
F3		12.0	19.7	55.0	3.3
Average		14.3	15.0	61.3	3.3

The compositions of the free sugars extracted with 75% methanol are shown in Table 2. The total content of free sugars ranged between 2 - 10% throughout the height of the tree. Sucrose is the main free sugar in all the samples followed by glucose and fructose. The level of sucrose remained fairly constant throughout the height of the tree; however, the level of glucose decreased whilst that of fructose increased with increasing height such that in the upper region these two sugars were present in comparable amounts. Higher amounts of sugars were detected after the wood meal had been hydrolysed with 72% sulphuric acid (Table 3). These sugar components are the products of the degradation of starch and other polysaccharides. The total amount of sugars after the acid hydrolysis ranged between 48 - 70% as shown by the acid hydrolysates in Table 1. Analysis of these hydrolysates by HPLC revealed the presence of glucose, xylose, galactose, arabinose, mannose and rhamnose, with glucose being the major component (35 - 48%) followed by xylose (11 - 16%). Each sugar component was evenly distributed throughout the height of the stem.

Table 2. Composition of free sugars from 75% methanol extract (% of O.D. original fibres)

Sample	Height (m)	Glucose	Fructose	Sucrose	Total
A1		2.89	0.58	5.18	8.65
A2		2.14	0.52	3.22	5.88
A3	1.5	1.07	0.30	1.62	2.99
A4		2.61	0.88	2.63	6.12
Average		2.18	0.76	3.16	6.10
B1		2.80	0.69	3.10	6.59
B2	3.0	1.79	0.64	2.96	5.39
B3		0.67	0.43	1.47	2.57
B4		1.30	0.51	2.60	4.41
Average		2.19	0.57	2.53	5.29
C1		2.13	0.69	6.10	8.92
C2	4.5	1.29	0.84	3.54	5.67
C3		0.51	1.27	2.29	2.29
Average		1.31	0.68	3.64	5.63
D1		3.47	1.03	3.92	8.42
D2	6.0	1.09	0.83	2.62	4.53
D3		0.49	0.46	0.85	1.80
Average		1.68	0.77	2.46	4.91
E1		1.86	1.18	6.27	9.31
E2	7.5	1.03	1.00	2.02	4.05
E3		0.55	0.57	4.22	5.34
Average		1.15	0.92	4.17	6.24
F1		1.54	1.37	6.89	9.80
F2	9.0	1.52	1.63	5.02	8.17
F3		0.87	0.93	3.48	5.28
Average		1.31	1.31	5.22	7.84

Table 3. Sugar contents after acid hydrolysis of oil palm stem (% of O.D. original fibres)

Sample	Height (m)	Glu	Xyl	Gal	Ara	Man	Rham
A	1.5	34.58	14.10	0.63	1.25	0.93	0.23
B	3.0	36.93	15.33	0.60	1.13	0.95	0.23
C	4.5	35.00	14.47	0.50	1.00	0.83	0.20
D	6.0	36.40	16.00	0.60	1.13	0.83	0.23
E	7.5	43.77	13.87	0.60	1.16	0.80	0.20
F	9.0	47.50	11.17	0.50	1.37	0.50	0.23

(Glu - glucose, Xyl - xylose, Gal - galactose, Ara - arabinose, Man - mannose, Rham - rhamnose)

The Klason lignin appears to be fairly evenly distributed throughout the tree except that the core in the upper region was slightly deficient in the component whilst the bottom contained an excessive amount (Table 1). These results are consistent with the fact that the number of fibrous vascular bundles increases towards the peripheral zone. These fibres are associated with lignin and the higher lignin content of the lower stem is due to the thickening of the older vascular bundles (Lim & Khoo 1986).

The ash content is quite similar throughout the height of the stem. No significant differences were observed either over the height or the cross-section of the stem.

Conclusion

The results show that a possibility exists of obtaining sugars, particularly glucose and xylose, from oil palm stem residues by means of a process involving acid hydrolysis. The potential yield of sugars would be between 50 - 60% of the dry weight and glucose and xylose would be expected to be the main products from such a process.

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