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Old oil palm trunk: A promising source of sugars for bioethanol production

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ABSTRACT

Oil palm trees are replanted at an interval of approximately 25 years because of decreased oil productivity of old trees. Consequently the felled trunks are the enormous amount of biomass resources in the palm oil producing countries such as Malaysia and Indonesia. In this report, we found that the felled oil palm trunk contains large quantity of sap, which accounts for approximately 70% of the whole trunk weight, and that sugars existing in the sap increased remarkably during storage after logging. Total sugar in the sap increased from 83 mg ml^{-1} to 153 mg ml^{-1}, the concentration comparable to that of sugar cane juice, after 30 days of storage, followed by the gradual decrease. The sugars contained in the sap were glucose, sucrose, fructose and galactose, all of which are fermentable by ordinary industrial yeast strains. The results indicate that old oil palm trunk becomes a promising source of sugars by proper aging after logging and, thus, its sap can be a good feedstock for bioethanol.

1. Introduction

Oil palm (*Elaeis guineensis*) is widely planted for its edible oil in tropical countries such as Malaysia and Indonesia. The production of palm oil is 39 Mt per year in 2007, which is the most produced plant oil in the world [1]. The oil is mainly used for food and related industries, and is also used as a raw material for various products such as detergents and cosmetics. Moreover, a number of research studies have been carried out for biodiesels and bio-plastic materials from the oil in recent years [2–6].

In general, the palm starts bearing oil-contained fruits in 2.5 years after planted and its productivity becomes lower after 20–25 years. Therefore it is necessary to cut the old palms and to replant new seedlings at plantation sites. In Malaysia, about 120,000 ha of oil palm is estimated to be replanted annually from 2006 to 2010 for maintaining the oil productivity [7]. When replanting, old palms are cut and most of them are discarded or burnt at the plantation site. Therefore, efficient ways for utilizing oil palm trunks is desired for ideal oil palm plantation and sustainable palm oil industry.

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It has been traditionally practiced to produce palm sugar and palm wine using sap obtained by tapping the inflorescence of various species of palms including *Arenga pinnata*, *Borassus flabellifer*, *Cocos nucifera*, *Nypa fruticans* and oil palm [8]. Among these palm species, oil palm is considered to produce much smaller amount of tapped sap, or low sugar yield [9]. Oil palm sap was reported to contain approximately 11% sugars with sucrose as a major component accounting for approximately 90% of total sugar [10]. Meanwhile, it has been reported that the 75% methanol extracts of the dried oil palm trunk (OPT) fiber contains 4.9%–7.8% sugars, which correspond to 2.1%–3.4% sugars in the sap assuming that moisture content of OPT is 70% [11]. The ratio of sugars in the methanol extract of the pulverized trunk is significantly different from the one in the tapped sap.

In order to clarify the discrepancy between tapped sap and the methanol extracts, and to evaluate the sap of the felled palm trunks as a source for sugars, we investigated the amount and composition of sugars in the sap squeezed from felled trunks together with moisture contents. We also examined effects of storage of the felled trunks on sugars in the sap. This is the first report that described the amount, composition and change of sugars contained in the sap of felled oil palm trunks. The results clearly show a significant increase of fermentable sugars in the oil palm sap occurs during storage of the trunks after logging, indicating the old and felled oil palm trunks are the promising feedstock for bioethanol.

2. Materials and methods

2.1. Sample preparation

Three oil palms of *tenera* type aged 25 years old were logged at Ara Kuda, Kedah, Malaysia (N5°36', E100°31'). Total height of each palm was approximately 12 m and testing logs (2.5 m long and 36–41 cm in diameter) were taken from the middle part of the whole log as shown in Fig. 1. The log was stored under a roof avoiding direct sunlight and rain at the Penang Campus of Universiti Sains Malaysia. Temperature during the storage was 28–32 °C with humidity of 70–80%.

A disc with 10 cm thickness was sliced from each log after a certain days of storage between 0 and 120 days. To avoid microbial contamination, 5 cm from the end was trimmed before the slicing. Then the disc was cut into three sections; inner (A), intermediate (B) and outer (C) as shown in Fig. 1.

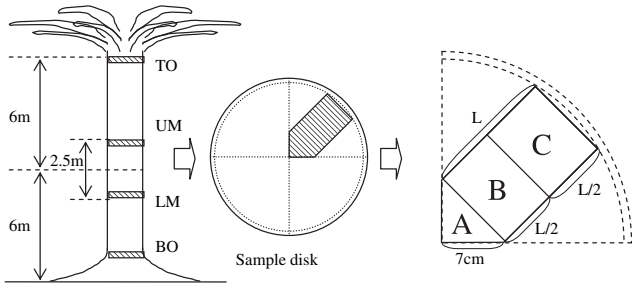

Fig. 1 – Preparation of oil palm trunk samples.

Each sectional sample was placed in an airtight plastic bag and kept in a deep freezer at −20 °C until analysis.

Further sample disks were prepared from the different positions of the trunk according to the height as shown in Fig. 1. Top and bottom parts of the tree were cut and designated TO and BO, respectively. Two more disks were obtained from the end part of the 2.5 m sample log and designated upper middle (UM) and lower middle (LM), respectively. The disks thus prepared were cut into three sections in the same manner as mentioned above.

2.2. Analysis

Moisture content of each OPT sectional sample was determined by drying at 105 °C for 48 h. The sample was cut out from each section at the size of 2 cm × 2 cm × 5 cm. Collection of sap was carried out by squeezing each sample with a laboratory-scale press at 80 MPa. The sap was then centrifuged at 7,000G for 15 min and the supernatant was collected and kept in a deep freezer.

Total sugar content of sap samples was determined by the Dubois method using phenol and sulfuric acid [12]. A filtered sap sample was diluted to 1/3000 with distilled water and 0.2 ml of 5% phenol solution was added to 0.2 ml of the diluted sample, followed by an addition of 1 ml of sulfuric acid. Then the solution was vigorously mixed and cooled at room temperature for 30 min. Absorbance of the solution was recorded at 480 nm. The calibration was carried out with glucose as standard.

Determination of sugar components in each sap was carried out by high performance liquid chromatography (HPLC; Shimadzu LC-20A) with a CAROBO-Sep CHO-682 (7.8 mm I.D., 300 mm, TRANSGENOMIC) column at 80 °C. Distilled water was used for the solvent at a flow rate of 0.4 ml min^{-1} with a refractive index detector. Ribose was used as an internal standard and calibration curves were made for individual sugars, using commercial products purchased from Wako Pure Chemical Industries Ltd.

For quantitative analysis of starch, a small amount of each sectional OPT sample was prepared in powder form by grinding (<0.5 mm) after oven-drying at 105 °C. To remove free sugars, 100 mg of the powdered sample was washed in 10 ml of 80% ethanol at 80 °C for 10 min, which was repeated twice. The total starch assay kit from Megazyme International Ireland Ltd was applied to the extracted powder sample and the absorbance of the sample mixture at 510 nm was recorded. Glucose was employed as a standard for creating the calibration curve.

3. Results and discussion

Total sugar contents in the sap samples from inner (A), intermediate (B), and outer (C) parts of the disks obtained from different height of the oil palm tree are shown in Table 1. Total sugar contents were higher in the inner part than peripheral part except for the bottom most position. The sap obtained from top contained roughly 20%-less sugars compared to the sap from the bottom to middle positions, where vertically even distribution of sugars was observed.