

POTENTIAL OF OIL PALM FROND LIQUID EXTRACT AND FIBER AS FEEDSTOCK FOR BIO-BUTANOL PRODUCTION

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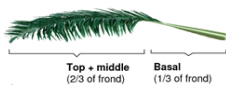
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Graphical abstract



Abstract

Oil palm frond is the most abundant yet untapped biomass in Malaysia. The objectives of the present work are to study the influence of the age of oil palms on productive sugar yield from oil palm frond extracts and to highlight the potential OPF liquid extract and fibers as feedstock for biobutanol production. Oil palm tree age between 5-10, 10-15 and 15-25 years were sampled for the study. The analysis was conducted using DNS method. The findings indicated that OPF petiole with the age limit of 15- 25years gives higher glucose concentration of 40.50g/L as compared with 17.85g/L of 5-10 years. Furthermore, the percentage carbon content of 41.04% and 37.45% obtained from the elemental analysis conducted using various micro elemental analyzers, indicated the suitability of OPF as a promising feedstock for biobutanol production.

Keywords: Oil Palm Frond, liquid extract, Bio-butanol production, fiber, fermentable sugar

Abstrak

Pelepah kelapa sawit biomas adalah yang sering diabaikan fungsi alternatifnya. Objektif kerja ini adalah untuk mengkaji pengaruh umur pokok kelapa sawit pada hasil gula produktif daripada ekstrak pelepah kelapa sawit dan untuk menyertakan potensi ekstrak OPF cecair dan serat sebagai bahan mentah untuk pengeluaran biobutanol. Umur pokok kelapa sawit antara 5-10, 10-15 dan 15-25 tahun dipilih sebagai sampel kajian. Dapatan kajian menunjukkan bahawa daun OPF dengan had umur 15-25 tahun memberikan kepekatan glukosa yang lebih tinggi 40.50g / L berbanding dengan 17.85g / L untuk 5-10 tahun. Tambahan pula, kandungan karbon peratusan 41,04% dan 37,45% yang diperolehi daripada analisis unsur dijalankan menggunakan vario mikro analyzer unsur, menunjukkan kesesuaian OPF sebagai bahan mentah untuk pengeluaran biobutanol.

Kata kunci: Pelepah kelapa sawit, ekstrak cecair, Pengeluaran Bio-butanol, serat, gula fermentasi

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1.0 INTRODUCTION

The high rate of fossil fuel depletion over the decades, coupled with environmental deterioration resulting from consumptions of the product as transportation

fuels, the recognition of the fact that fossil fuel reserves are finite and its depletion is occurring faster than predicted have necessitated the search into alternative and more sustainable resources like biobutanol and bioethanol in large capacities using low cost and readily available substrates [1]. Thus, the

concept of waste to weight focuses particularly on agro wastes that can be transformed into value added products thereby reducing waste generation and enhancing eco-efficiency [2].

Malaysia, being one of the world's largest palm oil producers have generated approximately 80 million tonnes of dry solid biomass from the oil palm industry in 2010 and this figure is expected to reach 110 million tonnes by the year 2020 [3]. Since biomass residues are generated at plantation and mills site annually, Malaysia has a potential to utilize these residues resourcefully and efficiently into other value added products.[4] . Oil Palm Frond is a major biomass in the form of solid generated in the plantation as a result of harvesting and pruning, which is left to decay in order to ensure nutrient conservation in the soil [3, 5-7] . Another vital point of view for OPF is that it is the most generated biomass that amounted to 83 million tonnes

(wet weight) annually [8] and is available daily during pruning for harvesting fresh fruit bunch (FFB). Currently, the OPF are usually left to decay in the natural environment or are disposed off by burning. These practices are creating environmental problems, hence alternative ways to utilize this abundant resource are needed [9] . In order for this feedstock to be viable as fermentative substrate for biofuel production, there are some criteria that need to be satisfied. These include being practically cost effective, impurities free, can produce high yields of desired product, substantially available locally and can be handled at minimum risk of health and safety [3, 10].

Preceding studies have shown that OPF is appropriate to be used as fermentation feedstock as it is free from microbial growth in product formation and can easily be operated devoid of threat on health and safety [11].

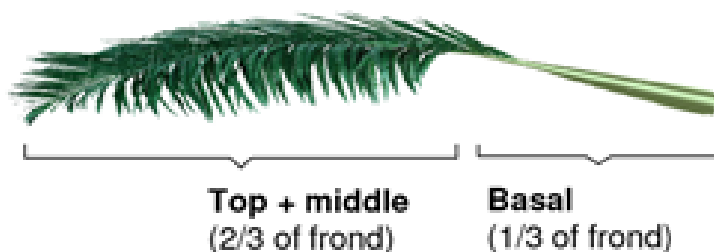


Figure 1 Oil palm frond length

Table 1 Percentage of nutrient content of oil palm frond (OPF)

	Percentage of top & middle (2/3 frond)	Percentage of basal (1/3 frond) lower.
Nutrient	66	34
Cellulose	40	60
Sugar	34	66

Source: [12]

1.1 Nutrient Content of Oil Palm Frond

The oil palm frond is approximately 2-3 meters long and weighs about 10kg (wet weight). It consists of the petiole (the stem) and many long leaflets on either side of the stem. As shown in Figure 1, most of the nutrients are contained in the top two thirds of the fronds while the basal, which is the lower part, is rich in cellulosic materials and sugars that are needed in the production of biobutanol and bio-based chemicals as indicated in Table 1. Furthermore, oil palm biomass are also rich in lignin, cellulose and hemicellulose [13],[14]. It has been revealed that oil palm fiber from OPF contains high compositions of hemicellulose compared to coir, pineapple, banana and even soft wood [15]. The high glucose content of oil palm fronds shown in Table 2 is an indication that juice extracts from OPF have the potential to produce biobutanol fuel devoid of the use of any pre-treatment processes.

Moreover, the juice extract exhibit richness in minerals and nutrients that are essential for fermentation for most microorganisms [11]. However juice extraction process is challenging owing to difficulties in maintaining aseptic conditions attributable to environmental condition during pressing. To obtain perishable juice extracts from oil palm frond, nutritionally rich and suitable for bacterial growth, sterility measures ought to be maintained during pressing and storage. This study had never been reported elsewhere, therefore is desirable to offer information on the extraction process, estimation of glucose concentrations based on the age of oil palm trees and to demonstrate the potential of OPF as feedstock for fermentative biobutanol production using carbon content analysis.

2.0 EXPERIMENTAL

2.1 Raw Materials

Fresh OPF petioles were obtained from Parit Sulong oil palm plantation, Batu Pahat Johor Malaysia. The OPF has an approximate length of 3 meters in which the basal part that constitutes 1/3 of the original OPF petiole length was used in this study. The three samples were collected each weighing 10 kg, 12 kg and 13 kg; making a total of 35kg. All the petioles were kept in sealed plastic bags at ambient temperature (27-30°C) prior to pressing; Figure 1 indicates the structure of the OPF petiole.

2.2 Extraction Process

Extraction was conducted by blending, using a conventional sugar cane pressing machine, model (Elephant W.H.L. Machinery, Malaysia) at the Automotive Development Centre (ADC), Universiti Teknologi Malaysia (UTM). The steps were repeated several times to obtain the desired quantity of extractives (juice). The juice extract were then filtered to remove fibrous debris. The filtrate extract was stored at -20°C prior to sugar analysis.

The obtained juices were subsequently filtered to remove fibrous solids and scum, whereby it was then centrifuged at 4000 rpm for 5 minutes. Oil palm extraction characteristics based on palm tree age are as presented in Figure 2.

2.2 Sugar Content Analysis

The dinitrosalicylic acid (DNS) method was used to determine the reducing sugar concentration as representative of the total monosaccharide or disaccharide present; usually based on standards. This method does not only give a relative measure of the reducing sugar concentration but also provides insight into saccharification process. The process involved dilution of 0.2 ml of sample into 9.8ml of distilled water. 1 ml of sample was pipetted from sample dilution and mixed with 1 ml of DNS, followed by 2 drops of NaOH, then vortexed.

The solution was boiled at 100°C for 5 minutes, and then cooled to room temperature. Thereafter, 10 ml of distilled water was added and the reaction mixture was thoroughly mixed by vortexing. Sample absorbance readings were recorded under the wave length of 540 nm using a spectrometer as presented in Table 3.

From the standard curve graph equation shown in Figure 3, $Y = 1.0357x$, with the dilution factor of 50, the glucose concentration for the three samples were

determined as 36.11g/l, 17.23g/l and 40.50g/l respectively.

3.0 RESULTS AND DISCUSSION

The result of glucose concentration in OPF Petiole is presented in Table 3; showing the highest sugar concentration of 40.50 g/l was recorded on sample 3, which was extracted within 48 hours collection period as compared with 37.4g/l and 17.85g/l for other samples. The gradual drop in sugar concentration is attributed to prolonged extract storage prior to processing as reported by Che Maail et al., 2014. However, the application of autoclave provides a suitable method for preserving the OPF extract as the high temperature provided during autoclave kills more microbes and hence provides a better environment for sugar stability for prolonged storage. Furthermore, the result of nutrient contents of OPF fibers and juice extracts were analyzed using Vario MICRO Elemental as presented in Table 5.

From the results, the percentage content of carbon in the OPF fibers and OPF extracts were 41.04% and 37.45%, which is higher compared to other elements. The higher content of carbon in OPF signifies its suitability as a carbon source for the production of biobutanol via bacterial fermentation. The presence of high sugar content (Glucose) and nutrient in the OPF juice and fiber provides a nutritional content for growth of bacteria during fermentation. Based on the results, OPF juice and fiber meet all the criteria as a good fermentation substrate as it is renewable, consistently available and easily obtained; it inhibits microbial growth and product formation and contains no impurities.

4.0 CONCLUSION

The study demonstrated the potential of both OPF juice extracts and fibers as renewable feedstock for biobutanol production. A substantial amount of sugar 40.50g/l, in addition to the percentage carbon content of 41.04 and 37.45 for OPF fibers and juice extracts are the indications of viability for OPF as a promising new fermentation feedstock for biobutanol production. Furthermore, OPF extracts are rich in nutrients that are essential for bacterial growth and eventually, in the production of biofuel such as biobutanol. Therefore, conversion of oil palm plantation residues to green fuel can enhance energy security and offers the potential of sustainable transport fuels in the future.

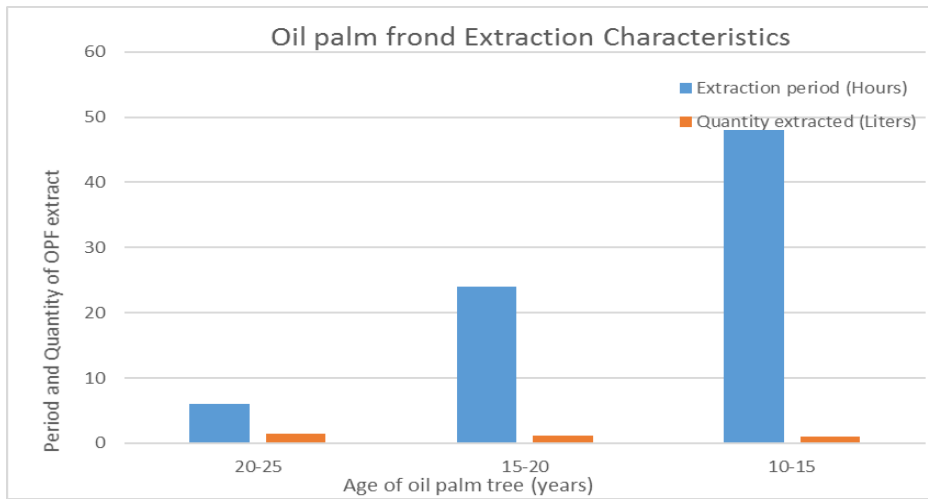


Figure 2 Extraction characteristics of oil palm frond based on oil palm tree age

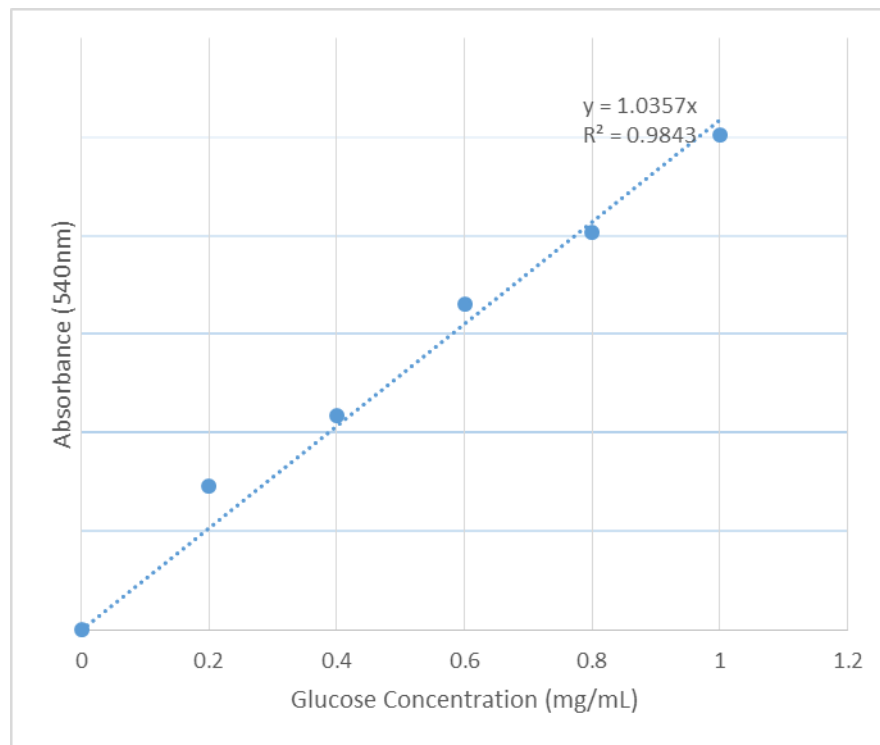


Figure 3 Glucose standard curve for DNS test

Table 3 Spectrometer reading of sample solution

Sample Number	Spectrometer Reading	Glucose concentration (g/l)
1	0.748	36.11g/l
2	0.357	17.23g/l
3	0.839	40.50g/l

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