Chemical Composition of Oil Palm Frond

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Abstract

The growth of oil palm plantation has created the massive amounts of biomass especially oil palm frond. This issue will give negative influence on the environment and replanting operations. The higher amount of biomass gives an idea of the possibility to produce panel product or wood composite product and therefore reduce the dependency of wood based industry on solid wood. The objective of this study was to determine the chemical composition of oil palm frond. The findings in this study will provide advanced understandings on its chemical composition and the suitability in panel product production. The chemical analyses observed were lignin, ash, holocellulose, alcohol solubility, alkali solubility, and hot and cold water solubility. The results are 23.86%, 3.41%, 75.65%, 5.68%, 33.52%, 12.5% and 10.23% respectively. This study was conducted according to TAPPI standard and Wise et al. The chemical composition of OPF indicates that OPF is suitable in production of panel product.

Keywords: oil palm fronds, chemical composition

INTRODUCTION

Oil palm tree (*Elaeis guineesis Jacq.*) is an agricultural plant consists of non-woody fibers, lignocellulosic material, originally from West Africa and widely cultivated in Malaysia for its oil producing fruits. In the year 1960s, Government's agricultural diversification programme has started to widely cultivate the oil palm tree plantation as in the intention of reducing the dependency on rubber and tin (MPOC, 2009). Today, oil palm tree are available in abundance as the plantation area is the largest in Malaysia with 4.49 million hectares.

The great expansion of oil palm tree plantation in this country has generated the massive amounts of residues such as oil palm fronds, oil palm trunks, and empty fruit bunches which may create the problems of replanting operation. Great environmental problems may be created if the residues are left and to be burn. Furthermore, there will be a problem of burning them as they consist of a lot of moisture. The residues may take up to five years to be degraded naturally and this will be something that is wasteful to the industry. Being an abundant and yet an important bioresource, oil palm frond has the potential to be an alternative source of cellulosic materials for engineered product. Rather than to be leftover on the field, the biomass can be collected and be processed. Basically, oil palm frond and empty fruit bunches are used for animal bedding and feeding.

In order to completely evaluate the potential of oil palm frond for new applications, a detailed and comprehensive chemical study of its components is necessary. The fundamental aspects considered in the literature include general chemical composition, hemicelluloses composition, and lignin structure (Neto, 1996). This paper presents the results of the chemical analysis of oil palm frond, grown in local oil palm plantation at Universiti Teknologi MARA, Pahang. A comparison with other lignocellulosic and hardwood plant was also discussed in this paper.

MATERIALS AND METHODS

Materials Preparation

Oil palm fronds were collected from oil palm plantation at Universiti Teknologi MARA, Pahang. Every two weeks of harvesting the fruits, the oil palm fronds have to be removed. The chemical used in this analysis are, alcohol toluene, 1% NaOH, acetic acid, 72% sulfuric acid, 10% glacial acetic acid, and acetone acid. The chemicals used in this study were analytical grade and obtained from a local supplier.

Chemical Properties Determination

Two fronds from a single tree were harvested using a long armed sickle and approximately six fronds were collected for chemical analysis of oil palm frond. The leaflets of frond were stripped off and stalks of oil palm frond were randomly fractioned and they were chemically analyse in detail. The oil palm fronds were cut into smaller width using a narrow band saw. They were then chipped in wood chipper and flaked to yield particles. The particles were screened and the finest size residue from the process were collected and grounded. British standard size, 60 mesh were obtained and air dried 2 to 5 percent moisture. The chemical analyses of the raw material in relation to moisture content, ash, extractives, and lignin were carried out according to the Technical Association of Pulp and Paper Industry standard (TAPPI, 1978) while the holocellulose was determined by using the method described in Wise et al (1946).

RESULTS AND DISCUSSIONS

Chemical composition of oil palm frond

The result of chemical composition of oil palm frond (OPF) is presented in the table 3.1. The values are compared with other values from other studies on OPF.

Table 3.1 The comparison of values in the different studies on same species

CHEMICAL COMPOSITION	**OIL PALM FROND**			
(%)	a	b	c	d
Ash content	3.41	n.a	1.30-6.04	2.40
Extractive content	5.68	3.50	2.70-12.00	4.50
Lignin content	23.86	20.15	13.20-25.31	20.50
Holocellulose content	75.65	83.13	68.30-86.30	83.50
Hot water solubility	12.50	n.a	2.80-14.76	n.a
Cold water solubility	10.23	n.a	8.00-11.46	n.a
1% NaOH	33.52	n.a	14.5-31.17	n.a

[a] This study [b] Hashim et al [c] Shinoj [d] Abdul Khalil et al

According to the Table 3.1 above, the result of chemical analysis for this study are 3.41% for ash content, 5.68% for extractive content and 23.86% for lignin content. Meanwhile, 75.65%, 12.50%, 10.23% and 33.52% for holocellulose content, hot water solubility, cold water solubility and 1%NaOH solubility respectively. All of the results gained are comparable and in the range of values from literature, Hashim et al, (2011) , Shinoj, (2011) and Halil et al, (2010).

Oil palm frond chemical composition compared to other species

Table 3.2 shows some of the chemical properties of the oil palm frond examined in the present study, and a comparison with the values for some other crop residue and wood species obtained from literature. The result indicate that the ash content of OPF (3.41%) was in the limit for OPF reported by Shinoj (2010), lower than ash content in kenaf, but higher than in coconut, bamboo and hardwood spp. Previous studies much showed the same trend of high extractives and ash content for non wood lignocellulosic materials (Wanrosli, 2006, Khalil, 2009, Han, 2009). The amount of ash can be considered as higher than that of hardwood which normally less than 1%. The high content of ash might be due to the high silica in that of non wood plant which will contribute to the negative effects in mechanical strength properties. The less amount of ash in certain species is very important towards the industry economy in term of machining (Jamaludin, 2006).

Extractive are the extraneous wood components that may be separates from the insoluble cell wall material by their solubility in water or organic solvent (Shebani, 2008). The cold and hot water soluble are important in the evaluation of water soluble extractives such as tannin, sugar, pectin and phenolic compounds within any lignocellulosic materials. The higher cold water and hot water soluble contents of sample may reduce the natural durability of the species.

Result shown that the solubility of 1% NaOH is highest with value of 33.52 % followed by hot water, cold water and alcohol benzene with value of 12.5%, 10.23%, and 5.68% respectively. Tadena and Villaneuva (1971) state that, the high degradation of cellulose and low polyphenol content leads to the high alkali soluble. Bortoletto and Moreschi (2003) reported that water soluble extractives such as tannins, gums, sugar and pigments are free to pass through with liquid water movement in the wood. The hot water extractive solubility also superior than others because it eliminates a greater quantity of materials, removes a portion of the cell structure and extracts some inorganic extractives (Shebani, 2008).

Other than give dark colour to the heartwood, some of extractives provide protection from decay fungi and insects (Bowyer, 2007). However, extractives should be removed or discarded as it is not functional in the bio-composite production and manufacture. The removal of extractives is very necessary in order to manufacture bio-composite product. For example, compatibility between lignocellulosic material and polymer matrix in thermoplastic composite will be better with the removal of extractives which by means of better wettability (Han, 2009).

The observed lignin content (23.86%) in OPF was comparable to that value reported by Shinoj (2010), bamboo and hardwood species, but slightly lower than kenaf and coconut as shown in Table 3.2. About 70% of lignin is found in the plant secondary cell wall (Rowell, 1996). Lignin that composed of p-hydroxylphenyl, guaiacyl and syringyl is very advantageous for structural protection of plant. Lignin becomes an encrusting agent in the holocellulose for mechanical support (Rowell, 1996, Wanrosli, 2006). Lignin is also functioned as a protection to avoid the plant from chemical and physical digestibility (Abdul Khalil, 2006). The adhesiveness between the fibrils is also contributed by lignin characteristics. However, these beneficial behaviors do impede fiber orientation which will affect the load transfer and mechanical strength of fiber in a particular composite product (Saha, 2010). Thus, in order to apply lignocellulosic as a raw material in engineered product, lignin is necessary to be removed. But somehow, there was a study that investigated the application of lignin as compatibilizer in the coconut fiber – polypropylene composite. The incorporation of lignin as a coupling agent in the thermoplastic composite possessed higher flexural properties than control specimens. But overall, composite with inorganic coupling agent display better result (Rozman, 2000).

Table 3.2 indicates that holocellulose content of OPF (75.65%) was higher than study on Coconut and bamboo, lower than kenaf in limit of hardwood spp. In this analysis, the holocellulose content of OPF still in range of values reported by Shinoj, 2010. Holocellulose is a natural component in plant that consists of hemicelluloses, celluloses, and minor amounts of other sugar polymers. These polymers are rich in hydroxyl groups that make the plant intend to absorb moisture through hydrogen bonding. 70% of the plant dry weight comprises holocellulose. Holocellulose seemed to be a preferable property in order to manufacture binderless board. This is because, holocellulose provide starch and sugar which will assist adhesion within the particles (Hashim, 2011). Oil palm biomass is also suggested to be an ideal raw material for the production of value added because of its carbohydrate richness.

Table 3.2 Comparison of the values of this study to others species

Raw material	**Ash content, %**	**Lignin content, %**	**Holocellulose, %**	**Solubility,%**			
				Alcohol benzene	1% NaOH	Hot water	Cold water
Oil palm frond [a]	3.41	23.86	75.65	5.68	33.52	12.50	10.23
Kenaf [b]	4.00	21.2	87.70	6.40	n.a	n.a	n.a
Coconut [c]	2.20	32.80	56.30	6.40	n.a	n.a	n.a
Bamboo [d]	1.05-1.39	23.80-26.05	65.61-69.39	2.49-3.60	11.23-25.52	1.11-8.02	2.40-10.19
Hardwood [e]	<1	14-34	71-89	0.1-7.7	n.a	n.a	n.a

[a] This study, [b] Abdul Khalil et al (2010), [c] Hashim et al (2011), [d] Jamaludin (2006), [e] Abdul Khalil et al (2006)

CONCLUSIONS

The chemical composition of oil palm frond was investigated and the results illustrate that it is suitable for the production of wood based product. The analyses shows that the chemical composition were comparable to others crops biomass that had used in production of panel product and wood plastic composite.

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