Oil Palm Lignocellulose Biomass Utilization: Novel Value-added Products

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ABSTRAK

Pokok sawit banyak mengeluarkan biojisim lignoselulosa. Penggunaan biojisim ini masih dalam bentuk tradisional lagi, iaitu untuk pengeluaran gentian, baja organik (untuk pembaikan struktur dan kesuburan tanah) dan pencegahan hakisan. Walaupun ini sebagai amalan mesra alam, ianya masih mempunyai nilai tokok yang kecil. Keadaan ini merangsang betapa perlunya meningkatkan kuantum penggunaan dan julat pelbagai produk baru yang boleh diperbuat daripada biojisim lignoselulosa sawit. Sayugia diingatkan bahawa penggunaannya hendaklah seimbang, di mana sebahagiannya dipergunakan untuk produk baru, manakala sebahagian besarnya pula hendaklah dikembalikan ke tanah demi untuk memastikan pemuliharaan persekitaran dan penggunaan sumber asli yang cekap.

ABSTRACT

Oil palm produces a large amount of lignocellulose biomass. The exploitation of this biomass is still traditional and low, i.e., *for fibre production, organic fertilizer (for soil amelioration, structure and fertility improvement) and erosion prevention. Although these are environmentally friendly practices, there is little value addition, thereby prompting a need to increase the quantum of exploitation and the range of novel products to be made from oil palm lignocellulose biomass. The idea is to have balanced utilization, some for conversion into novel products and a substantial amount returned to the soil, to ensure environmental protection and efficient natural resource utilization.*

INTRODUCTION

The total oil palm area in Malaysia was 3.2 million ha in 1999, and is expected to increase to 4.5 and 5.2 million ha in the years 2010 and 2020 respectively.

An oil palm plantation produces a large amount of total dry matter (TDM), averaging 55 t ha^{-1} yr^{-1}. The commercial exploitation of the TDM is mainly focused on palm oil (PO) and palm kernel oil (PKO), constituting 5.5 t ha^{-1} yr^{-1}. This represents about 10% of the TDM, whilst the remaining 90% are still under exploited.

Normally, the industry uses the empty fruit bunches (EFB) and the oil palm fronds (OPF) for mulching (to improve soil structure and fertility) and erosion prevention. The oil palm trunks (OPT) are chipped for similar use during replanting. There is still little commercial exploitation of TDM.

With the current trend of production and with the replanting programme of between 100 000 to 150 000 ha yr^{-1}, there is therefore a large amount of TDM or biomass in the form of lignocellulose to be exploited (Chan, 1999).

This short communication attempts to highlight the utilization of oil palm lignocellulose biomass in different value-added products which can be produced commercially. Many of these products would require research and development inputs before commercialization. And of course, there must be a balanced commercial exploitation of the lignocellulose biomass and the amount returned to the soil to ensure the sustainability of the soil and environment.

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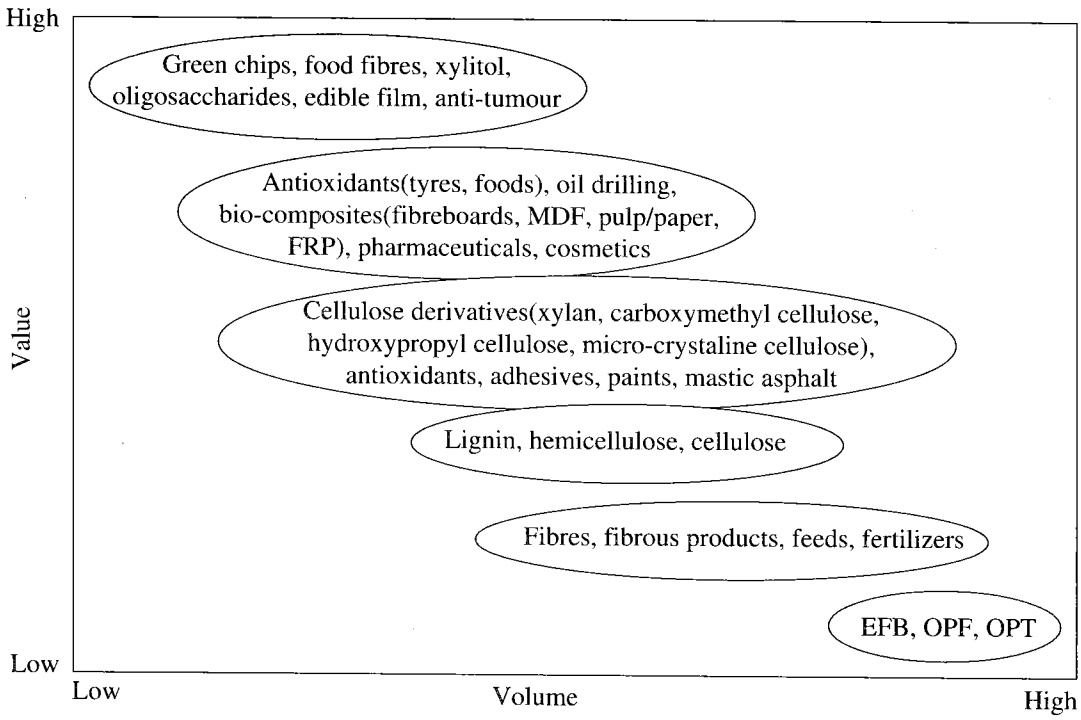

Figure 1. Oil palm lignocellulose biomass utilization.

CONVERSION OF HIGH VOLUME, LOW VALUE LIGNOCELLULOSE INTO LOW VOLUME, HIGH VALUE PRODUCTS

Oil palm biomass from EFB and OPF can be obtained daily, but that from OPT only at can replanting. These materials can be extracted and processed into lignocellulosic, liquid fuel and chemical raw materials for reconversion into a host of value-added products (*Figure 1*).

EFB, OPF and OPT could be processed quite easily into fibre (Kamarudin *et al.*, 1999), feeds (Abu Hassan and Yeong, 1999) and fertilizer (Teoh *et al.*, 1999; Singh *et al.*, 1999; Lim *et al.*, 1999). The fibre can be further processed into products such as planting medium for rockwool substitute (Kamarudin *et al.*, 1995), car seat, mat, *etc.*

Oil palm biomass (EFB, OPF and OPT) consists of about 70% polysaccharides, 18% lignin and up to 12% extraneous components (Mohd Nor, 1985; Akamatsu *et al.*, 1987a, b; Halimahton and Abdul Rashid, 1991; Kamishima *et al.*, 1994; Anon, 1997; Astimar *et al.*, 1997; Kumar, 1997). Potentially, oil palm may be the world's single most important source of carbohydrates but its efficient use would require fractionation of the biomass into its individual components (Mohd Azemi and Harun Sarip *et al.*, 1998; Mohd Azemi *et al.*, 1999b), since these can be processed more efficiently separately than in their admixture in lignocellulosic form. Preliminary studies have been conducted to fractionate, isolate and purify these constitutive biopolymers from OPT and OPF (Mohd Azemi and Harun Sarip *et al.*, 1998; Mohd Azemi *et al.*, 1999b). These products are in demand due to a shortage in supply and due to their versatile uses (Jalani *et al.*, 1999).

The above biopolymers could be further processed to produce derivatives *e.g.* micro-crystalline cellulose(MCC) from cellulose, lignin sulphonic from lignin, *etc.*

The cellulose exists as fibre, which, with some surface modification is widely utilized for reinforcement of commodity thermoplastics (polyethylene, polypropylene) (Rozman and Wan Daud, 1999; Rozman *et al.*, 1998a, b, c, d). Cellulose derivatives impart certain desirable func-

tional properties in food, *e.g.* carboxymethyl cellulose (CMC), hydroxypropyl cellulose, microcrystalline cellulose (MCC). In non-food applications, cellulose serves as binder and carrier as mastic asphalt (Wan Hasamudin *et al.*, 1999) for pharmaceutical products, for separation of water and mud in oil and mineral drilling operations, and as an acoustic component in electronic items.

A combination of prehydrolysis and chemical treatment produces a substrate containing hemicellulose (water-soluble), lignin (methanol-soluble) and cellulose. The hemicellulose fraction consists mainly of pentosan, predominantly xylan. Xylan, as a dietary fibre, has proved to be an effective hypocholesterolemic agent, and on incorporation into bakery products, a shelf life extender. Xylitol, a low-calorific value sweetener, is a hydrogenated product of xylan widely consumed in food (*e.g.* diabetic foods) and non-food (*e.g.* tooth pastes) uses. An edible xylan film for coating of foods and pharmaceuticals is readily synthezised from xylan and certain xylan derivatives have been reported as having anti-tumour activities (Rauschenberg *et al.*, 1990).

Through chemical modification, a variety of lignin derivatives of superior handling characteristics can be produced. These lignin derivatives may be incorporated into various thermoplastic and thermosetting polymeric materials. Besides functioning as water soluble surfactants, the water-insoluble lignin derivatives have a well recognized potential in various thermosetting resins and adhesives. Examples are phenol formaldehyde resins for plywood manufacture, epoxy and acrylate resins for composites, polyurethanes and computer chips (Glasser and Wu, 1984), which can be dubbed 'green chips'.

In tyre manufacturing, lignin derivatives have been incorporated as antioxidant, and similarly lignin as an antioxidant in processed foods have been observed (Glasser and Leitheiser, 1984).

The lignocellulose can also be exploited in bio-composites, including fibreboard, (Kamarudin *et al.*, 1993), medium density fibreboard, or MDF (Koh *et al.*, 1999), pulp and paper (Kamarudin *et al.*, 1999) and fibre reinforced products, or FRP (Rozman *et al.*, 1998e; 1999). The FRP, amongst others, can be used for furniture (Ridzuan *et al.*, 1999a) and automotive components (Ridzuan *et al.*, 1999b).

CONCLUSION

The current level of exploitation of oil palm lignocellulose as fibre and organic fertilizer is still small. There is an urgent need to increase the exploitation of lignocellulose into novel value-added products which will help increase the income of the oil palm industry. Exploitation of the lignocellulose biomass must, however, be balanced, *i.e.*, with some recycled back to the soil for amelioration and erosion prevention. This will ensure that the industry remains competitive, sustainable and environmental friendly.

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