POTENTIALS OF BIOENERGY FROM THE SAGO INDUSTRIES IN MALAYSIA

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Summary

The sago palm grows without the need for any form of fertilization, apart from some ground clearing during its first year of growth. It thrives mainly on peat soil which is unsuitable for most other crops. These make sago palm the best option as the starch source for tropical countries. Although the initial waiting period is long (up to 10 years for the plant to be harvestable), sago is the world's highest starch producer at 25t/ha/year. The effluent which flows into the rivers is potentially polluting to the environment, more due to the voluminous amount of liquid and suspended solids, than from the minor concentrations of starch and sugar residues. The focus of this project is the production of bio-ethanol on the wastewater and solid residues (fibres), on the average containing about 3% starch and 5% dry matter, respectively.

A sago mill typically generates about 25t (dried) sago starch/day. At a minimum of 20L wastewater per kg of starch produced, this generates about 500t effluent, containing 25t fibres and 15t starch. Both wastewater and fibres can be converted to fermentable sugars by enzymatic hydrolysis for subsequent production of ethanol. Current project generates about 20% sugars from sago fibres, producing about 5t of fermentable sugars/day. Lab-scale analysis yields 98% sugars from sago starch, or about 15t/day. Therefore, it is possible to generate bioethanol for fuel entirely on sago effluent, based on the amount of recovered sugars (approx. 20t/day) from a sago mill.

1. Introduction

Ethanol is one of the world's most important products of fermentation processes. Utilizing renewable substrate will certainly render the process of production more attractive since production costs can be minimized and availability of the substrate can be substantiated at all times, two of the main factors influencing all fermentation processes. The high cost of the substrate (approx. 70-80% of the total unit production cost) can be attributed to the use of expensive feedstock or one that requires expensive pre-treatments. Thus, the use of biomass and renewable plant sources is the sensible option for the production of alternative energy. An alternative energy source such as ethanol has a high potential for automotive enhancement purposes since the natural energy resources such as fossil fuel, petroleum and coal are being used at a rapid rate and have been estimated to only last over a few years. Currently, investments are made by the US government to upgrade ethanol plants producing biofuels to generate ethanol from cellulosic material such as corn stalks or other sources of plant fiber. The reality of this scenario is demonstrated in the current spike in oil prices and passage of the energy bill, which has ignited interest in ethanol production. The present trend is that ethanol is being used as the major additive for gasoline in the automobile industries, from the previous 3% to 25%, or even higher as is common in Brazil (see also – *Bio-Refineries – Concept of Sustainability and Human Development*).

This paper demonstrates research and development on the production of bio-ethanol from sago starch in Malaysia, with special reference to the Universiti Malaysia Sarawak (or UNIMAS), Malaysia.

2. Starch Industries

Starch is considered to be one of the most abundant plant products and a major source of energy in the human diet. The world production of starch is estimated to be around 27.5 million tons. The world consumption of sago starch lies between 200,000 to 300,000 tons per annum and accounts for about 3% of the total world market which is dominated by corn, potato and tapioca starches.

In Malaysia, more than 90% of all sago-planting areas are found in the state of Sarawak in East Malaysia. The largest (75%) sago planting area is Mukah where over 50% of the sago starch is produced. The annual export of sago starch from Sarawak fluctuates between 30,000 to 50,000 tons between the years 1988-1990's, procuring incomes of between US$3.4 million to US$10.8 million. The downtrend of sago starch prices saw a decline to US$9.15 million in spite of increased production at 61,000 tons for the year 2000. About 100,000 tons of sago starch is used annually in Malaysia for various applications, mainly in the production of glucose (15,600t), MSG (15,000t) and noodle (13,200t) while other household uses account for 36,000t.

3. The Sago Palm

A fully-grown sago palm is about 10-12m high, and a diameter of about 0.8-1m (Figure 1). It is a hepaxanthic plant, flowering once in its lifetime, after which it dies. The palm is planted using young suckers and develops more suckers before reaching maturity after 9-11 years. Once planted, re-planting is totally unnecessary since young palms will develop from these suckers, thus assuring a continuous supply of fresh logs. Apart from unknown serious pests, sago palm is the only starch crop that thrives and grows with minimum care in swamp areas.

Figure 1: Large sago plantations like this are a common sight in Sarawak, Malaysia

Figure 2: Harvested sago logs awaiting collection

The sago trunk is cut into 1m logs (Figure 2), which are transported to the sago mill using lorries, or tied to form rafts (Figure 3). The log is protected by a hard and thick bark (about 2-3cm), which is debarked manually or using debarking machine (Figure 4). The debarked logs are mashed using a rasper (Figure 5) followed by hammer mill, then water is added to form starch slurry. The detail of this process is shown in Figure 6. Depending on the efficiency of the extraction system used, it takes less than an hour for the dried sago starch to be produced (Figure 7), from rasping of the pith to final flash drying of the starch slurry.

Figure 3: Sago logs are transferred using lorries or as sago rafts to sago mills.

Figure 4: Sago logs are debarked using either an auto debarking machine or manually with a machete.

Figure 5: The pathway of sago starch processing at Nitsei Sago Mill Pte. Ltd., Mukah, Sarawak

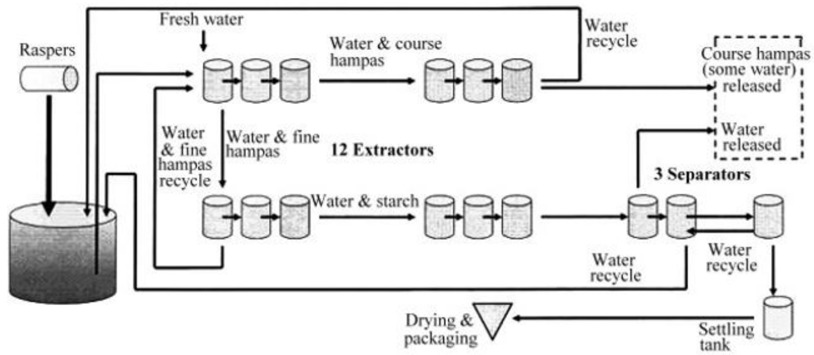

Figure 6: Schematic plan of a typical sago mill in Sarawak.

Figure 7: Bagged sago starch ready for export.

A typical sago mill consumes about 1,900 to 2,000 logs per day, producing 20 tons of food grade sago starch. The amount of starch per log has been estimated to be about 20% of the fresh weight of each log and each log typically weights between 100-130kg.

Starch yield depends on soil condition and varies from place to place. For example in Sarawak it is in the range of 180-385kg starch/trunk; in Bengkalis (Indonesia) about 550kg starch/trunk; in Jayapura (Indonesia) about 250kg starch/trunk and in Maluku (Indonesia) about 184kg starch/trunk - all base on dry weight basis.

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Biographical Sketch

K.B. Bujang is a Professor in Starch Fermentation Technology of the Faculty of Resource Science and Technology, University of Malaysia Sarawak and also the Dean of the Centre for Graduate Studies (CGS), since April, 1998 and May 1st, 2005, respectively. He obtained PhD in Biotechnology in 1992

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His current teaching load is 3 credits (1 subject) per semester on Bioprocess Technology and Application of Biotechnology II for the 1^{st} and 2^{nd} semester, respectively. Before this, he used to teach Biochemistry, Food Technology, Environmental Technology and Industrial Microbiology.

To date, he supervised 50 undergraduate projects, starting from the first batch of final year students in 1996, primarily on treatment of solid waste and sago starch fermentation. Supervision of research projects started in 1997 and up to date, a total of 14 MSc has been supervised, including 2 new PhD projects.