CHAPTER 1

INTRODUCTION

1.0 GENERAL

The sago starch bearing palm (*Metroxylon* spp.) is one of the earliest crops exploited by mankind. In Malaysia, the sago palm is being grown mainly in the state of Sarawak for many hundreds of years. Tie and Lim (1991) reported that the hectarage under sago cultivation was about 19,720 in 1991 in Sarawak, East Malaysia. In Peninsular Malaysia, the major sago area is located in Johore with an estimated area of 4,000 hectares (Tan, 1981).

On a commercial scale, about 90 palms per hectare per year are harvested with each palm yielding an estimated 166 kg dry starch (15 tons per hectare per annum) (Kueh and Jong, 1993). The sago palm cultivation however has a potential yield of 37 tonnes per hectare per annum and is currently the most inexpensive source of starch (Anon, 1995). It is for these reason that sago is termed by many, including the Japanese as the "Starch crop of the 21st century".

During the last decade, Sarawak has exported sago starch of about 25,000 to 30,000 tonnes annually to Peninsular Malaysia, Japan, Brunei, Singapore and other parts of the world (Table 1). For more than 50 years, sago has been Sarawak's primary revenue earner. However at present, among Sarawak's palm crops, sago palm ranks second after oil palm as an agricultural export earner. For the year 1992, sago ranked fourth as an agricultural revenue earner after oil palm, pepper and cocoa, earning about $31.1 million (Ringgit Malaysia) (Agricultural Statistics of Sarawak, 1993).

Table 1. Exports of Sago Flour and Meal and Starches of Sago from Sarawak

YEAR	*SAGO FLOUR AND MEAL*		*STARCHES OF SAGO PALM*	
	Tonnes	*RM*	*Tonnes*	*RM*
1984	22 094.84	8 500 824	3 406.11	1 521 147
1985	10 688.21	3 518 632	9 835.50	3 537 588
1986	17 432.95	7 263 859	10 822.03	4 738 239
1987	10 146.97	4 269 004	10 766.56	4 454 807
1988	6 898.54	2 464 117	27 502.30	11 351 438
1989	4 539.84	1 767 236	25 471.96	12 011 585
1990	3 670.13	1 649 848	40 041.43	20 898 297
1991	3 871.56	2 307 321	33 566.33	20 544 744
1992	3 703.84	2 331 486	45 779.96	28 813 504
1993(p)	3 963.90	2 314 787	34 960.11	20 835 851

(p) Preliminary
RM = Ringgit Malaysia.

Source: Agricultural Statistics of Sarawak (1993).
About RM 2.50 ≈ US$1.00

Apart from export, sago starch together with rice, corn and potato is used in the local food industries in the manufacture of vermicelli, noodles, biscuits and other products. It is also used as a thickener, sweetener and a feedstock for monosodium glutamate production (Azudin, 1992).

Zulphilip *et al.* (1991) reported that during the past several years, an increasing number of efficient and modern sago factories have been established. These factories with multi-million dollar worth of modern processing machinery produce about 300 to 900 tonnes of good quality starch per month. It is reported that in order to further improve the flour quality, most of the modern factories have their own mini water treatment plants.

With the increase in production and the downstream uses of sago starch (Fig. 1), the sago starch industry is now being confronted with solid and liquid waste disposal problems. The sago starch processing industry produces three major types of by-products, viz. bark, pith residue, commonly known as 'hampas' and wastewater (Plate 1 and Fig. 2). Sago 'hampas', the fibrous pith residue obtained after starch extraction from the rasped sago pith, consists of about 66% starch, 15% crude fiber and 1% crude protein on a dry weight basis (Shim, 1992). Sago processing wastewater containing high amounts of 'hampas' are normally discharged indiscriminately into nearby rivers. This is believed to be the main cause of poor water quality in rivers nearby sago factories (Anton, 1992; Shim, 1992). Analysis of the quality of river waters in the

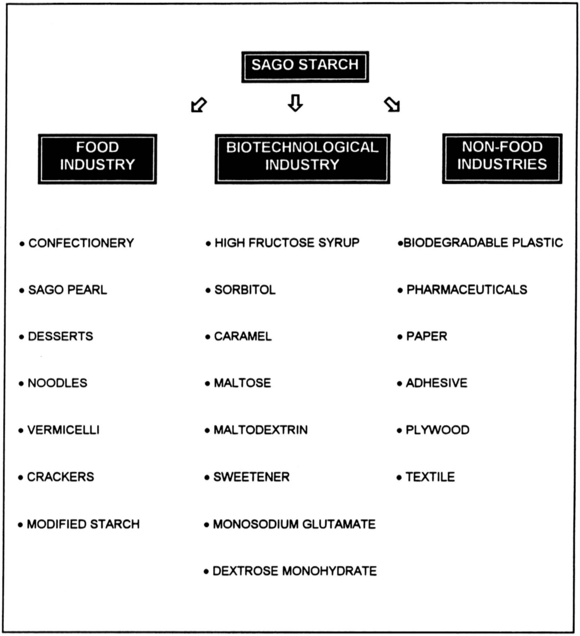


Figure 1. Utilization of sago starch
Source: Kueh & Lim (1993)

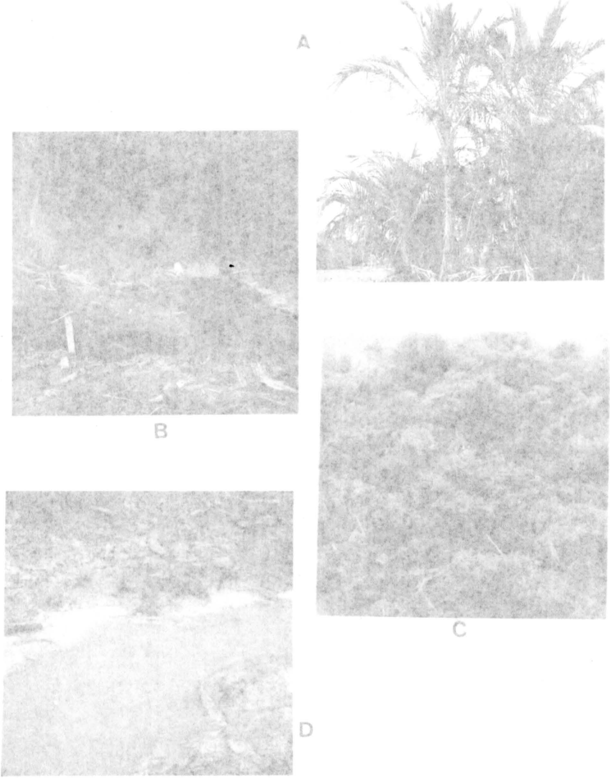
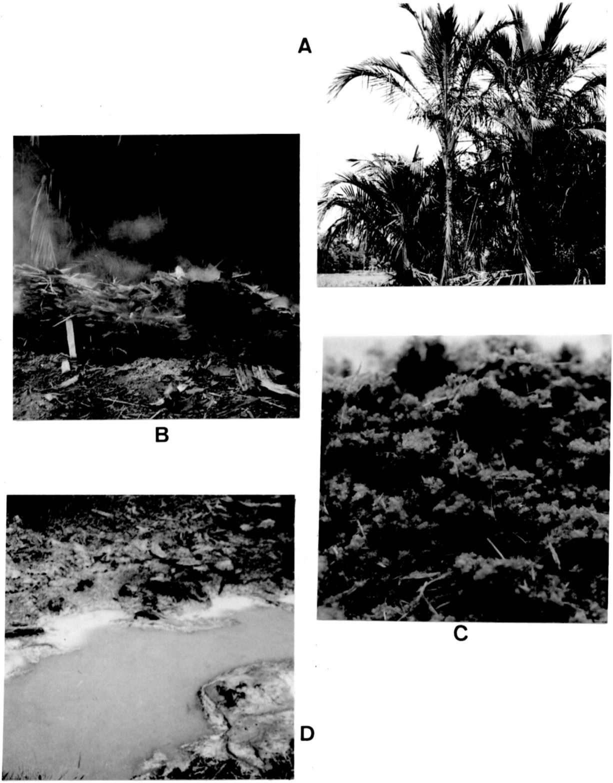


Plate 1. Wastes produced from sago palm (A) processing
(B = bark, C = 'hampas', D = wastewater)



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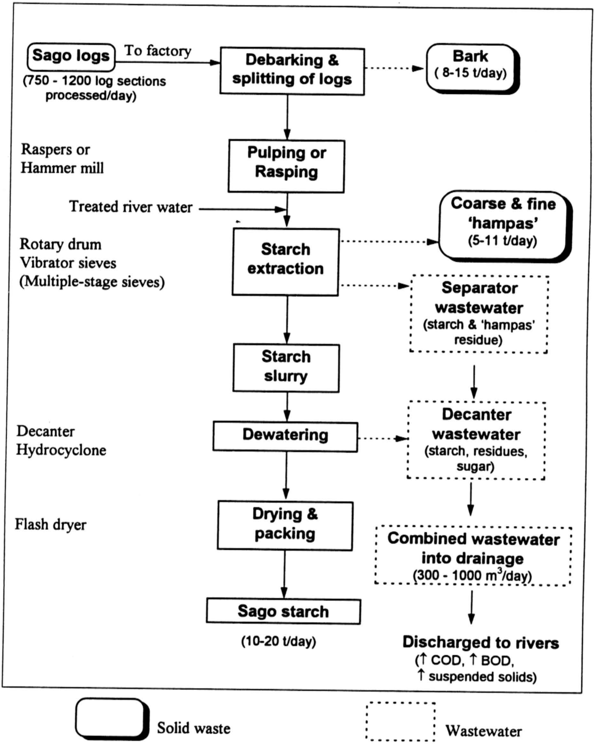

Figure 2. Sago processing at a conventional factory and by-products generated (adapted from Shim, 1992; Chew and Shim, 1990, 1993)

vicinity of sago factories showed high Biological Oxygen Demand (BOD) while the presence of bloodworms (*Tubifex* sp.) at the river bed suggested anaerobic conditions (Anton, 1992).

Till date, although much attention has been focused towards increasing the efficiency of sago processing, little or no attempts have been made to utilize the wastes generated, especially 'hampas', which is normally washed off into the drain along with the wastewater. In some cases and in some areas, 'hampas' has been to a limited extent used as a dietary fiber or as a cheap carbohydrate supplement in ruminant feed rations.

The development of appropriate technology for converting sago 'hampas' into value-added products has been undertaken by several workers (Pongsapan *et al.*, 1984; Horigome *et al.*, 1991; Haryanto and Pangloli, 1991; Paridah, 1992 and Tuen, 1994). 'Hampas', which contains large amounts of trapped starch granules, has been studied by Shim (1992) and Vikineswary and Nadaraj (1992) for its utilization by amylolytic and ligninolytic fungi. Shim (1992) found high activities of cellulase and α-amylase during growth of *Myceliopthora thermophila* on sago 'hampas'. Based on these findings, sago 'hampas' might be a preferable choice of substrate for utilization by white rot fungi for enzyme production.

It has been reported that the white rot fungi is a suitable microorganism for utilization of lignocellulosics (Zadrazil, 1977) such as 'hampas'. The fundamental principles of fermentation of lignocellulosics has been used in composting (Moo-Young *et al.*, 1983), mushroom cultivation (Zadrazil, 1978), animal feed (Zadrazil, 1977), tempeh (Hesseltine, 1972) and also enzyme production (Bailey and Ollis, 1986). The solid substrate fermentation (SSF), which emulates nature, has been found to have numerous advantages for enzyme production which are well documented (Hesseltine, 1972; Cannel and Moo-Young, 1980; Aidoo *et al.*, 1982; Mudgett, 1986). Solid substrate fermentation has also been exploited commercially to convert agricultural and lignocellulosic residues to edible mushroom.

In any attempt to utilize agro-wastes properly with the aim of minimizing pollution, suitable strategies incorporating simple and effective methods need to be devised. Producing value-added products such as enzymes through SSF would be an effective and advantageous option. Hence the utilization of the solid waste 'hampas' for enzyme production by solid substrate fermentation was undertaken.

2.0 OBJECTIVES OF THE RESEARCH PROJECT

The main objective of this study was to attempt the use of sago 'hampas' for enzyme production. The specific aims of this study were to:

a. characterize sago 'hampas'
b. develop 'koji' inoculum with the white rot fungus, *Pleurotus sajor-caju*
c. assess the growth of *P. sajor-caju* on sago 'hampas' supplemented with nutrients in solid substrate fermentation
d. optimize 'koji' inoculum age and density for SSF of 'hampas'
e. investigate enzyme activities during fungal utilization of 'hampas' to gain an insight of the substrate degradation pattern
f. select the enzyme which was produced in larger quantities and study its behavior
g. induce, characterize and purify the selected enzyme produced by *P. sajor-caju*
h. assess possible utilization strategies of sago 'hampas'