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Income analysis of sago (*Metroxylon sagu*) starch production in the Municipality of Dulag, Leyte, Philippines

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Abstract The amount of starch extracted is highly dependent on the growth stage of the sago palm. In this study, three sago palms at different growth stages, namely flowering stage, 4-5 years trunk formation stage and 3-4 years trunk formation stage grown in mineral soils were cut down. The objectives of this study were to compare the amount of starch accumulated in its stem and to perform economic income and feasibility analysis using traditional starch extraction methods in the Municipality of Dulag, Province of Leyte, Philippines. The results showed that the largest amount of starch accumulated was found in sago palm at flowering stage with a potential of nearly 60 kg per palm, while 4-5 year sago palm at trunk formation stage only resulted to approximately 22 kg per palm and no starch was extracted in 3-4 year old sago palm. The sago pith was 60% of the total volume of sago logs and large amounts of residue were observed. The labor required in harvesting sago palm at flowering stage was 5 man-days, mostly provided by the family labor force. The total cost of harvesting in sago palm at flowering stage was US$ 13.89. The retail price of air-dried starch was US$ 0.093 per 150 g, which was cheaper compared to that in Mindanao. The gross income was US$ 33.76 producing a net income of US$ 19.87 per palm. On the other hand, harvesting young sago palms at 3-4 year and 4-5 year trunk formation stages is considered to be impractical.

Keywords: Dulag, family labor, gross income, harvesting cost, net income, sago starch, traditional starch extraction,

フィリピン・レイテ島・ドラグ地区における サゴ澱粉生産に関する収入解析

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要約　サゴヤシから抽出できる澱粉量は生育ステージに依存している．本研究は，フィリピン・レイ

テ島・ドラグ地区において異なる生育ステージにある3本のサゴヤシ，すなわち，開花ステージ（sago palm A），4～5年の幹生育ステージ（sago palm B）および3～4年の幹生育ステージ（sago palm C）にあるサゴヤシを伐採し，レイテ島の伝統的な抽出法を用いてサゴヤシ幹から澱粉を抽出して，その澱粉収入可能性分析を行ったものである．研究に用いたサゴヤシの中では，開花ステージにあるサゴヤシが最大の澱粉集積を示し，1本当たり60 kg程度を集積していた．一方，4～5年の幹生育ステージにあるサゴヤシは1本当たり約22 kgの澱粉を集積していたが，3～4年の幹生育ステージにあるサゴヤシは全く澱粉を集積していなかった．サゴヤシの髄はサゴヤシログの60%を占めたが，髄中には多量の抽出残渣となる部分が存在した．開花ステージにあるサゴヤシの収穫・澱粉抽出に必要な労働は5日・人で，多くの場合，家族労働である．フィリピン・レイテ島・ドラグ地区における開花ステージにあるサゴヤシの収穫に必要な費用は，13.89米ドルで，ドラグ地区市場における風乾澱粉の小売価格はミンダナオに比較して安く，150 gで0.093米ドルであった．市場で風乾澱粉がすべて販売できたとすると，サゴヤシ1本当たり33.76米ドルが粗収入で，正味の収入は19.86米ドルとなる．一方，試験的に3～4年および4～5年の幹生育ステージにあるサゴヤシからも澱粉を抽出したが，収入に結びつけるほど澱粉を集積していないことが明らかになった．

キーワード　ケース・スタディ，サゴヤシ，収入解析，生育時期，澱粉蓄積，フィリピン・レイテ島

Introduction

Metroxylon sagu, commonly known as sago palm, is exploited for its economic importance of accumulating starch in its stem. Although the sago palm grows in peat soils as well as in mineral soils, the optimum growth conditions are minimum temperature of 15℃, full sunshine, regular flooding but not in continuous flooded condition, flood water with large amounts of nutrient content and slightly brackish, mineral soils with 20% organic matter; and a pH of 4 or more (Flach 1983). Vast stands of sago palm are found in regions of Southeast Asia and Oceania between 10° north and south latitudes and up to an elevation of 700 m above sea level (Flach 1997). In Malaysia, extensive peat swamp areas are mainly utilized for commercial sago palm plantations, producing about 50,000 tonnes of air-dried starch annually (Jong 1995) and ranking as the 4th agricultural revenue earner.

The growth and development of sago palms are highly dependent on the type or cultivar and the environmental growth condition (Jong 1995). Although the sago palm can grow in shallow and deep peat soils, the growth rate, development and starch production in peat soils were greatly lower than those in mineral soils. Early studies conducted in Sarawak, Malaysia have showed that trunk formation stage starts on the 6th year after planting and full trunk growth can be observed on the 13th year of growth stage in peat soils (Yamaguchi et. al. 1997) and the potential extractable air-dry starch ranges from 180 to 413 kg per trunk (Jong 1995).

In the Philippines, sago palms are found in the islands of Visayas region, such as in Cebu, Leyte, and in some provinces in the island of Mindanao, namely Misamis Oriental (Josue and Okazaki 1998), Agusan del Sur, Davao, Cotabato and in the western part of Mindanao. However, detailed information on the distribution and size allocation of sago palms throughout the country is yet to be known (Baconguis and Panot 1991). Unlike Malaysia, the sago palm in the Philippine economy is of minor importance in the agricultural sector. The leaves are mainly exploited as an additional source of income (Celiz et al. 2002) and the starch serve as food in poor farming households (Josue and Okazaki 1998). Since there are no commercial plantations and processing plants, the sago starch is extracted with the traditional means and sold in the local market on designated marketing days. This paper aims to report on the traditional starch

extraction method, the amount of starch accumulated in the three different growth stages, namely flowering stage, 4-5 years trunk formation stage and 3-4 years trunk formation stage, and to perform economic income and feasibility analysis of traditional starch extraction method employed in the Municipality of Dulag, Province of Leyte, Philippines.

Materials and Methods

1. Study site

The location of study site is in Barangay Tigbao, Dulag, Leyte, Philippines, as shown in Figure 1, with a geographical position of 10°58'021"N and 124°59' 973"E. The area is categorized as Type 2 climate, which has no dry season with a very pronounced maximum rain periods in the months of December to February. The respective average annual rainfall and the mean annual temperature in Tacloban, Leyte are, 2355.6 mm and 27℃ (Bargayo 1990). The sago palms selected for starch extraction were growing in mineral soils along the irrigation canal in the paddy field.

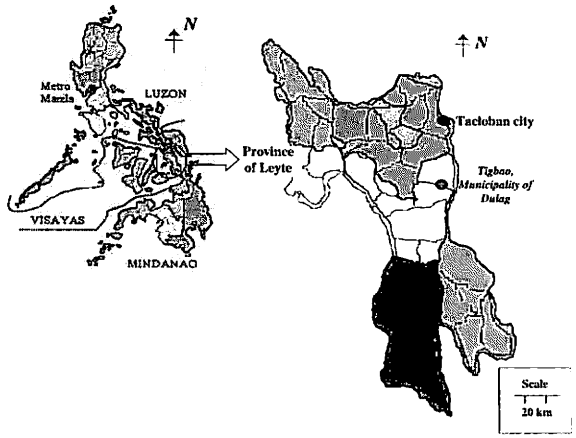

Figure 1. Study site in the Municipality of Dulag, Province of Leyte, Philippines.

2. Sago palms for starch extraction

Three sago palms at different stages (sago palm A, flowering stage; sago palm B, 4-5 years trunk formation stage; and sago palm C, 3-4 years trunk formation stage) were cut down near the base of the trunk using a diesel-operated chainsaw. The total length (cm) of the felled palm to the tip of the longest leaf was measured. The trunk was then cut into logs approximately 60 cm in length for weighing. The sago logs were numbered from bottom to top (Log 1 - Log 12).

3. Sago log measurements

The sago logs were measured according to actual length (determination limit, 0.5 cm), top and bottom diameter (0.1 cm), total log weight (0.5 kg).

4. Sago starch extraction

Sago starch extraction was carried out in field conditions. The materials needed for sago starch extraction were a timer, a bolo (handmade sword), a wooden mortar and pestle, 2 large basins, clean water, flour sackcloth, 100-kg and 2-kg weighing scale; and a drying mat. First, the sago logs were cut vertically into halves to expose the sago pith. Using a bolo (sword), the pith was chopped into smaller size to macerate easily. The chips are then crushed with a large wooden mortar and pestle into finer pieces. The crushed pith was mixed with water in a basin and filtered in a separate basin using a sackcloth allowing the water with starch particles to be separated from the pith residue. The sackcloth with residues was squeezed to remove remaining water with starch particles. In the separate basin, the water with starch particles was allowed to stand for a while to allow sedimentation. Finally, the water was carefully discarded. The wet sago starch was dried under the sun on a polyvinyl drying mat and the dry weight of starch and residue was measured.

In order to quantify the amount of starch accumulated in the sago palm at flowering stage, starch was extracted from the whole of Log 5 while other logs were sampled in the upper 10 cm of the log for starch extraction. Log 5 showed that the total amount of pith sampled was 45.5 kg from a fresh log weight of 76.5 kg and 69 cm long, which is about 60% of the total log.

Results and discussion

1. Starch accumulation and extraction

The total weight and its corresponding average log length of sago logs for starch extraction at different growth stages are shown in Figure 2. The sago logs should have been cut at a length of about 60 cm. However, an inconsistency in sago log length was observed due to unavoidable reasons, such as difficulty in controlling the cutting pattern of a huge diesel operated chain saw. The respective total fresh log weight of sago palm at flowering stage (sago palm A), 4-5 years trunk formation stage (sago palm B) and 3-4 years trunk formation stage (sago palm C) were 736.5, 715.5 and 300.5 kg. The average log length of sago logs from bottom to top ranged from 44 cm to 242 cm. Sago palm A totaled to 12 logs with weights varying from 35 to 79 kg, while sago palm B resulted to 8 logs ranging from 72 to 102.5 kg, respectively. Similarly, six individual logs of sago palm C varied from 26.5 to 60 kg in weight.

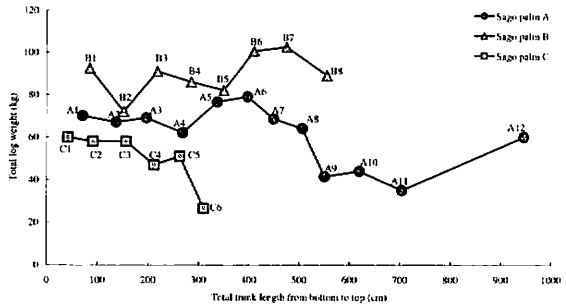

Figure 2. The total weight (kg) and its corresponding actual length (cm) of sago logs for starch extraction at flowering stage (sago palm A), 4-5 years trunk formation stage (sago palm B) and 3-4 years trunk formation stage (sago palm C) in Dulag, Leyte.

Although sago palm at flowering stage showed the largest fresh total weight of logs markedly due to the increased number of logs than other palms, 4-5 year sago palm showed larger log weights when compared on log basis because of high moisture content. These results confirm the fact that moisture content is relatively high and remain constant along the trunk of young sago palms. As the palm matures, moisture content decreases sharply especially in the lower portion of the trunk (Jong 1995). Jong (1995) cited that the lowest mean moisture content was found in palms from full trunk growth stage to flowering stage which corresponds to the highest starch content in the trunk. He further discussed that in young and over-mature palms, the mean moisture content is higher and that a high negative correlation was observed between moisture and the amount of starch accumulated indicating the mutual replacement of starch and moisture in the trunk.

Since starch accumulated was extracted in the whole of Log 5, the amount of extracted air-dried starch was 6.5 kg, as shown in Figure 3, leaving large amounts of residues. The amount of starch in Log 5 was about 60% of the total log, which is relatively low and provided large amount of residue. Sago palm residue from starch extraction is a potential in producing biodegradable plastics made of fiber and starch (Sasaki et al. 2002). Figure 3 also shows the estimated pith weight (kg) and starch yield (kg/kg pith) in sago palm at flowering stage (sago palm A) in Dulag, Leyte. The amount of pith weight per log was estimated through the percent ratio and proportion based on Log 5, while the amount of air-dried starch yield was calculated based on the amount of pith sampled in each log. The largest amount of starch is found in Log 6 with an estimated pith weight of 47.0 kg and a potential extractable air-dried starch of 10.5 kg. The lowest amount of starch is estimated in Log 8 with 4.5 kg of extractable air-dried starch. In the upper part of the trunk, no extractable starch will be extracted. The total estimated amount of potential extractable starch in sago palm at flowering stage is 54.5 kg. The estimated fresh pith weight range from 36.9 to 45.5 kg per log, while the percent starch content in fresh pith differed from 11.8 to 22.3 with Log 6 as the highest. Based on Figure 3, it indicates that more than 77% of the fresh pith weight is starch residue which contains fiber and some starch which is ideal for the production of biodegradable plastics (Sasaki et. al. 2002). The percent of starch in fresh pith of sago logs at flowering stage has the following decreasing order:

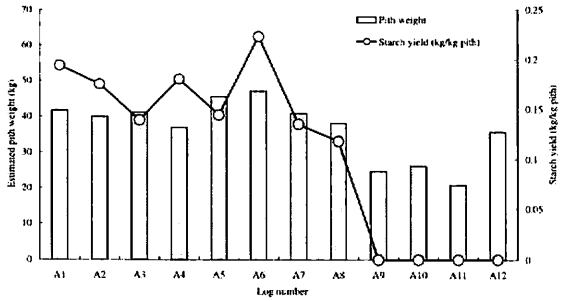

Figure 3. The estimated pith weight (kg) and starch yield (kg/kg pith) in sago palm at flowering stage (sago palm A) in Dulag, Leyte

Estimated pith weight: (Log weight x pith %)/100

Log 6 > Log 1 > Log 4 > Log 2 > Log 5 > Log 3 > Log 7 > Log 8

The highest percent starch was observed in Log 6, nearly 500 cm from the base of the trunk. In this study, the large amount of starch accumulated was found between 140 cm to nearly 500 cm from the base of the trunk, or from Log 1 to Log 6. The height of the stump was 140 cm and the total trunk length was 1086 cm in sago palm A. Jong (1995) cited that Sim and Ahmed (1978) found that starch was generally accumulated from the base upwards and that the highest starch concentration was found between 150-600 cm from the base of the trunk, while the lowest at the top of the trunk is utilized in the flower and fruit development. In his study, Jong (1995) further cited that starch appears to accumulate from the base upwards in young sago palms and that at flower initiation, starch appears to disperse upwards to settle anew at the top of the trunk, thus low starch concentration is observed at 100-200 cm below the crown, as indicated in Log 7, Log 8 and onwards. Air dried starch content varied from 4.3 to 19.0 per cent. Similarly, in sago palm B, residue accounts for more than 80% of the fresh pith weight. Regardless of pith weight, which can also be observed in Figure 4, the percent of starch decreases as the log number increases, suggesting that large amount of starch at this growth stage are accumulated at the lower part of the trunk. Jong (1995) emphasized that the highest concentration of sago starch in young sago palms was found on the lower part of the trunk especially in the early stage of trunk development. Starch is generally accumulated from the base upwards (Jong 1995). Thus in the upper part of the trunk, small amount of starch is extracted. On the other hand, the estimated pith weight (kg) and the potential extractable air-dried starch in sago palm at 4-5 years trunk formation stage (sago palm B) is shown in Figure 4. Results showed that the highest amount of potential extractable starch is found in Log 1, estimated at 10.5 kg air-dried starch. Eventually, no potential extractable starch will be extracted from Log 5 onwards. The total amount of estimated potential extractable air-dried starch in sago palm at 4-5 years trunk formation stage is 22.3 kg.

Unfortunately, no starch has been extracted in sago palm at 3-4 years trunk formation stage (sago palm C). It is likely that the sago palm C was still on its initial trunk formation stage.

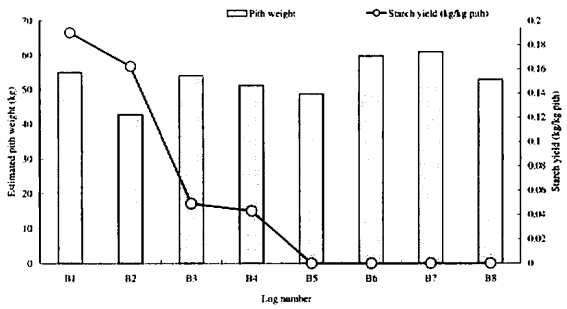

Figure 4. The estimated pith weight (kg) and starch yield (kg/kg pith) in sago palm at 4-5 years trunk formation stage (sago palm B) in Dulag, Leyte

2. *Income analysis of sago starch production at flowering stage*

In the Philippines, since family labor is cheaper compared to hired labor, most farmers do not allocate an amount for family labor, and they charge it as free labor (Celiz et al. 2002). It has been practiced that family members are required to provide labor in any farm-based income generating activity for a larger net income and eventually, they divide the income among themselves. Table 1 shows the income analysis table of sago starch production at flowering stage per palm

Table 1. Income analysis table of sago starch production at flowering stage in Dulag, Leyte per palm basis

I. Harvesting cost of sago palm at flowering stage in Dulag, Leyte	
Labor required for harvesting sago palm at flowering stage; 5 man-days	
Family labor: 4 man-days at US $ 1.39	US $ 5.55
Hired labor: 1 man-day at US $ 1.85 per man day	1.85
Chainsaw rental at US S 5.56. per palm	5.56
Diesel fuel US $ 0.93 per palm	0.93
TOTAL HARVESTING COST	**US $ 13.89**
II. Projected gross income	
Amount of air dried starch accumulated at flowering stage 54.46 kg	
Price of air-dried starch US $ 0.093 per 150g	
TOTAL GROSS INCOME	**US $ 33.76**
III. Projected net income	
Total Gross Income - Total harvesting cost = Net income	
TOTAL NET INCOME = US $ 33.76 - 13.89	**US $ 19.87**

basis. Family labor accounts for 75-80% of the total workload while 20-25% was hired labor comprising of heavy workloads. With the starch extraction data at hand, the income return of sago starch per palm basis, depending on the growth stage, can be assessed accurately. Recently, the cost of hired labor in Dulag, Leyte, Philippines is US $ 1.85, which increased with a difference of US $ 0.39 after a year due to scarcity of hired labor. Hired labor workers tend to migrate to urban areas, where daily wages are comparably higher. Family labor is 75% of the hired labor cost totaling to US $ 1.39. In harvesting a sago palm at flowering stage, the number required for labor is 5 man-days (which literally means 5 men working for 1 day or 1 man working for 5 days). In this case, family labor provides 4 man-days and hired labor is 1 man-day in harvesting sago palm at flowering stage. Other costs included are chainsaw rental (US $ 5.56) and diesel fuel for chainsaw operation (US $ 0.93) on a per palm basis. Therefore, the total harvesting cost is US $ 13.89 per palm at flowering stage. Air-dried sago starch in Dulag, Leyte is locally available in the village market on a particular marketing day and it is retailed at a price of US $ 0.093 per 150 g, which is cheaper, compared to the retail price in Mindanao (Celiz, et al, 2002). The retail price of air-dried sago starch in Cagayan de Oro City of Mindanao is US $ 0.15 per 150 g. Prices of commodities in major commercial urban centers are rather expensive than in rural areas such as in Dulag, Leyte. Since the potential extractable air-dried starch is 54.5 kg per sago palm at flowering stage, the projected gross income is US $ 33.76. Therefore, the projected net income is US $ 19.87 per palm at flowering stage. While in young sago palms, since there is relatively few amount of starch accumulated in the whole trunk, harvesting sago palms at younger stage for starch productivity is impractical.

Regardless of the cultivar having different amount of potential extractable starch in a particular variety and a given environmental condition, the growth stage of the sago palm is the most important factor to be considered in sago starch production. The type of cultivar is the second most important factor (implied by Flach, 1997). The amount of starch produced is highly related to the genetic aspect of the palm. In the Philippines, biomass production for thatch has the priority rather than starch production for the genetic selection.

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