IMPROVEMENT ON SAGO FLOUR PROCESSING

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ABSTRACT

Improvement on sago flour processing was analyzed by researching potential replacement of existing system. A study was conducted by imitating the process in a down-scaled operation employing two equipments with different techniques to compare the feasibility and efficiency. General process flow for both techniques followed the same extraction-sedimentation-drying pattern; differing only in extraction step. The first equipment was blender which was used to extract starch from raw sago by grinding; aided by sufficient amount of water. Resulting starch slurry was filtered and squeezed manually to produce starch paste. The second technique involved equipment which extracted sago starch by dry grating followed by squeezing. Less water was used. Produced sago flour was subjected to proximate analysis. The first technique resulted in 26% yield; that was 257.64 g of sago flour produced from 1 kg raw sago. The second technique yielded 13% recovery of starch; that was 134.8 g sago flour produced from 1 kg raw sago. Grating without assistance of water might be the explanation for the fewer yield in the second technique as water helped to dissolve and release starch granules. Revised from varying aspects, the ideal processing system of efficient sago flour production might be an integration of both blending and mechanized squeezing into one unit operation; aided by controlled amount of water.

Key words: *ash content, sago flour, extraction, sago starch, yield*

1. INTRODUCTION

Sago flour processing can be characterized as a process industry, since it transforms a raw material (*Metroxylon sagu* or sago palm) via a primary process, into a product (sago flour) that is of value to consumers. The processing is carried out using certain unit operations, thus, chemical engineers should make improvement in the processes or to the unit operations.

In Malaysia, sago palm is inexpensive and not nearly as agriculturally intensive as rice. Although rice is generally preferred as main staple food crops in Malaysia, sago is also a reliable source of carbohydrates. Presently, commercial production of sago flour in Malaysia occurs mainly in Sarawak and small parts of Johor. In Sarawak, the planting area of sago is estimated above 60, 000 hectare which is the fourth largest area for crops in Sarawak [1]. Sarawak is also one of the biggest exporters of sago. Sago brings above RM30 million in exports earning in latest year for Sarawak [1]. This value is expected to rise in coming years.

Sago flour has mainly been supplied as a raw material to food or cosmetic manufacturing companies. In Malaysia, many food manufacturing industries have used sago flour as main ingredient in the production of *bee-hun* (vermicelli), *Kuay-Tiau*, biscuits, cakes and many other foods. These sago flour-based products have great potential to expand in the Malaysian market, especially if there are improvements in production capacity and product quality. The production capacity could be increased by improving the processing level (technology improvement).

The principles and methods of palm sago extraction are similar for both traditional and commercial productions, differing only in scale of operation. In general, palms are selected and felled. Bark-like layer is stripped from the trunk and cut into sections or floated whole to a central processing facility. There, it is reduced to battens and rasped either manually or mechanically to pulverize the pith and loosen starch particles within the fiber. The starch is removed from the fibers by kneading with hands or trampling by feet or by a spray of water. Starch-laden water runs into a settling container, where the starch is precipitated and the water overflows. The starch is then removed and dried. Native starch extracted from debarked pith yields only 25-30 % of total starch content [2].

Several studies have been done to improve the processing and quality performance of sago flour production. A process flow has been proposed with improvement in the extraction unit that produces sago flour [3] and another researcher has studied the optimization of extraction of sago starch (flour) using a prototype machine [4]. Both studies have used different unit operations at laboratory scale. Thus, research studies have facilitated the transformation of sago flour processing from traditional technology to a modern technology. Recently in Malaysia, these modern sago processing plants which are mainly in Sarawak have been claimed to be fixed with high technology equipments [5]. These modern factories are processing the sago to obtain sago flour (starch) by using the latest extraction technology [5] and a factory situated in Sarawak also has claimed to use the rotary drum dryer in the drying section [6]. In term of quality, it was claimed that the product from modern technology gives better quality compared to traditional factory [7].

One part of sago extraction technology is a process of milling or disintegration of sago starch and most operations are using hammer mill for this activity. Less research activity has been undertaken at this process level of milling (grinding). The performance of grinding could possibly be improved by using other types of grinders or by designing a new design of machine that could integrate the grinding and extracting of sago starch. It is expected that with a new design of machine for extracting sago starch, operation could be more efficient than hammer mills, and could produce better quality of sago flour.

The aim of this research project is to make improvement in sago flour processing that could increase the production capacity in compromise with quality. The first step in the study is to analyze the most crucial part in the whole operation; namely the extraction part, hence this paper focuses on identifying the most ideal method of extraction.

2. MATERIALS AND METHODS

Materials

Raw sago palms of *Metroxylon rumphii* species were purchased locally in Melaka and transported to the laboratory for the study. The sago trunks were first debarked manually; unveiling the pith which contains most of the starch [8]. The debarked pith was then chopped into small pieces which were packed in plastic bags and stored in a freezer at -20 °C.

Equipmenst Used

Employing different techniques, two different equipments were used for extraction; a standard electric blender and a machine resembling a coconut milk extractor called *"AutoSqueezer"*. The *"AutoSqueezer"* was developed in the laboratory of Process & Food Engineering, UPM. It consists of three parts: grater, squeezing part (screw extruder) and collecting funnels (liquid and waste).

Process Flow

The process flow of the whole operation that has been carried out in this study is outlined in Figure 1. There are four distinct stages of operation; 1) preparation of raw sago samples, 2) extraction of starch from sago pith using specified equipment, 3) sedimentation, and 4) drying.

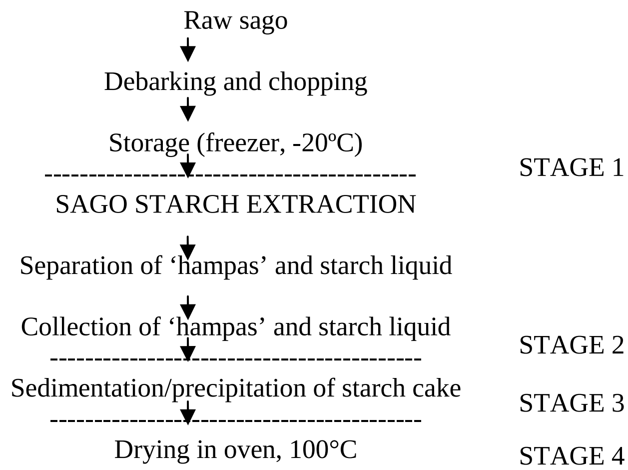

Figure 1: General process flow of operation.

Preparation of crude sago flour was initiated by extraction of sago starch from the pith. In this study, the extraction was carried out using different techniques in order to identify the most ideal between the two. The first technique was to grind the sago pith with sufficient amount of water using a standard electric blender. Samples of chopped sago pith weighing 1000 g each were fed into the blender and proportional amount of water was added; meaning 1 L water for every 1000 g raw sago. Resulting slurry was then filtered using a sieve and squeezed manually to produce starch liquid.

The second technique was to grate and squeeze the sago pith mechanically using the *"Auto Squeezer"*. Samples of chopped sago pith weighing 1000 g each were fed into the *"Auto Squeezer"*. Grating was performed by the mechanical grater and so was squeezing. Using *"Auto Squeezer"*, water was added during the squeezing process.

The resulting starch liquid from both operations was collected and left for sedimentation to allow starch particles to be precipitated. The 'hampas' was weighed and bagged for further treatment. After 2 hours, the liquid was drained out and the initial weight of the starch paste was taken. The starch paste was then dried in the oven at 100 °C and the weight of the produced sago flour was taken periodically until it became constant.

Ash Analysis

Ash content of the sago flour samples was determined by employing gravimetric method; following the Standard American Association of Cereal Chemists [9]. The analysis was done in duplicate. The values were compared with those of industrial grade, according to SIRIM specifications [10].

3. RESULTS AND DISCUSSIONS

3.1 Process

Sago flour has been successfully produced by following the process flow in Figure 1. Figure 2 shows the existing process flows currently practiced by traditional and commercial operations.

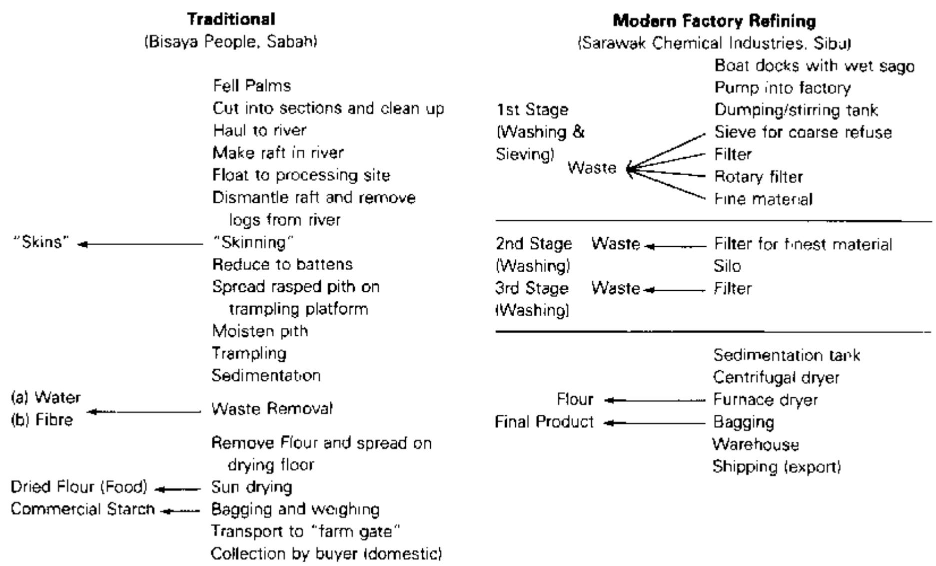

Figure 2: Process flows of sago flour production in traditional and commercial operations. Adapted from Ruddle et al., 1978 [11]

Ineffective extraction poses adverse effect on production yield since it depends greatly on the sophistication of the methods employed [12]. There are extensive studies on extraction and many are focusing on improving and increasing the efficiency; and subsequently the yields. In present study, two methods were analyzed. In respect with production yield, it was observed that the technique of grinding aided by water was the better option in giving more efficient extraction. The starch granules present in the pith were dissolved in water and subsequently released when it was ruptured by grinding. The second technique resulted in lower yield perhaps owing to the fact that grating was not aided by water. Although the sago pith was disintegrated into fine bits by grating, the starch granules remained trapped within the parenchyma cells.

Manual filtration and squeezing in the first technique however affected the yield in that losses due to inefficiency were inevitable. By hand, not all starch liquid was successfully squeezed from the pith. It was also far from hygienic. In the second technique, grated sago pith was squeezed mechanically by the machine and the 'hampas' was separated simultaneously. This resulted in clean or absolute performance in squeezing. The resulting 'hampas' contained very minimal moisture, which meant that most of the starch liquid had been successfully squeezed out. In addition to efficiency, mechanized squeezing was also more hygienic.

Thus, another step toward designing a new unit operation of processing sago flour should be initiated with designing new equipment for extraction. Based on the findings thus far, integrating grinding with mechanized squeezing seemed an excellent proposition. Furthermore, compared with usage of copious amount of water in traditional and commercial operations, controlled amount of water was used in the study. This should be highlighted as it would help in cutting back cost of water utilization.

3.2. Quantity

Figure 2 represents the diagrammatic mass balance of sago flour produced in the study using two techniques. Meanwhile, the percentage of yield is displayed in Table 1. The production yield of sago flour was calculated as follows:

$$\frac{\text{total end product}}{\text{total input of raw material}} \times 100 = \text{percentage of yield (\%)}$$

Table 1
Percentage of yield

Extraction method	raw sago (g)	sago flour (g)	yield (%)
Technique 1	1000	257.64	25.76
Technique 2	1000	134.80	13.48

A total of 25.7 % (wt) of starch was recovered from the sago pith via the first technique. The yield is slightly higher than achieved by traditional and commercial operations as reported in literature. To date, only about 21 % of starch can be extracted from debarked sago pith depending on the technique used, and there is at least 66% of starch remaining in the 'hampas' [8]. Meanwhile, using the second technique, the yield decreased to nearly half of the first. Only 13.48 % (wt) of starch was recovered and converted into sago flour.

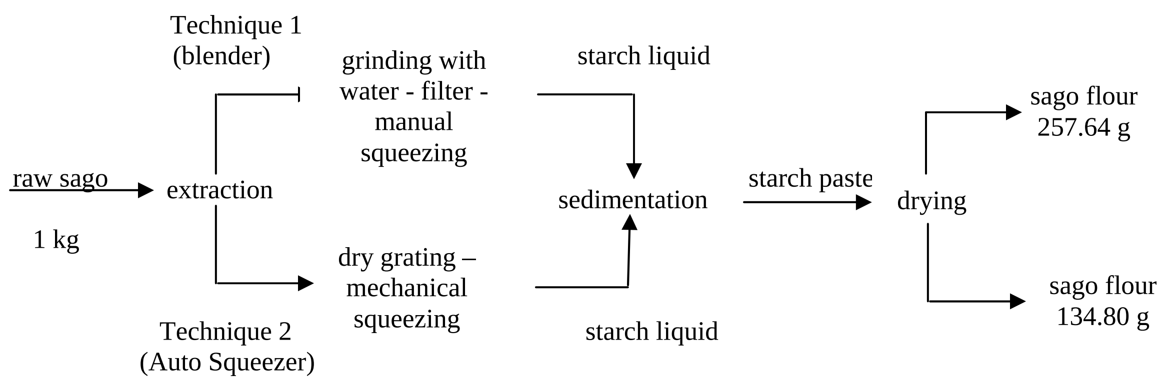

Figure 4: Mass balance of lab-scale sago flour production.

Proper development of a processing system employing the right technique promises a big potential of higher degree of yields than already achieved in the study carried out.

3.3. Quality

The ash contents of tested sago flour samples are displayed in Table 2. The values are low and similar to industrial grade (by referring to SIRIM standard [10]). Low ash content was observed in the produced sago flour and this indicated that the quality was good and comparable to sago flour in the market. The values are also consistent with the findings by Fasihuddin et al. [13] that had tested sago starch samples of varying origins and of both food and industrial grades. Furthermore, as included in Table 2 for comparison, the values are in accordance to the specifications set by SIRIM [10]. Ash content is a commonly used index in flour refinement; showing the quality of the product [14]. Ash is present in all starches and consists mainly of salty, inorganic constituents which normally originate in the crop or from the water used in starch processing [13].

Table 2
Ash content of sago flour samples (average value)

Sample	Sago flour[a]	Sago flour[b]	Sago flour[c]
Ash content, %	0.18	0.12	0.2

[a] by Technique 1
[b]by Technique 2
[c] SIRIM, 1992.

There are other methods of determining ash content, other than the oven/furnace method specified in this study. *Branscan*; an online equipment developed using image analysis technique was claimed to be able to determine the quality of flour in every stream of a flourmill [15]. It measures the quantity of bran specks and correlates the result with ash content [16]. The reliability of this piece of equipment has yet to be verified to convince plant operators to apply it in the industry, yet it is still dependable for analysis of flour refinement. Another option is the online Near Infra Red (NIR) technique that has been used widely by researchers and industrialists due to its rapid measurements [17]. It was suggested however that the accuracy is checked regularly against laboratory reference measurements [18]. Even though both techniques are mostly used in studies on wheat flour, there is excellent prospect of their application in future research on sago flour, so as to obtain more accuracy in the determination of ash content.

CONCLUSION

Sago flour was successfully produced in a laboratory-scale operation using two techniques in the main unit operation of extracting sago starch. Grinding or blending aided by water worked reasonably well in producing end product of improved quality and yields. Via this technique, approximately 25.76 % of the starches in the debarked sago pith has been recovered and turned into sago flour. The second technique which is grating followed by mechanical squeezing gave lower yield of only 13.48 %. This reduction might be caused by absence of water in the dry grating process. Water addition was observed as a hugely important element in the extraction process as it helps dissolve and release the starch granules. The flour produced also exhibited lower content of ash; indicating better quality. Thus, a conclusion could be drawn that the most ideal technique of extracting sago starch is by integrating grinding with controlled amount of water and mechanized squeezing into one unit operation. This would result in a more efficient operation in terms of production yield, time consumption and also hygiene aspect. Labor and energy requirements could also be reduced reasonably owing to the fact that a few separate steps are combined into a single unit operation. Improvement on the whole processing system may take time to be accomplished yet is worth all the efforts seeing that sago production is still one of the most important industries in our country.

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