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# Improvement of the Traditional Sago Starch Processing in the Philippines Through Mechanization

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**Abstract** Sago (*Metroxylon sagu* Rottb.) is widely grown in the Philippines in waterlogged areas or near creeks and water embankments. The utility of the crop varies. Leaves are formed into shingles and used as roofing materials; leaf stalks are dried and used as firewood or fence material; the bark is dried for fuel wood; and the pith is extracted with the starch, roasted, and sold in the market in a dried and crumbly form that can be processed further into various foods. The traditional method of starch extraction requires at least 22 steps beginning with the harvest of the logs. It involves knife-stripping, drying and series of hand pounding and subsequent screening to reduce the size prior to sedimentation. The whole process is tedious and time-consuming. Processing one whole sago log is estimated to require 10-12 man days and 5 to 6 days to completely extract the starch. The entire process was studied, and a sago-pith grating machine was developed.

The developed grating machine eliminates the bottlenecks of the traditional starch extraction process, namely; knife-stripping, sun-drying of the stripped pith and repeated hand pounding and subsequent screening of the powdered pith. The number of steps in the traditional starch extraction process was reduced by as much as 50%. Splitting the sago logs into quarters is required prior to sago-pith grating. About 60-65 seconds is required to split a 32-cm diameter x 50-cm length sago log into four pieces. Only one person is needed to operate the machine with a grating capacity of 155 - 180 kg/hr depending on the skill of the operator. The parts of the machine utilized local and commercially available materials for easy repair and maintenance.

**Key words:** sago starch extracting process, grating machine, Philippines

# フィリピンにおける伝統的サゴヤシ澱粉プロセシングの機械化による改良

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**要約**　サゴヤシ（*Metroxylon sagu* Rottb.）は，フィリピンの多くの地域の湛水している地帯あるいはクリーク・堤防周辺などに生育する作物の一種である．サゴヤシの葉は編んで屋根葺き材に，葉軸・葉柄は乾燥して薪やフェンスの材料に，樹皮は乾燥して燃料に，髄から澱粉を抽出し，抽出した澱粉はデザートなどに利用できるように加熱乾燥して粒状にし，市場で販売している．フィリピンの伝統的なサゴヤシ澱粉抽出は，ログ採取から少なくとも22工程を必要とする．斧で樹皮を剥ぎ，乾燥し，一連の手作業によって澱粉を含む髄繊維を取り出し，水洗しながら布を用いて澱粉を絞り出し，澱粉を水中で沈積させるものである．全工程には長時間を要し，一本のサゴログ全体から澱粉を抽出する

には，10-12日・人で，すべての澱粉抽出工程を完了するには，5あるいは6日が必要である．開発した破砕機は，斧による樹脂剥ぎ，髄の天日干し，手作業による澱粉を含む髄繊維の取り出し，髄繊維からの澱粉の絞り出しのような伝統的サゴ澱粉抽出の障害を解消するものである．この破砕機は，伝統的なサゴ澱粉抽出工程を50％低減させた．直径32 cm，長さ50 cmのログを4つ割りにするのに60-65秒かかるが，一定の破砕技術を持つ技術者であれば，155-180 kg/hrの破砕能力を持つこの破砕機の操作には一人で十分である．簡単な修理やメンテナンスに必要な破砕機の部品は，地方でも市販されているものである．
**キーワード：**サゴ澱粉抽出プロセシング，破砕機，フィリピン

## Introduction

Sago palm (*Metroxylon sagu* Rottb.) is an underexploited crop in the Philippines. Traditionally, it is a source of starch in many native foods, such as "*landang*," "*suman*," "*palagsing*," and "*nilidgid*," which are very popular in the rural areas where sago palm is grown. However, there are other sources of starch (e.g., buri palm and cassava starch) that can substitute sago starch in the preparation of some native delicacies. An interview with the sago processors in the Visayas indicated that consumers prefer to eat foods made from sago starch rather than from substitutes. Despite consumer preferences, the cultivation of sago palm in the country is not as widespread as that of coconut. Moreover, the uses and importance of sago starch are not well understood and appreciated in the Philippines.

Other Asian countries, such as Japan, Indonesia, Thailand, and Malaysia, have carefully studied the physicochemical properties of sago starch. Fashihuddin and Williams (1998) reported that the amylose content of sago starch was 27% and the average particle size was around 30 $\mu$m, values which are very similar to those of potato starch. In addition, its swelling and solubility increase with temperature at a magnitude similar to those of potato and tapioca starches but higher than those of maize and pea starches. Sago starches generally have better freeze-thaw stability than other starches. Furthermore, sago foams are more biodegradable (NSTQ, 2001). Owing to the superior physicochemical properties of sago starch, it has a high potential for various uses. Aside from food product preparations, sago starch can also be used in various applications, such as adhesives, biodegradable plastics, pharmaceuticals, and cosmetics. It may also be used industrially for products such as tablet binders, calamine lotion, hand cream, make-up bases, shampoo, shaving cream, toothpastes, eye shadows, ointments, and pesticide emulsions.

The potential for sago starch is so great that it should not be ignored. However aside from the utility of the starch, the method of extraction is also important. Traditional methods include pounding the trunk after the tree palm has been cut into pieces. This method is time consuming and requires a lot of energy before the starch can be extracted from the sago palm. The inefficiency of the process produces low yields and a poor quality of starch. To overcome these deficiencies, this study attempted to determine how mechanization can be used to improve the traditional method of sago starch processing.

## Methods

### Traditional starch processing

There are many ways of extracting sago starch, but there are also similarities among countries where sago starch is processed. Tribal groups, such as the Asmats and Biduyah, normally process it by felling the trees, debarking it with an ax and stick, and pounding the pith. The crushed pith is continuously splashed with water until the starch is extracted. In the Philippines, the traditional method of starch extraction requires at least 22 steps, starting with the selection and harvest of the logs (Fig. 1). It involves knife-stripping, drying, hand-pounding, and subsequent screening, which is used as a process of size reduction prior to sedimentation. The whole process is tedious and time-consuming. One sago log is estimated to require 5 to 6 days to complete the starch extraction process employing as much as 10-12 workers for the duration.

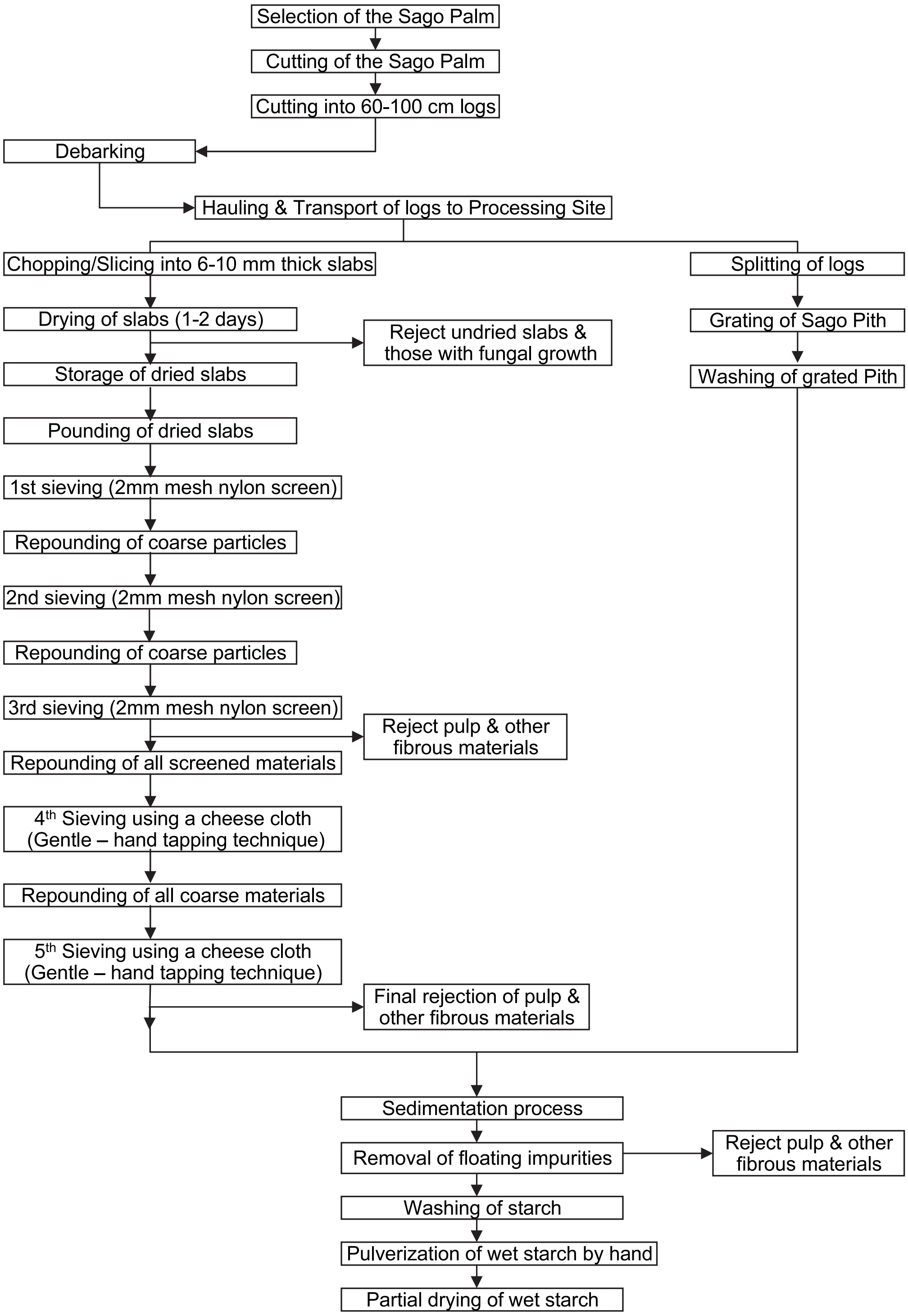


**Fig. 1.** Flowchart showing the traditional starch processing (left column) in the Philippines and the improved method (right column) with the developed grating machine. (Loreto and Quevedo, 2004).

Points of mechanization

Analysis of the traditional process revealed that there are two major bottlenecks of starch extraction, namely, a) sun-drying of the pith slabs, which is entirely dependent on the weather, and b) size reduction of the dried slabs in which pounding and screening are repeated at least 5 times to obtain the starch. These two aspects were studied, and an effort was made to determine whether mechanization would shorten or improve the process. An interview with the sago starch processors revealed that drying has two important results, namely, a) the dried pith slabs can be stored for several days prior to pounding; hence, it does not require that the sago starch be immediately extracted, b) pounding the dried pith slabs can be done at home, which permits the processors to attend to family chores, such as cooking and child care (Loreto and Quevedo, 2004). However, while these can be an advantage to the processors, it can also be a disadvantage because numerous pith slabs are discarded as a result of incomplete drying and subsequent fungal growth, creating major losses. Therefore, the two areas in which mechanization is important are size reduction and starch extraction.

Two methods of size reduction were considered: a) using an attrition mill on dried pith slabs, and b) developing a grating machine for fresh pith. The latter was considered because the use of a grating machine would hasten the size reduction of sago pith and possibly eliminate the need for the drying process.

Development and description of the machine

Prior to the development of the grating machine, the design criteria were established. It requires locally available food-grade materials and higher capacity and efficiency than traditional methods, and it must be economically feasible for a group of processors to own, maintain, and operate.

The machine has four main components: a) a frame, b) a cylindrical blade frame, c) blades, and d) a power unit and transmission. It uses a 38 x 38 x 6-mm angle bar as the framing material, a 10-mm thick stainless steel plate for the cylindrical blade frame, 1.6-mm stainless steel sheets for its cover, and 10-mm diameter bars to support the blades. The blades were fabricated from 1.6-mm stainless steel sheets, perforated to serve as cutters, and case-hardened to withstand the fibrous materials that are incorporated in the pith (Fig. 2).

## Results and discussion

Test and evaluation of the machine

The machine was evaluated with 2 different blade speeds (730 and 875 rpm) and 2 blades with different distances between the perforations (10 and 20 mm). Sago palms were gathered from Brgy. Tigbao, Dulag, Leyte. The palms were selected based on the

(a) (b)

**Fig. 2.** Prototype of the developed sago-pith grating machine (a) and the grater blade during operation (b).

indigenous techniques of the rural residents for determining the appropriate maturity of the harvestable sago palm. Results showed that the grating capacity (kg/hr) of the machine is affected by the rpm of the blade (Table 1). The capacity using the blade with 10-mm spacing was 39.08 and 32.91 kg/hr at 730 and 875 rpm, respectively. On the other hand, the capacity using the blade with 20-mm spacing was 153.09 and 180.37 kg/hr, respectively. The capacity when using the blade with 10-mm spacing was attributed to the space between the perforations. At higher rpm, the blades did not grate well but, rather, tended to push the pith away from the perforations as a result of the centrifugal force. In addition, at high rpm, the operator had more difficulty pushing the sago pith against the blades than he did at lower rpm. The grating capacity of the 20-mm blade is directly proportional to the rpm. A test at rpm values higher than 875 was conducted; however, there was too much vibration, which presented a hazard to the operator.

**Table 1.** Capacity (kg/hr) of the sago grating machine as affected by the rpm of the blade and the distance between the perforations in the blade.

| Blade rpm | Capacity (kg/hr) | |
|---|---|---|
| | 10 mm blade | 20 mm blade |
| 730 | 39.08 | 153.09 |
| 875 | 32.91 | 180.37 |

The fineness modulus (F.M.) of the grated sago pith was also determined. The F.M. indicates the uniformity of the grind in the resultant product. A lower F.M. value indicates a finer product. Theoretically, a more finely grated sago pith makes it easier to extract the starch from the pulp. The F.M. of the grated sago pith ranged from 2.12 to 2.87 (Table 2). The trend with a blade-perforation distance of 20 mm indicated that a higher rpm resulted in finer grated particles. However, this was not true with the blade with 10-mm spacing. Similarly, this was attributed to the centrifugal action of the perforations against the sago pith.

After grating, the starch was extracted from the grated material by washing with tap water and using a cheese cloth as the primary screening material. The pulp was extracted twice with a 200 mesh Tyler sieve as the final sieve. Crude fiber analysis of the extracted starch samples revealed that the traditional method and the blades with 10- and 20-mm spacing between perforations yielded values of 3.2-4.8, 0.7-3.2, and 0.4-1.10, respectively. These findings indicated that the traditional method of starch processing results in a high percentage of fiber remaining in the extracted starch, which is attributed to the sieve and the process used. On the other hand, using the blades with 10-mm spacing between perforations resulted in a higher amount of crude fiber in the starch than that obtained when the blades with 20-mm spacing were used. These results can be attributed to the fineness modulus, as the blades with 20-mm spacing between perforations resulted in finer grates than those with 10-mm spacing.

**Table 2.** Fineness modulus and average size ($\mu$m) of the grated sago pith as affected by the rpm and the distance between the perforations in the blade.

| Blade rpm | Fineness Modulus | |
|---|---|---|
| | 10 mm | 20 mm |
| 730 | 2.737 (694 $\mu$m) | 2.684 (669 $\mu$m) |
| 875 | 2.871 (761 $\mu$m) | 2.126 (454 $\mu$m) |

Implications of the machine

The grating machine appears to be significantly better than the traditional process of sago starch extraction. The number of steps in the traditional process can be reduced by as much as 50% when using the grating machine shown in Fig. 1.

Also, using the grating machine will enable the processors who continue to dry the sago pith prior to extraction to dry the grated pith in less than 2 days. This is possible because the product being grated has more surface area exposed to the sun hence, dries faster.

## Conclusion

There is still room for improvement of the developed sago grating machine. It could be tested with different blade configurations and rpm's to determine the optimum operating conditions to recover a higher percentage of starch. A Surface Response Analysis could be conducted to determine the best operating conditions for the machine. The use of the grating machine would definitely improve the traditional method of sago starch extraction in the Philippines.

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