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Mechanical process for flour extraction from Kithul (*Caryota urens*) bark: Cost effective and product quality consistent approach

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Abstract
Development on Kithul flour processing was examined by researching possible replacement of existing system. Preparation of crude Kithul flour was initiated by extraction of Kithul starch from the pith. In this study, the extraction was carried out using different techniques as manual and mechanical processes, in order to identify the most ideal with the sense of the feasibility and efficiency. Mainly three parts has designed as grinder, sifter and dryer. The flour extraction was carried out using three Kithul palms Time and cost for each process was recorded as mean of triplicates. According to the calculations newly designed mechanical process has 10% ability of recovery yield than existing manual process. It could reduce the production cost per Kilogram by SLR.250 and it was three times reduction of production cost than manual process. Newly designed mechanical process was effective three times than existing traditional extraction based on time factor. Based on the findings thus far, integrating grinding with mechanized squeezing seemed an excellent proposition. Labor requirements could also be reduced reasonably because few separate steps are combined into a single unit operation. At the same time mechanical processing has the potential to inspire the economy and encourage the use of local resources.

Keywords: Kithul (*Caryota urens),* mechanical process, flour extraction, starch, pith

Introduction

Flour is a better raw material which has broad capability to move about wide variety of uses [1]. It is mainly applied as taste enhancer, thickener, binder, and filler [1, 2, 3]. Further it acts as stabilizer, edible film former in food industry [4], and also used to produce adhesive, agro-chemicals, cosmetics and toiletries, detergent, paper making additives, pharmaceuticals, paints, textiles, water purification agents, and biodegradable plastics [5, 6].

Palms are proper source for starch production [7]. Modern scientist pay their keen attention to discover novel sources of starch, which exist in the wild. Kithul (*Caryota urens*) is a better invention, which is still keep as semi-wild species [8]. This palm is native for tropical Asian countries specially for Sri Lanka and India [9]. According to the Rajalakshmi (2004) quality of flour from *Caryota urens* to be equal to the best sago of commerce extracted from *Metroxylon sagu rottb* [8]. Because of the high necessity due to number of industrial applications, a huge demand on few well-known starch sources. Therefore it is creating requirement on new sources for the continuous supply as commercially viable starch.

Kithul flour processing can be characterized as a process industry, since it transforms a raw material (*Caryota urens* or Kithul palm) through a basic process, into a product (Kithul flour) that is of value to consumers. Kithul flour preparation is still remaining as manual process using number of unit operations in very un-hygienic manner, thus, food engineers should make improvement in the processes or to the unit operations with the sense of food safety.

The traditional way of producing Kithul flour in rural areas in Sri Lanka, is, by pounding the pieces of pith in a mortar with a pestle, wash with water with a screen and sundry the remaining flour. However it can no longer meet the demand for the requirement in food industry as qualitatively and quantitatively. There are bundle of hygienic problems with this traditional process. Villagers just use normal home environment, and ground floor for this flour preparation and drying purpose which cause to addition of much adulterant especially sand, dust [10] and foreign matters. Contamination of flour due to multi-steps nature of the open-area, particularly in non-specialized production processes [11].

In the traditional, flour making process, the flour tends to become clumpy and moldy within a short time period, after preparation which leads to short shelf life of the flour. In contrast, flours that are produced by a practice with hygienic methods have a much longer shelf-life [11].

The next highest problem with the traditional methods for making flour is the labor-cost. On the other hand the labor force will soon be insufficient to do the traditional processing, if it start in mass scale [12]. Especially villagers who are engaged with Kithul industry (basically treacle and jaggery production) in rural area are reducing due to they are being encouraged to gain an education. Consequently, the processing and production tasks will be shortened.

The aim of the work reported herein was to undertake a development of effective and hygienic mechanical process to extract from Kithul (*Caryota urens)* bark which leads to produce high yield in compromise with quality to full fill industrial requirements.

2. Materials and Methods

Three Kithul palms as two non-tapped and one tapped which were from Kurunegala and Kandy area in Sri Lanka were in the form of fallen and split in to blocks of the same Kithul bark with the same size (Length 2' and diameter:2' ½'').Three blocks from each palm were used for both extraction methods as manual and Mechanical. Different manpower, the cost, time and the quantity or collected flour of both processes were recorded.

2.1 Existing manual extraction (Used by Villages)

Pieces of pith were removed (Heartwood pulp) and pounded it thoroughly in a mortar. Then, a pot is filled with water and a clean cloth is tied to its mouth. After the crushed pith is mixed with water and allowed to strain through the cloth to the pot. The flour settled at the bottom of the pot and the water skimmed off. Finally, the flour was put in the sun to dry. Weight of the dried flour samples (dried up to 10% to 15% moisture level) were taken.

2.2 Mechanical extraction

The machine consists of three basic parts: grinder, sifter and dryer. Before producing good quality flour from the designed machine, some modifications were made to the first design. Big Pieces of pith were crushed by grinder. Then, the sifter is filled with an appropriate water level and crushed Kithul pith (volume 2:1). After the crushed pith is mixed with water by stirrer allowed to strain through the mesh. The flour settled at the bottom of the pot and the water skimmed off by tap. Finally, the flour was put in the trays of dryer to dry. Temperature of the dryer is maintained by fiber as economical materials which can be collected as by product from sifter operation. Air circulation in the dryer is efficient by using very low energy (0.25 hp) fan. Kithul flour is dried up to 10% to 15% moisture level.
Efficiency calculation was done according to Table1 and Table 2 and the calculation according to the section C.

2.3 Final calculation of the two processes

a. Depreciation cost of machine**:** Total value of machine = R
Recommended time period for depreciation = 3 years

Depreciation rate per hour= LKR (R/ (3*365*24)) =S …….(1)

b. Total Cost for flour preparation by Machine= (P)+ ((I+J+K)*S)………………………………………….(2)

c.

$$\text{Recovery yield\%} = \frac{\text{Wight of total end product}}{\text{Wight of total input of raw material}} \times 100 \quad \text{….(3)}$$ [13]

d.

$$\text{Efficiency of mechanical process \%} = \frac{\text{Difference between variable}}{\text{Value of the relevant variable for Manual process}} \times 100\% \quad \text{...(4)}$$

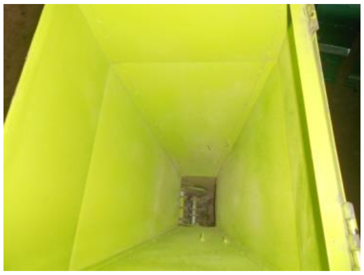
3. Results and Discussion

3.1 Machine design

The developed mechanical process consists of three basic mechanical parts: grinder, sifter and dryer.
Part A, Grinder (Fig.1), which grinds the big pieces of pith into pulverized parts. There are two feeding points as the top feed point (Fig.1, B) with 44.5 cm x 38 cm size and arm feed point (Fig.1,D) with 38 cm length. The purpose of two openings for feeding is to feed two sizes of Kithul bark pieces as more convenient to use. Because of lots of fiber in the Kithul pith practical problems occurred when the blades of the grinder blocked with fibers. To remove those there is a small door in the rear side (Fig.1,C). Front outlet (Fig.1,E),which can be covered with polythene bags to collect the crushed materials.
Motor, which supply the energy to this grinding process used 2.2 kW (3 hp). Drawing of the grinder is apparently figured out the inside arrangements (Fig.2).
The second part (Part B) is a flour sifter, which separates the flour from fiber parts and other pith materials. After various sifters that were tested, and finally, two pore sizes had been selected as 354 µm (45 mesh) and 149 µm (100 mesh) which is a relatively simple, two-screen design to get the best recovery yield and fine flour particles. To get maximum flour content from the fibrous part, it is better to re-process the part of sifted flour using a small mesh (149 µm). Stirrer (0.88 kW) with 800 rpm (with load) is provided better rotation to mix flour with water as it's easy to pass through the sieve (Fig.3, B). Remaining fibrous part does not contain more wastage in this process.
Because, dried fibers can be used as fuel for the dryer (part C). Removable stirrer (Fig.3,C) and two buckets (Fig.4) are very easy to clean which provides the provision to keep food hygienic conditions.

Part A: Grinder

A) Grinder (Front Elevation)



B. Top feeding point

D. Arm feeding point

C. Fiber removal door(back side)

E. Front outlet

Fig 1: Parts of the grinder

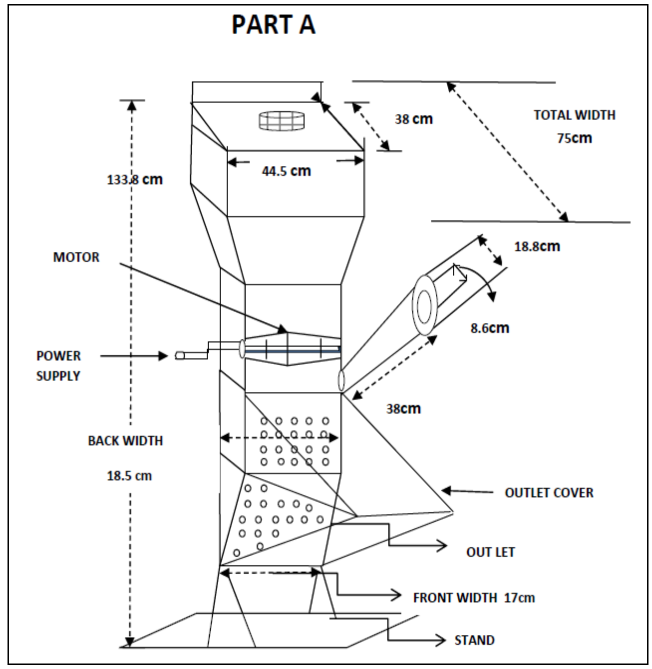


Fig 2: Drawing of the grinder

Part B : Sifter

A. Front elevation of Sifter

B. Inside of the sifting bucket

C. Removable stirrer

Fig 3: Parts of Sifter

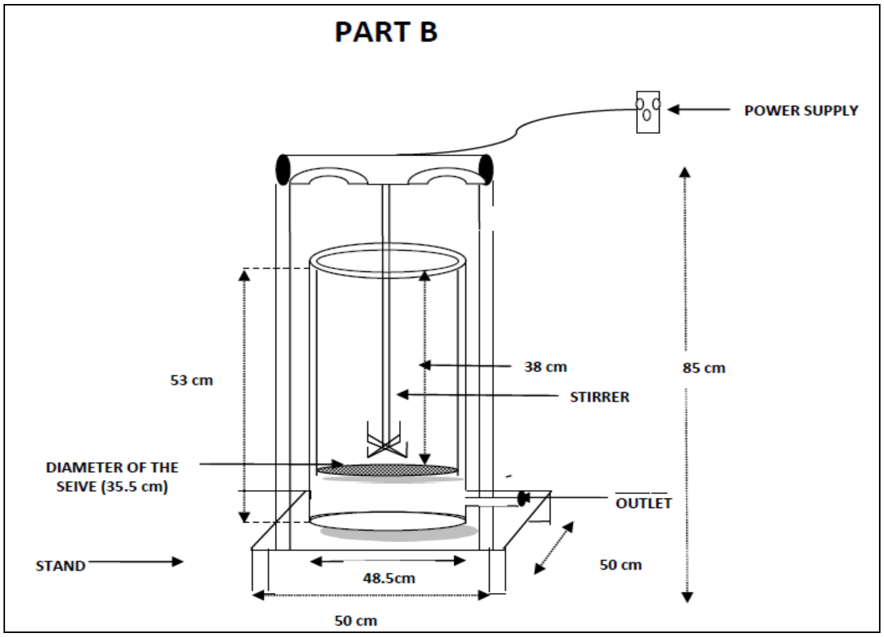


Fig 4: Drawing of Sifter

The third part (part C) is a dryer, which is design to run with low power motor 0.18 kW (0.25 hp).The motor supplies the power to the fan that increase the efficiency of removing moist-hot air from the top of the dryer. The interesting point with the dryer is the dried pith fiber (which is wastage of part B) could be used as fuel to generate the heat. Apart from that wastage of sifter that comes with water can dry using this dryer too. So this dryer is very economical to introduce for home scale flour production too (Fig.5, 6).

Part C: Low cost Dryer

C. Fiber removal door(back side)

A. Front elevation of Dryer

D. Arm feeding point

Fig 5: Parts of dryer

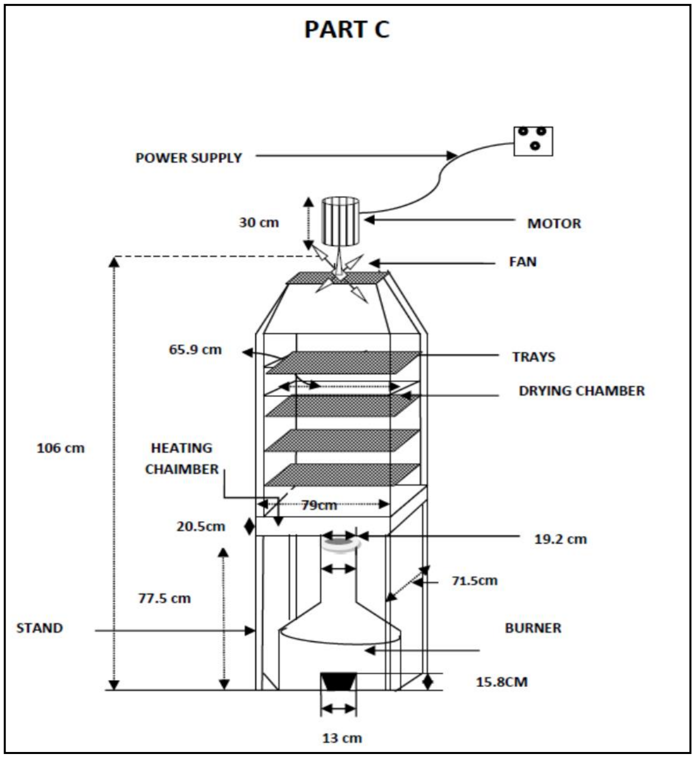


Fig 6: Drawing of the dryer

3.2 Comparison of the effectiveness of two processes

Through repeated testing with different blocks of the same Kithul bark with the same size (Length 2' and diameter: 2' ½'') in different manpower, the cost, time and the quantity or collected flour of both processes were recorded.

Table 3: Comparison of the effectiveness of two processes

Variable	Manual process (MN)	Mechanical Process (MC)
Recovery yield%	35.83 ±6.29^{a}	45.28 ±1.73^{a}
Total production yield (kg by bark volume of 0.0225 m^3)	2.15 ±0.377^{a}	2.72 ±0.104^{a}
Total man Power (hrs)	6.50 ±1.26^{a}	2.17 ±0.14^{b}
Total Cost (LKR)	793.10 ±130.70^{a}	338.21 ±6.71^{b}
Total time (hrs)	21.76 ±1.67^{a}	9.08 ±0.53^{b}
Cost per kg (LKR)	370.08 ±41.4^{a}	121.25 ±9.77^{b}
Time per kg (hrs)	10.00 ±2.64^{a}	3.25 ±0.29^{b}

Data are the average of three repetitions ±standard deviation. The values in a raw flowed by the same letter are not statiscally different at a significance level of 5%.

Ineffective extraction steps had an adverse effect on production yield since it depends greatly on the sophistication of the methods employed [14]. In this study, two methods were analyzed on the production yield; it was observed that the technique of grinding aided by mechanical force was the better option in giving more efficient pulverization of the Kithul bark (Recover yield increased by 10%). The starch granules existing in the pith were moved into the water and subsequently released when it was blended by the stirrer. According to the results obtained there was no any significant difference (P>0.05) among recovery yield or total production yield (Table 3).Although the mechanical process showed little bit higher recovery yield as approximately 10 kg greater than the manual method. Hence, the present values for small-scale production, as this difference will be significantly affected on the yield. Another observation was the manual method showed higher standard deviation (6.29) than mechanical method (1.73) when presenting the variation of the effectiveness of the manpower.

The mechanical process had produced 0.57 Kg of more flour than the manual process that would be a considerable amount of the mass scale production. The lower yield in manual method perhaps remaining with the starch among fibers and the pounding was not sufficient, and water extraction step has not given effective force to disintegrate the starch granules remained trapped within the parenchyma cells [13]. In manual filtration by hand, would not allow all starch liquid to be effectively squeezed from the pith fibers. Hence mechanical force was given a considerable contribution to recover the yield than the manual method.

There is huge variation among the required manpower among these two process as expected. Manual process required 4.33hrs than the mechanical process that will be the highly effective point in the mass scale (Fig.7). Labour requirements could also be reduced reasonably because a few separate steps could be combined into a single unit operation [13].

Total cost and cost per unit were showed the attractive difference as mechanical process reduced the unit cost around by LKR 250.00 (Table 3) and it means to mechanical process is three times cost effective than existing manual method. Base on time factor proposed mechanical could reduce production time per unit by around 6.75 hrs.Hence mechanical process efficient by three times than existing manual flour extraction method.

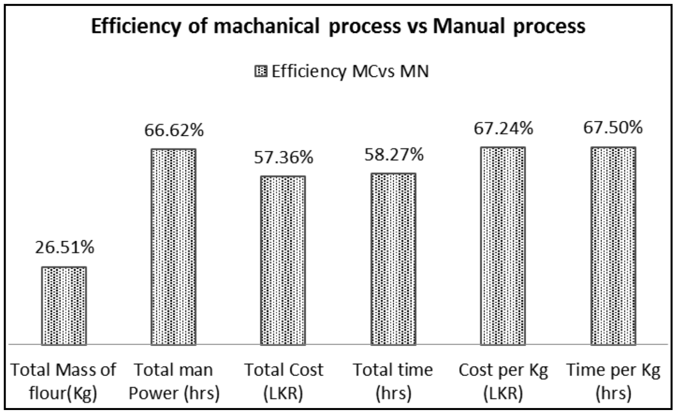


Fig 7: Efficiency of Mechanical process vs Manual process

Comparison of efficiency in these two processes were exhibited positive values to powered the mechanical process (Figure 7).Total mass of flour was increased by 26% while manpower was replaced around 66%. This new Methodology could reduce the total cost by 57% while total time reduction was marked as 58%.As it takes as a summary the flour extraction cost and time per unit using this mechanical process is efficient by 67% than existing manual process which directly effect on productivity.

In practice, some conditions may differ from those assumed in the foregoing. For example, efficiency of man power depend on gender, time of the day, mental situation of them etc [15]. At the same time drying process will be taken various time and man power due to sun-drying totally depend on the climatic changes. Hence in the rainy season it is not suitable for the preparation of flour by manual method due to higher moisture in atmospheric leads to mold attack.

Sanitary conditions are needed for production of any food or raw material of food flour. The building used for the operation need to have a masonry floor and walls and was screened to keep out birds, rats, and other vermin according to the ISO standards [16]. Raw materials and products were so handled and stored as to minimize opportunity for contamination. However mechanical process was more effective than the traditional flour extraction, in terms of sanitation sense [17]. It was stated the same idea by Kamal *et al.* (2007) for sago flour extraction. During the traditional extraction, each and every step has food hygienic risk because of not only whole process conducted by untrained (For food safety concept) manpower but also processing area basically home garden (open area) of villagers which is not hygienically controlled.

The current society in the world more concern on eco-friendly production process which release minimum wastage and lowest pollutants. This process will be a positive answer for environmental friendly with waste water (which from part B of the machine which only contained antioxidants) and ash (from part C, the dryer).

4. Conclusion

Based on the findings thus far, integrating grinding with mechanized squeezing seemed an excellent proposition. Labor requirements could also be reduced reasonably because of few separate steps are combined into a single unit operation. By taking into account of all these considerations, mechanical process could be introduced as low cost operation comparable with manual method with better recovery yield of flour, which has increased by 10% at a time in effective manner which gain more profit for both manufacturer and customer. Efficiency of Mechanical process vs. Manual process on both cost and time factor is around 67%,which will beneficial to direct the Kithul flour industry into global market. Improvement on the processing system may take time to be accomplished which leads Kithul flour production as one of the most important industries in Sri Lanka.

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6. Reference

1. Mengistu SL, Shimelis AE. Evaluation of the Physico-Chemical Properties of Ethiopian Maize Variety (Bh-660) For Dextrose Production. Journal of Food, Agricultural Nutrition and Development. 2012; 12:6503-6516.
2. Radosavljević M. Cornstarch as an important renewable resource. Maize research Institute, Zemun Polje, Belgrade-Zemun, Yugoslavia. 2002; pp. 23-31.
3. Sprague GF. Corn and corn improvement' (2nd ed.). Madison, Wisconsin, USA. 1979; pp.721-732.
4. Krisztina RV. Starch bearing crops as food sources, cultivated plants, primarily as food sources. 2009; 1:42-66. ISBN: 978-1-84826-100-6 (eBook) (http://www.eolss.net/Eolss-sampleAllcharecter.aspx)visited on 2013.10.02)
5. Zehr BE, Eckhoff SR, Singh SK, Keeling PL. Comparison of wet-milling properties among maize inbred lines and their hybrids. Cereal Chem. 1995; 72:491-497.
6. Shimelis E, Meaza M, Rakshit S. Physico-chemical properties, pasting behavior and functional characteristics of flours and starches from improved bean (*Phaseolus vulgaris* L.).CIGR E Journal of Agricultural Engineering International. 2006; 8:1-19.
7. Ishizuka K, Hisujma S, Darryl RJ, Macer. Sago palm, a promising renewable carbohydrate resource, a material for environmental conservation and sustainable development. In: Proceeding of the international seminar on traditional technology foe environmental conservation, development in the Asia- Pasif ic region, UNESCO, Tsukuba science city, Japan. 1995; pp. 75-76.
8. Rajyalakshmi P. *Caryota* palm sago O A potential get underutilized natural resource for modern starch industry Naturakl product redience. 2004; 3(3):144-149.
9. Wealth of India. A dictionary of Indian raw materials and industrial product Vol.3, Council of Scientific and Industrial Research, New Delhi Publications and Information directorate. 1992; 3:321-324.
10. Wijesinghe JAAC, Wickramasinghe I, Saranandha KH. Deviation of Chemical Properties of Kithul (*Caryota urens*) Flour Obtained from Five Different Growing

Areas in Sri Lanka. July 2015, International Journal of Innovative Research in Technology. 2015; 2(2): 67-76. ISSN: 2349-6002

11. Eastman P. End to pounding: a new mechanical flour milling system in use in Africa' Ottawa, Ont., IDRC, 1980. 64 p. ill., International Development Research Centre Postal Address: Box 8500, Ottawa, Canada KIG 3H9, 1980.
12. Williams SW, Rathod KL. Case Study of Expeller Production of Soybean Flour in India', 1974. http://pdf.usaid.gov/pdf_docs/PNAAA649.pdf.
13. Kamal SMM, Mahmud SN, Hussain SA, Ahmadun FR. Improvement on sago flour processing. Int. J. Eng. Technol. 2007; 4:8-14.
14. Cecil JE. Small-, medium- and large-scale starch processing. FAO Agricultural Services Bulletin. 1992; 98.
15. Nwaigwe KN, Nzediegwu C, Ugwuoke PE. Design, Construction and performance Evaluation of a Modified Cassava Milling Machine. Research Journal of Applied Sciences, Engineering and Technology. 2012; 4(18):3354-3362, 2012,ISSN: 2040-7467
16. ISO 22000:2005. International standard for food hygiene.
17. Mohd NA, Kelvin Lim, Eng-Tian KL. An Evaluation Of The Quality Of Sago Starch Produced in Sarawak, Malaysia, *Proceeding of the Fourth International Sago Symposium*, Kuching, sarawak, Malaysia. 1991; pp.149-152.