Optimized Design and Development of a Coconut Meat Extraction Mechanism after Weighing the Cost and Benefit to the Environment

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Abstract. The aim of this research was to enable easier access to the food value of coconut for humanity. There was a span of time from the 1950s-1990s where much media coverage discouraged the consumption of coconut, even though it was used in the West since the 16th century. This started due to the supply cut off during WW2, thereby Western researchers had to enable humans to consume corn and soybean oil which had become an established industry by the end of WW2. Therefore, propaganda was used to defame coconut oil. The main argument was that coconut oil has a high percentage of saturated fats, neglecting the fact that a huge sample of humans in Asia have been consuming it for millenniums. Later Western researchers realized that the balance between LDL and HDL is more important and coconut has a good balance. This caused a resurgence in consumption. The biggest problem with coconut is accessing the coconut meat through the hard husk and shell. Therefore, two setups were designed and developed in this work. The first setup enables cutting the coconut fast with utmost safety and environmental benefit and the second setup enables grinding out the coconut meat.

1 Introduction

Many have realized the advantages of coconut and some philanthropists have even started growing coconut in fallow lands. Studies have found that growing trees can rejuvenate the water cycle and many groups are planting trees to bring back drying rivers systems. This is because they form part of the riparian zones where their extensive root system strengthens the soil providing a solid bank which will prevent silting into the river. Without this strength of soil, water will just seep underground [1]. Growing coconut trees will help in this aspect plus provide valuable nutrition to the humans near the trees. This author's home area is one where philanthropists grew coconut trees in all fallow lands in the housing estate. But most

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coconuts are not utilized because of the high human strength and skill needed to slowly tear apart the husk. There are coconuts which fell to the ground all over the housing estate with no takers.

To solve this problem, two innovations were developed in this research. The coconut must be grinded with a wall cutter fitted with a wood cutting blade. But this will cause fine dust to go all over the surroundings and even in the human's eyes. Therefore, a workbench must be built that is low enough such that the dust does not reach the human eye. The coconut must be held in place because it is very dangerous to cut a coconut with a grinder blade that turns at 13,050 RPM. A coconut with husk can easily slip off a human hand. Initially a vice which can hold the average coconut was acquired. Then a small work bench was built to fasten the vice on. This workbench must be movable; therefore, wheels were welded to the base of the workbench. This way the whole cutting of the coconut can be done near a tree or plant which can utilize the dust exhausted as fertilizer. If the cutting of the coconut was done on a cemented floor, the whole area needs to be cleaned which will utilize quite a lot of water. This will make it unattractive for others to use it. The wheels at the bottom of the workbench needed to be big but the biggest available was not chosen because it would increase the cost and weight of the whole system. Reasonably big wheels are needed because the whole workbench needs to be moved over uneven terrain to be near a tree or plant. The workbench must also be made sturdy via welding more steel members as the uneven or sometimes muddy terrain is common near a tree or plant. The system built is shown in Fig. 9. Three handles (the silvery ones in Fig. 9) were also installed on the workbench to help move it over the non-flat land near a tree or plant. The vice must be retracted before moving the workbench or else the center of gravity will not be right, and the workbench will tip over. A face shield can be used while cutting the coconut but is not necessary since dust generated tends not to reach the height of the human eye. The next innovation was to build a system to grind out the meat from the coconut. The system built is shown in Fig. 10.

But all this effort of making it easier to extract food value from coconut must have a justification. Therefore, the justifications were studied. Unrefined coconut oil which does not go through any heat of chemical process has been used for human consumption for millenniums in India, and Southeast Asia [2]. Unrefined coconut oil provides HDL (high-density lipoprotein); which is beneficial for humans and low levels of LDL (low-density lipoprotein); which is bad for humans [3]. The total serum cholesterol in the human body is what causes clogged blood vessels and heart diseases. But HDL and LDL have the opposing effect on the total serum cholesterol [4]. These days, a medically accepted indiccation is the total cholesterol to HDL cholesterol (total:HDL) [5]. This measure indicates that saturated fats from coconut have a neutral effect on cardiovascular problems.

Unrefined coconut oil also helps the human body prevent inflammation, increases immunity, and reduces cognitive decline [6]. Oil fats have a structure shown in Fig. 1. Fig. 1 is a six-chain fatty acid. The three blue wavy lines at the bottom have a carbon atom at each sharp edge. This is the structure of caproic acid. The one with eight chains is called caprylic acid and the one with 10 chains is called capric acid. The 12 chains one is called lauric acid which forms 47% of coconut oil [10].

The MTC (medium chain triglycerides) which are the portion of coconut oil which has six to eight chains of carbon atoms forms 15% of coconut oil. MCTs can be absorbed directly into the bloodstream to provide energy as shown in Fig. 2. This flow chart also shows that the LTC which are the long chain triglycerides need to be broken down by the lymph system before it can go into the bloodstream and thereby be utilized by the body. MTCs increase the metabolism of the human body thereby enabling the removal of fat in the abdominal and legs which most older humans aim for [9].

Coconut oil has the shortest chain of carbon atoms among oils used by humans. Coconut also has 12,14, 16, 18, 8:1 and 10:2 structures within it. 8:1 means eight carbon chain with

one double bond between carbon atoms, similarly 10:2 means ten chain carbon atoms with two double bonds between carbon atoms [10].

90% of coconut oil is saturated which means there are single bonds between C atoms and a H atom on either side as shown in Fig. 3. Both coconut oil and palm oil need not go through hydrogenation to break it up for human consumption [11].

Comparatively unsaturated fats have one or more double bonds between the C atoms as shown in Fig. 4. Trans fats as shown in Fig. 5 occurs after the process of hydrogenation is performed upon the oils such that some double bonds and hydrogen bonds end up on the different sides of the chain. 'Trans' means across in Latin [12].

This process of hydrogenation is necessary for the consumption of long chain oils such as soybean and corn oil; humans cannot ingest such long chain oils; hydrogenation breaks up the chains. A solvent extraction process is used in hydrogenation, and the most common solvent used is hexane which is in the petrochemical family, making it similar to diesel used to drive cars. Once the hydrogenated oil is extracted, it must be desolventized using heat and pressure and hexane is extracted as a portion of the resulting steam [13]. Even after taking out the hexane, it is not edible. The soybean oil must go through a process of degumming, neutralizing, bleaching, winterizing, and dewaxing [14]. All this process provides the soybean oil with a mild flavor and high smoke point. But some hexane residue is still within the soybean oil. Also, the high heat and pressure in the presence of oxygen will result in the production of reactive oxygen species (ROS) which is very damaging to tissues and creates 95% of all human diseases. Besides the above problems, cooking oils from soybean and corn has a high level of polyunsaturated omega 6 which the human body needs in small amounts but beyond that, it becomes inflammatory to the body [15]. The omega 3 oils are anti-inflammatory in their natural state but when they are damaged by chemical tinkering, they become inflammatory [16].

Coconut oil is also a source of antimicrobial lipids which helps humans with deficient immune systems and is non carcinogenic and helps in treating some heart diseases. Bakers and food processors have independently realized the advantages of coconut oil in deriving the best products for ages [16].

2. Figures and tables

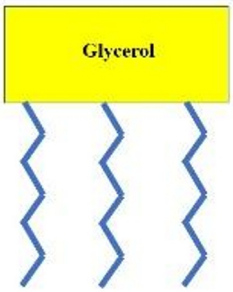

Fig. 1: 6 chain fatty acid (caproic acid).

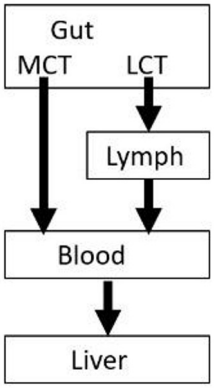

Fig. 2: MCT and LTC movement to the body.

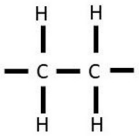

Fig. 3. Saturated fat.

Fig. 4. Unsaturated fat.

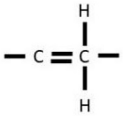

Fig. 5. Trans fat.

Fig. 6. Initial system where grinding was done next to a wall and on a cemented floor.

Fig. 7. the coconut just after cutting.

Fig. 8. Rebuilding the work bench with more steel members onto the workbench to increase the strength of it.

Fig. 9. The workbench with wheels, handles and sufficient steel members welded to make it very sturdy to move over uneven earth near a tree or plant. The vice must be retracted to move it else there the center of gravity will shift inappropriately.

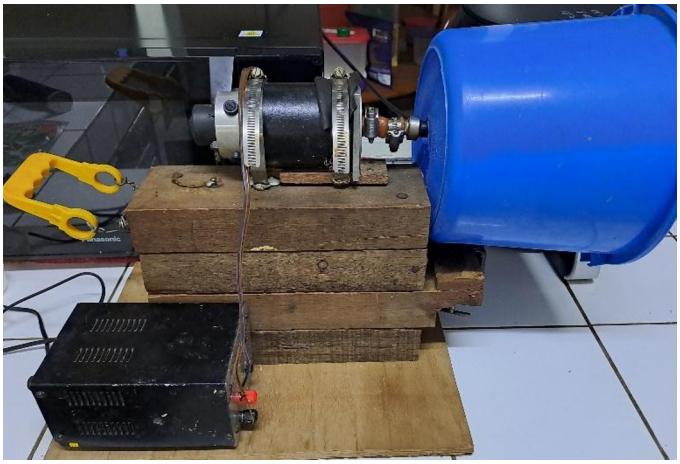

Fig. 10. the whole coconut meat grinding system.

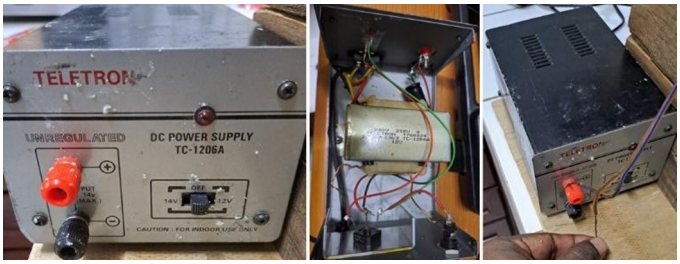

Fig. 11. The power supply for the DC motor which can supply 12V or 14V; the blade turns faster and with more power at 14V.

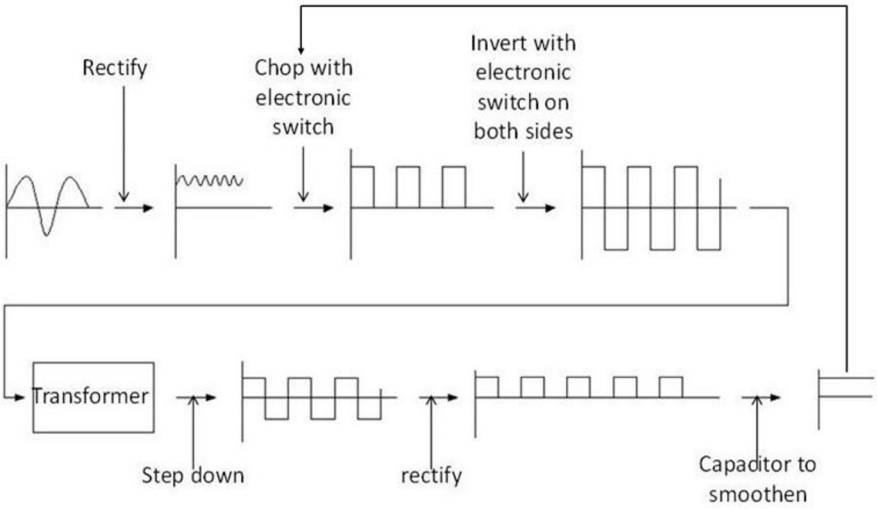

Fig. 12. Schematic of an SMPS.

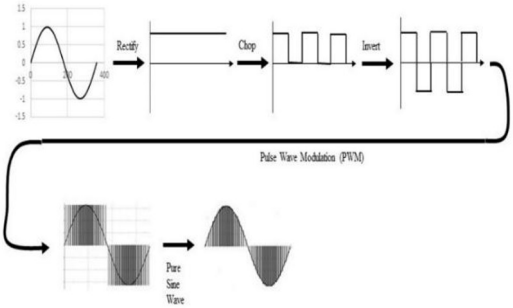

Fig. 13. Schematic of a VFD (variable frequency drive).

Fig. 14. The wood base depicting that the second of the four 4" X 2" wood piece is longer to enable holding the coconut meat grinding mechanism.

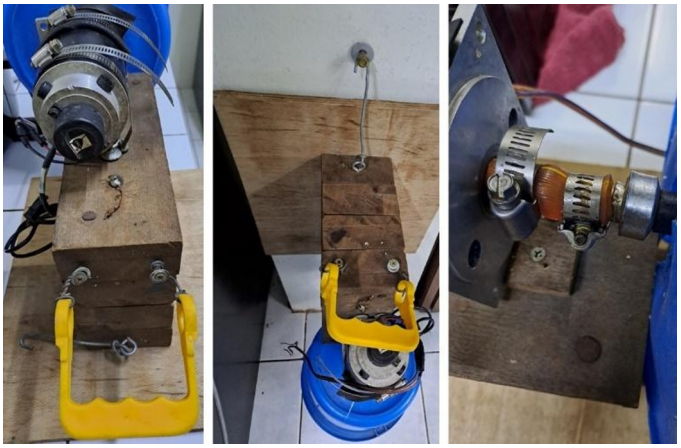

Fig. 15. Leftmost image shows the DC motor used and the yellow handle to carry the whole system so that it can be hung (stored) on a wall as shown in the middle image. The rightmost image is the garden hose connection between the motor shaft and the coconut meat grinding blade.

Fig. 16. Grinding the coconut.

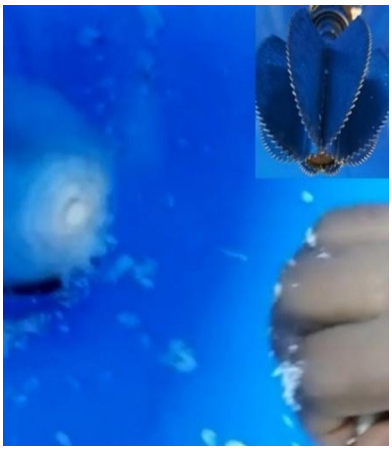

Fig. 17. The blade of the coconut grinder (top left) is not turning too fast as to hurt a human hand. The top right image is a picture of the non-moving blade.

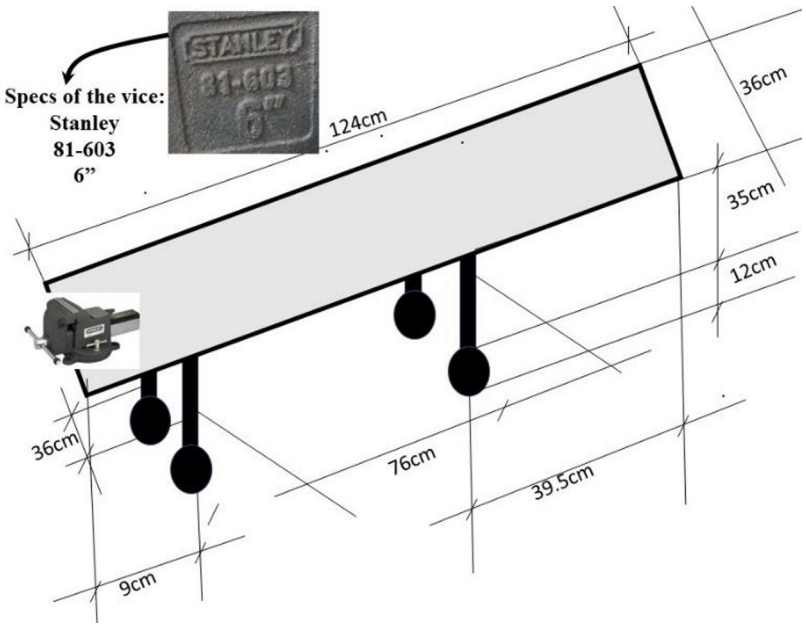

Fig. 18. the dimensions of the workbench.

Table 1. Data of the various portions of the coconut meat extraction system,

RPM of the wall cutter and brand	13500 De Walt
Power rating of wall cutter	1270W
Model	DW862
RPM of motor at 12V	1044
RPM of motor at 14V	1071
Average time of cutting and grinding per coconut	2 minutes
Bucket top diameter	23.5cm
Bucket bottom diameter	20cm
Bucket height	21cm
Wood base dimension	4" X 2" X11" X 3 pieces
Wood base dimension	4" X 2" X 14" X 1 piece
Bottom plywood dimension	10mm X 33mm X 40.5mm
Vice size and brand	6" Stanley

3 Literature Review

Coconut oils have been given lots of negative propaganda since the 1950s to the 1990s. Historically coconut has been consumed widely in India, Sri Lanka, Malaysia, Indonesia, and most of Southeast Asia [17]. But antagonists such as one Harvard professor are even today making statements that, "it is pure poison" [18]. Europeans were importing coconut oil since the 16th century but by the 19th century Europeans began importing a significant amount of coconut oil [19]. Thereby the demand for it was high till WWII when suddenly the supply was cut off to Europe and American consumers. This is when research into enabling the consumption of corn and soybean oil became intensive and succeeded. By the time WW2 ended the corn and soybean oils had become a big industry which did not want a comeback of coconut oil. Therefore, an extensive propaganda of the dangers of consuming saturated fats got a hold in Western countries to such an extent that coconut plantations in Southeast Asia were unharvested. In fact, a large coconut plantation is still mostly unutilized not too far from this author's home in Kuching, Malaysia.

A leader of the anti-coconut agenda was Ancel Keys from 1953 to 1957. His statement was that all fats (of which half are from vegetables) increase serum cholesterol or the amount of cholesterol in a human blood vessel [21]. An infamous experiment that fed hydrogenated (not natural) oil to rats which made them plumber enhanced the belief that coconut was bad [22]. This attack on coconut was enhanced in the 1960s, 1970s, 1980s and 1990s [23].

Among the leading persons standing on the side of the truth regarding coconut was Mary G. Enig, Ph.D. Dr. Mary Enig who passed away in 2014 was a licensed nutritionist in Malyland, USA. She was a Master of the American College of Nutrition and an editor of the Journal of the American College of Nutrition. Her statements were that coconut oil was at least neutral in causing cardiovascular problems and is beneficial for the prevention of some heart disease and helps in enhancing immune systems and reducing cancer. She said her and other researcher's experiments clearly indicates that coconut oil is at worst neutral with respect to atherogenicity of fats and oils and, in fact, is likely to be a beneficial oil for

prevention and treatment of some heart disease. Additionally, coconut oil provides a source of antimicrobial lipid for individuals with compromised immune systems and is a non-promoting fat with respect to chemical carcinogenesis [24]. For the later data, she cites Reddy et al (1984) who found that adenocarcinoma in a colon with coconut oil surrounding it was 3% while in corn oil it was 36%. And in the small intestine, coconut oil produced 0% of adenocarcinoma while in it was 8% when fed with olive oil. Adenocarcinomas occur in Stage 4 of cancer where it has metastasized to the other parts of the body [25].

Over the 40 years from the late 1950 to 1990, animal studies have concluded that saturated fats increased serum cholesterol level but the scientific basis for this relationship has now been challenged and accused with large-scale misinterpretations and misrepresentation of data mostly as paid propaganda for the corn and soybean oil producers [26].

4 Methodology and results

The contemporary method of extracting the coconut meat is by using a long, heavy, and sharp knife to chop a bit of the coconut husk at two nearby portions and then using high human strength to slowly tear off the husk from the coconut shell. Later the same knife will be used to crack the coconut shell into two to access the coconut meat inside. The problem with this contemporary method is that it takes a very high human strength but more importantly it is very dangerous to chop a slippery coconut with a long and heavy knife while holding the coconut with the other hand. Later there is the danger of not accurately cracking the coconut shell with the same knife while the other hand is holding the shell.

Detractors of this innovation designed and developed in this research will claim that it just causes laziness among humans because they do not need to use much muscular strength anymore. But the fact is that not many people can master the skills necessary to do it the conventional way. Therefore, the propagation of healthy coconut consumption cannot be achieved. Skilled humans cannot meet the demand thereby the price of coconut will increase beyond the reach of most humans. It takes a skilled person about five minutes to perform the tasks the conventional way compared to 30 seconds with this developed method even for an unskilled person. That is not counting the high strength required which causes exhaustion and therefore a small limit of how many coconuts a human can process in a day. It must also be noted that after testing the eventual system for hundreds of times, an average of about 20% of the coconuts that are spoiled and cannot be utilized, therefore with the conventional method, the five minutes of high skill human strength cannot bear any utility. Another factor is when the coconut shell is eventually cracked it may not be a perfect straight line cut leaving a certain percentage of coconut meat inaccessible to the grinder later. With the final developed system in this research the cut is almost perfect as shown in Fig. 7. The only way to get a straighter cut will be to use a longer wood cutting saw which normally has a strong metal base to enable cutting the wood as straight as possible, therefore it is not as movable as a handheld grinder. Another option will be to use a laser cut which is already implemented in woodwork industries. The cut with a laser has a width that is smaller thereby reducing the waste in the coconut meat. But both options will increase the cost significantly, especially the laser option. Also the laser cut will reduce the amount of fertilizer for the tree or plant nearby which is the output of this method of doing it.

Many iterations had to be designed and built before settling on the final design. Initially the cutting was done on a cemented floor and next to a wall as shown in Fig. 6. But both the wall and the floor got dirty with the coconut dust exhausted in the process. The water resource to clean up the area will make the system unattractive to be used by others intending

to rebuild this system.

Therefore, an upgrade to the system was designed and built as shown in Fig. 8. Wheels were welded to the bottom of the workbench's legs and more steel members were welded to strengthen the workbench. Of course, in case any others want to rebuild this system, it is important to note that the plastic wheels must be removed before welding or else they will melt. In fact, while welding the horizontal members, one can hear the evaporating grease within the horizontal bearings just above the silvery steel wheel-holders. Car engine oil was used to replace the evaporated grease. At the center of the plastic wheel, there is another cylindrical roller bearing without any ball bearings. It is just the center screw moving free within a metal cylinder. The dimension of the workbench is given in Fig. 18.

The next thing needed is to build a system to extract the coconut meat from within the coconut shell. This system used a blade as shown in Fig. 17 top right image.

The contemporary method of grinding the coconut can range from moving a half coconut over a fixed sawtooth blade which is fastened on an elevated portion of a piece of wood. Most shops in Malaysia will use a scraper to scrape out the coconut meat which include the brown and harder lower portion of the coconut meat. Then this coconut meat with the brown bottom is sent to a grinder. But many people do not prefer to consume this brown lower portion of the coconut meat. Some designs are similar to the one built in this system but made with much more expensive materials. The aim of this research is to develop a system that can easily be replicated elsewhere in the world where coconut grows.

Then a bucket must be installed to catch the grinded coconut meat. A right size plastic bucket which can easily be cut is the one shown in Fig. 16. It will provide just enough space to fit the coconut plus handle it with a human hand. The bucket has a dimension of bottom Ø=20cm and top Ø=23.5cm and a height of 21cm. The bottom of the bucket was cut with a high-powered soldering iron which melted the plastic fast enough. The bucket had to be cut to enable the grinding mechanism to be inside the bucket but still be connected to the DC motor.

But now the bucket is thicker than the 4" X 2" X 11" wood piece below it, therefore three more pieces of 4" X 2" wood pieces were stacked one upon the other and joined with long nails. But the nails were not just hammered into the wood. A drill was used to drill a hole with a slightly smaller diameter than the nail and then the nails were hammered in. Firstly, between the first and second piece of wood were fastened in this way and then the similar procedure was used to fasten it to the third piece and fourth piece of wood. The second wood piece from the bottom has a length of 14" versus 11" for the rest. This is to enable it to hold the coconut meat grinding mechanism as shown in Fig. 14. The right image of Fig. 14 is the measuring of the RPM of the motor using an app downloaded from Google Play Store. At the very bottom a 10mm X 33cm X 40.5cm piece of plywood was fastened so that the system will not fall over (provide stability).

As shown in Table 1, the speed is higher, and the blade turns with faster power at 14V; the turning also is with more power. Therefore, if the human operating it has a sensitive hand, he or she can turn down the voltage to 12V. This coconut grinding blade turns at just the right slow speed so that it doesn't harm the human who accidently touches it. The human hand touching the rotating blade tends to happen if the human does not concentrate sufficiently while performing the grinding. Fig. 16 and Fig. 17 depict how close the human hand is to the coconut meat grinding blade. Touching the rotating blade will hurt a little but bleeding tends not to occur at both RPMs.

Two big hose clips were used to hold down the motor onto the wood piece as shown in Fig. 15, leftmost image, but using a piece of steel-bend would have been a cheaper option. At the very bottom of this image is a yellow plastic handle to carry the whole system and

later hang (store) is on a wall as shown in Fig. 15, middle image where a thick galvanized iron (GI) wire is bent into a hook such that the whole system can be hung on the wall. Of course, the system was initially built without the yellow handle, but it took quite a lot of effort to hang it on the wall; the yellow handle was a big relief. Hanging the whole system on the wall is important because if it is stored on the floor, people may trip upon the whole mechanism and damage ir, especially the plastic bucket.

Fig. 15 rightmost image shows how the motor shaft is connected to the coconut meat grinding mechanism. A garden hose is used. The reason is because in any join in mechanical engineering the alignment must be as perfect as possible or else the motor or its bearing will deteriorate. But since alignment requires expensive equipment, a bendable garden hose allows for non-perfect join.

A DC motor is used because there are too many problems of using an AC motor since it turns at 50 Hz (3000 RPM) which is the local electric authority (LEA) frequency and that will be too fast for the safety of the human unless a VFD (variable frequency drive) is used. But that will bring the cost of the system up significantly. If the VFD spoils, there is no option to repair it since the circuit boards are multilayered with surface-mount technology (SMT) where a batch solder-reflow process is used to attach components. But just in case someone wants to use an AC motor, the schematic of Fig. 13 will help understand how the VFD controller works [27]. The IGBT (insulated gate bipolar transistor) is the main component that enables a VFD to control the speed of an AC induction motor. Prior to the VFD, two SCRs to switch the positive and negative sides of the AC wave were used. The main advantage of an IGBT over switching two SCRs is the speed of switching. IGBTs can be switched at tens of kHz while using two SCRs can only achieve a switching speed of only 50-60 Hz. Also, the SCRs tend to latch on until load current falls to zero, making it not so useful for hard switching applications [27].

But it should be noted that most industries used DC motors prior to 1982 before the invention of the first practical IGBT by B. Jayant Baliga [28]. And since most factories are changing out DC motors to AC motors because of the ever-decreasing price of VFDs; therefore, DC motors can be acquired for a cheaper price. The DC motor used in this project was discarded by the Western Digital factory in Kuching, Malaysia where this author worked. As can be seen in the leftmost image of Fig. 15, it also has an encoder which is not used in this project. An encoder is used to give a closed loop feedback to the PLC (programmable logic controller) of the actual speed of the motor. A PLC can send out a signal of what speed the motor should turn, but due to bearing jams etc. it may not turn at exactly that speed or position. Therefore, an encoder is used to measure the actual speed of the motor and if it is not according to the speed in the software, the software will instruct it to turn faster.

A fan controller with a 1Φ phase induction motor may be possible if the speed can be reduced sufficiently. The most common fan controllers use capacitors which vary the angle between the starting and running stator windings in the 1Φ induction motor to achieve different speeds.

The power supply used to power the DC motor is shown in Fig. 11 which is switchable from 12V to 14V. It is an old type which utilizes a transformer, bridge diode and capacitor as shown in the middle image of Fig. 11. An option for others who want to rebuild this system is to use an SMPS (switched mode power supply). Fig. 12 is a schematic of how the SMPS works [27]. As shown in the rightmost image of Fig. 11, the positive and negative wires are not permanently fixed to the motor. The wires can be easily removed by turning the red and black plastic screws. This is to enable washing the system without getting the power supply wet.

5 Conclusion

This research met all the objectives of developing two equipment for the extraction of the food value of coconut. A big section of this paper dwells on the justification for making it easy to extract the coconut meat thereby increasing the profit motive of increasing the growing of coconuts. There was much propaganda against its consumption from the 1960s -1990s in the Western media mainly because coconut imports were stopped to the USA and Europe during WW2. This led researchers in the USA to develop techniques of utilizing corn oil for human consumption. But the Western media has influenced the whole world. As an indication of the influence of Western media, the state of Kerala in India was almost totally covered by coconut trees for millenniums started importing non-coconut oils over that period. This has degraded the soil structure of the soil of Kerala which needed coconut trees because of the heavy rainfall during the rainy season causing a higher percentage of mud and clay. Thankfully the negative media has died down and the reason for the positive media today was also described. The coconut tree growing utilizes the least fertilizer. A common nutrient it needs is sodium chloride which is easily available in all seas and oceans. The roots of a typical coconut tree are very widespread, which is best for building up riparian zones which has over the recent years been found to be critical in reviving dying rivers. Roots of a single coconut tree can be found even up to five meters away from the tree. The widespread root system also enables the tree to absorb nutrients from a much larger volume of coil compared to corn, soybean, wheat, or rice.

The focus while designing and building the system was to ensure it is easily built all over the world where coconut grows. Complicated designs were avoided for building and maintenance of the system. Two setups were built, one to cut the coconut with a 13,050 RPM wall cutter and the other to extract the coconut meat with utmost safety.

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