Design and Fabrication of Cashew Nut De-Shelling Machine

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ABSTRACT

This research project is about designing a cashew nut sheller intended to semi-automatically process the sun-dried cashew nuts of our benefactor in Bataan. The first part of this research covers numerous information about the cashew nut production, cashew nut specification, pre-treatment methods, transversal cutting of cashew nuts. The researchers then classified the hazards in manual cashew nut shelling, which led to the development of the scheme to be used in this study. The concepts were applied for the assembly of a machine that can do most of the shelling process. Data gathering through queries, series of trials, and a survey were completed in order to evaluate the different aspects of the cashew nut sheller, the optimal working placement of the blades, length of the v-guide, and the efficiency of the cutting. The performance of the machine was evaluated using the quantitative and qualitative data collected from both testing and survey respectively.

Keywords: Cashew nut de-shelling machine, Cashew nut, Cashew nut shell liquid

INTRODUCTION

Cashew or “Anacardium occidentale L.” is an evergreen tropical tree which can be found in many tropical areas. Cashew farms and businesses areas are found in Palawan and Mindoro Occidental, which contribute 92% to the total national production. There were also plantations in Central Luzon which are Bataan, Nueva Ecija, and Zambales and at Northern Luzon Pangasinan and Ilocos Norte contributing up to 6% and 1% respectively. The raw cashew nut requires different types of thermal pre-treatment process to obtain the kernel inside. The mesocarp has a natural resin which is known as a cashew nut shell liquid. Cashew nut shell liquid contains anacardic acid and cardol. Both substances are dermatologic, like the oils of the poison ivy, which is hazardous during manual processing of cashew de-husking. It has the capability to irritate human skin, which is alarming because the process is still being done manually. The nut needs to be treated first to completely remove or at least reduce the oil in the shell so that the de-shelling process will be easier.

There are three methods of pre-treatment which are roasting, oil bath and the steam/boiling. Steam/boiling process is done by exposing the nuts to high pressure steam which makes the shell brittle and it loosens the kernel from the inside surface of the shell. This study pushes the shelling of cashew nut more effective by developing a machine or improving present machines which break or do a complete separation of the kernel from the shell without affecting the quality of the kernels. Processing of raw cashew nuts is done by hand or mechanically. The manual shelling is a tedious process and labor intensive. During the manual de-shelling process, the cashew nut shell liquid (CNSL) is a crucial problem that indirectly affect the quality of the kernels due to contamination.

The CNSL present in the shell is caustic in nature and can cause allergic reaction on skin when direct contact on skin occurs. The shelling process is the greatest problem in the processing of cashew nuts, because of the kernel's irregularity in shape and brittleness.

At present, the shelling process is mainly carried out manually. It consists of hitting the nut with a wooden hammer along the longitudinal axis. Cashew nut in the Philippines is locally known as "kasoy", cashew nuts are versatile nut crops as they find use in both food and feed industries. With the growing domestic and international demand for the commodity, cashew growers continue to seek innovations in creating new cashew nut products that could be sold on local and international market. Mr. Richard was a blogger from Bataan mentioned about his province that cashew nut is one of the native products of Bataan particularly in Morong and Bagac, Bataan.

Problem statement

The creation of the machine will simplify the cashew nut processing by reducing the time and labor consumption compared to manual shelling. During the manual de-shelling process, the quality of the cashew nut shell liquid is the key problem that indirectly affects the quality of the kernels. The cashew nut shell liquid present in the shell is caustic in nature and can cause skin problems. The prototype will be developed to remove shells from cashew nuts effectively and efficiently. The machine claims that it is capable on feeding a nut and place it properly in the guide and removing the shell without damaging the nut inside.

The researchers aimed to answer the following question:

1. How to develop a low-cost cashew nut de-shelling machine that could help MSME enterprises to improve their production rate.
2. The main objective of the study is to design and construct a prototype of cashew nut de-shelling machine that de-shell the nuts. Specifically, the study aimed:
3. To improve the production rate of the cashew nut industry
4. To develop a low-cost and effective cashew nut de-shelling machine made of local-ly available materials, adoptable to present researches and technology.
5. To conduct a simple cost analysis of the machine.

The importance of cashew nuts demanded the design of a much more efficient way of shelling, where in we dedicated our time and effort to conceptualize a machine that could help small scale cashew producing businesses to increase their income by producing shelled cashew nuts than selling them raw. Upon creation of this machine, we can simplify the cashew nut processing by reducing the work time and labor of manual shelling. The prototype will be designed for the shelling process of cashew nuts, but with further study it can actually be applicable to other types of nuts as well. Due to the limited processing plants and businesses regarding cashew nut shelling here in our province, most of the data and methods used on the study were based from the current and past researches only. The design and calculations were based on past and present methods available.

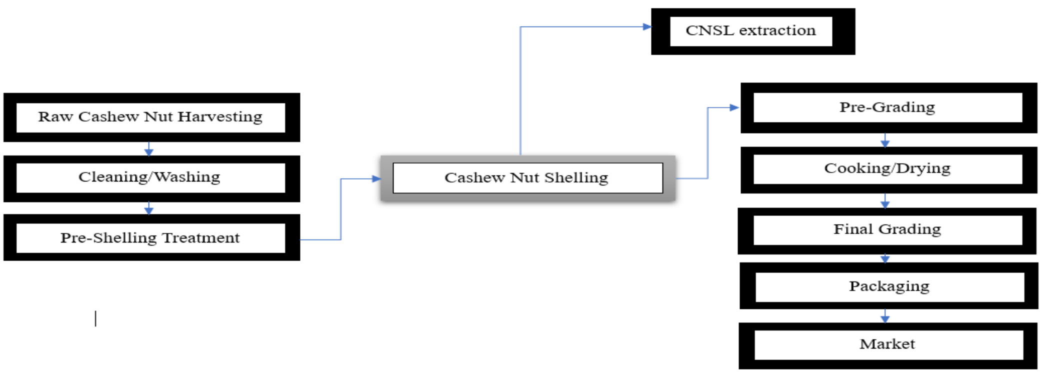

Figure 1. Flow of Chart Cashew Nut Processing

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The flow chart is all about how a cashew nut is being processed before we can see it on the market, the process starts from separation of the apple and cashew nut or the separation process, then the pre-cleaning process for some of the processors, then the pre-shelling treatment process which can divided into 3 types (a)Steam/Boiled, (b)Roasting, (c)Oil Bath. Pre-shelling process is done for the purpose of making the best quality out of the kernels to reduce the CNSL contamination for the kernels. Next is our research topic which is the cashew nut shelling. This is the most crucial part of the process, this process is the one responsible for the quality of the kernels in our research which focuses on how and what type of cutting or shelling technique should be implement to further increase the quality of the kernels being produced while reducing the effort or eliminate the tedious processing type that is manually done by our local farmers and processors. Our target is to design a machine that will help them with their production speed to increase productivity.

Pre-grading process, this process is done after the shelling process to check for the kernels and separate the good and bad quality kernels. After the pre-grading process is the cooking and drying process. Final grading is the process where they examine the cooked nuts to check if there are still bad quality nuts. Packaging process is for branding and freshness of the nuts. And lastly the marketing and distribution of the finished goods which is the cashew nuts.

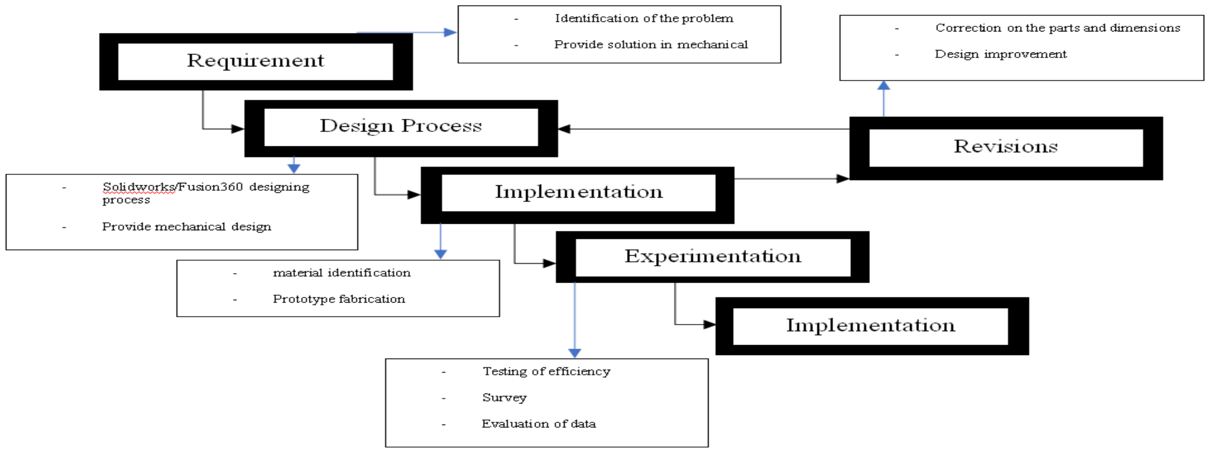

Figure 2. Conceptual Framework

Figure 2 shows the conceptual framework of this study. The first thing that we should consider would be the identification of the problem, followed by providing the most effective mechanical solution outsourcing from old and present researches. After identifying the problem and providing the solutions, we should design the appropriate output/outcome together with the 3d-model and mechanical designs. The next step would be the implementations of the ideas we have gathered including the material identification and fabrication. In case of revisions, correction on the parts and dimensions with design improvement will be applied. The experimentations procedure like testing of efficiency, surveys and evaluation of data must follow. Lastly, upon finishing all the steps we proceed with the implementations.

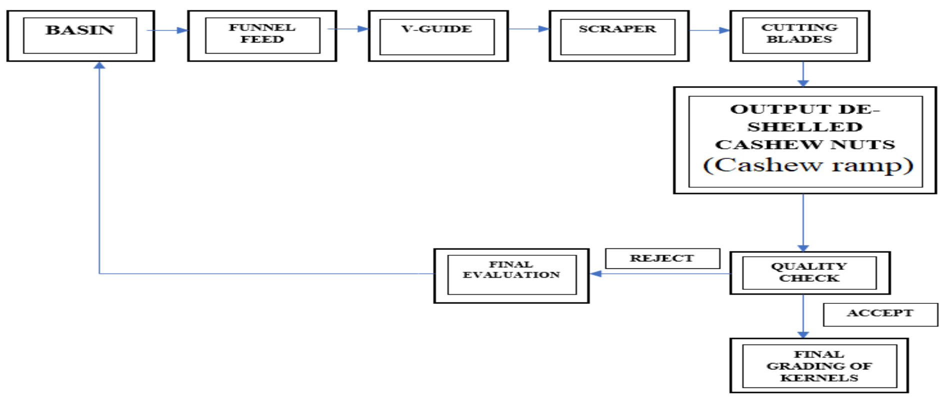

Figure 3. Machine Flow Chart Process

This figure explains the step by step process inside the machine. 1st is loading of cashew nuts inside the basin. 2nd is manual placement of the cashew nut inside the funnel feed. 3rd the cashew will standby at the lower v-guide waiting for the scraper to do the conveying process until it reaches the cutting blades in front of the guides where the splitting process occurs. Next step will be the quality check, checking each split cashew and the quality of kernel produced by the machine where we segregate the accepted and rejected cashew nuts, for the accepted cashew nuts there's final grading of the quality of kernel where in it is categorized as split or whole kernel, and for the rejected nuts, these nuts will fall on final evaluation, in the final evaluation the kernel are going to be checked for possible recovery.

REVIEW OF RELATED LITERATURE

Some of the manual process done on some businesses were mentioned from the re-search of (Renita SM. Dela Cruz, Andres Tuates & Isis DC. Davalos) from producing split or broken cashew kernel process using "kalukati", a wedge type tool using bolo as splitter, where splitting produces bad quality and broken kernels that are tainted with cashew nut shell liquid, the liquid from the nut shell will cause unpleasant taste. To get rid of the shell liquid some people wash the split kernels multiple times using water, and some use deter-gent, and dry them before cooking. (Renita SM. Dela Cruz, Andres Tuates & Isis DC. Da-valos (2016)).

The traditional way on shelling a cashew nut takes too much effort and that is the manual process. The manual processing method uses hammer, the nuts were roasted and placed on a flat stone and cracking with a hammer, this process is not efficient in terms of production because of too much effort is needed in a single process, it is a slow and a tedi-ous process. It may even cause hazard to the worker due to the corrosive action of the cashew nut shell liquid on human skin and the liquid may lower the quality of the ker-nel. (S.J. Ojolo, O. Damisa, J.I. Orisaleye and C. Ogbonnaya(2009))

The research based from B.S. Ogunsina and A.I. Bamgboye mainly focused on the fracture resistance of a cashew nut as they tested it with different pre-treatment in which they have subjected the nut in two pre-shelling treatments namely steam boiling and roast-ing in hot cashew nut shell liquid. On this test, they found out that the fracture resistance of raw, roasted and steam boiled cashew nuts are at 2.5 and 50mm/min loading rates in the longitudinal and transverse directions.

They also stated that pre-treated cashew nuts were found to require less force needed to be cut compared to raw cashew nuts and the least fracture resistance was exhibited by roasted nuts. B.S Ogunsina and A.I Bamgboye explained that all nuts are shelled using a hand op-erated cashew nut shelling machine because some of the kernels get broken. They conduct-ed a study and sorted the cashew nuts into three sizes: small (18-22mm), medium (23-25mm) and large nuts (26-35mm). The nuts we're conditioned with water at 25°C to five moisture levels of 8.34, 11.80, 12.57, 15.40 and 16.84%. The results are clearly investigat-ed that the effect of moisture content, nut size distribution is not enough for estimating the whole kernels out turn and found out that the average WKO of raw nuts is averaging 50% at the combination of moisture content and roasting time. (B. S. Ogunsina & A. I. Bam-gboye (2013))

The pre-shelling treatment on their study shows that the steaming process increases the gap between the kernel and shell, also the brittleness of the shell increased under this process. Their research shows that steaming for 40 mins and drying under 70°C is the op-timal pre-shelling treatment process that could give the best quality of the properties of a cashew nut. (Jie Gong, Wen Xia, Yun-Fei Fu, Hui Huang, Fan Zhang, Yi-Jun Liu, PengFei Zhao (2016)).

It was stated that the size of the kernel has a great impact to the shelling efficiency of the machine. They have also studied different machines in shelling cashew nuts classi-fied as Manually Operated Machine (MOSM), Automated Traditional Power Operated Machine (ATPOSM), and Automatic Improved Power Operated Machine (AIPOSM). They made a comparison of all the said machines with the following criteria: the shelling efficiency of the machine, whole kernel recovery, breakage, cashew nut picking efficiency and their monthly saving. Upon gathering the data, they came up with this result: The low-est breakage was found for AIPOSM. The improper cut percentage for AIPOSM rises as the size of the kernel gets smaller because kernels directly go to the cutting chamber with-out any obstructions. The picking efficiency of improve power operated shelling machine was decreased as weight from hopper decreases. MOSM has the lowest uncut due to hu-man interface. Whole kernels recovery has the best result with the use of AIPOSM. The shelling efficiency was found highest in MOSM, while the operating cost was found lowest in AIPOSM. To sum it all, the size of the kernels directly affects the result gathered from different machines on the given criteria. (Powar, R.V., Aware, V.V., Deogirikar, A.A., Aware, S.V. and Shahare, P.U. (2017))

Pre-treatment of the cashew nuts have a great impact on its dimensions. The physi-cal properties that was involved in their study were length, width, thickness, geometric mean diameter, sphericity, true density, bulk density, porosity, mass, and coefficient of fric-tion. It was observed that several dimensions increase except for the density and mass due to the loss of CNSL. (Kilanko Oluwaseun, Olojo Sunday Joshua, Inegbenebor, Anthony Omieraokholen, Ilori Titus Adeyinka, Leramo Richard Oluwafemi, Babalola Philip Olufemi, Onwordi Patrick Nwanne(2018))

It is really essential to limit the moisture content of the cashew nut that undergone steam boiling pre-treatment process to ensure that the whole kernel production will in-crease. (Babatunda Sunday Ogunsina, Adeleke Isaac Bamgboye(2012))

Based on Jim Fitzpatrick study, it was highlighted that the processing methods var-ies on different countries on cashew nuts like Vietnam, and Africa. The processing equip-ment in Africa needs to improve the competitiveness and profitability of their production, while the method used in Vietnam is focused on oil bath and steam process for their pre-treatment. (Jim Fitzpatrick (2011))

They also mentioned the advantages of a semi-automatic method to enhanced the productivity, quality and cost. We all know that there is no 100% efficient machine that’s why they encountered problems in their research tests. But as an advantage, they assured that the machine will increase in efficiency and its reliability on processing, secure the safety of the operator due to hazardous liquids during the processing phase. (Akshay Madnaik, Rohit Chougole, Chetan Bhabuje, Satish Dulange (2017))

Dealing with the characteristics of a cashew nut and cutting the shell in a mecha-nized way to reduce the processing time. Shearing of shell of cashew nut is done manually which is labor intensive and hazardous. During shearing of cashew nut shell, the liquid that is coming out is corrosive. It is hazardous and it consumes a lot of time to remove because of its oily property. This automatic power operated cashew nut Sheller can be operated by unskilled workers if guided properly. The machine can produce a kernel. An automatic power operated cashew nut Sheller is based on the principle of shear with respect to cutters mounted on a sliding guide. (Akshay Madnaik, et al., (2017))

Cashew nut farming is one of the prime occupations in Goa. However, due to lack of man power, it is getting tough for the farmers be involved in this occupation. The major risk involved is the of spilling of fluid from the shell that can lead to partial/permanent blindness if contact with the eye occurs. (Waquar Mazhar, Lal SurajKumar Shrikant, Anu-rag Labana(2017))

The Philippine Agricultural groups are struggling with the current technology pre-sent in the country and we need to innovate our current production and processing equip-ment available for our farmers to also expand their production on cashew. It was also said in the study that our export demand is greatly increasing which requires us to cope up with the global demand on the cashew production. (Concepcion A.E. Magboo[7]. (n.d.))

This research attempts to lessen human involvement by developing a semi-automated machine for collection and separation operations. These processes involve collection of cashews from ground by roller type collector and after collecting it is transferred to the sep-arator. (Prof. S A Wani, Teja Gavhane, Megha Lohar, Pratik Shinde, Sandip Thange, Omkar Vichare (2018))

India is the largest producer, processor, exporter and second largest consumer of cashew in the world. Since cashew processing industries are small, cottage category units. no conventional and techno-economically cost-effective pollution abatement systems are in operation elsewhere, it has become necessary to study the entire cashew nut processing in-dustry sector in India to suggest techno-economically feasible environmental standards. Even though the pollutant emission load in the environment by a single cashew nut unit is low, it has been observed that the total emissions load by number of such units in a cluster causes considerable environmental degradation. (Mohod, A., Jain, S., & Powar, A. (2010))

METHODOLOGY RESEARCH DESIGN

In the study, the researchers used descriptive and experimental research. Descriptive research design using the quantitative in gathering all the information needed to start the study. The live interviews and observations with the owner of the cashew nut business was the qualitative research. For the quantitative research, questionnaires and surveys were used in the study which where interpret and showed. Experimental research was also used to produce the product desired by the researchers using their designed machine. A lot of trial and error as well as adjustments were done by the researchers just to achieve the product that they desire. The final part was analyzation, comparison and interpretation of data to achieve the reasonable result.

From the studies and research of Mao-Fang Huang the optimal parameters for the machine are the following velocity of the scraper of 0.36 m/s, distance between upper and lower cutters of 8.5 mm, and the pre-pressure caused by spring of 170 N. working performance of cutters would not be affected adversely during a span of 495 days when the working time of the adaptive cashew shelling cutter is 18 hours per day

Calculation of the velocity of impact (Sharma and Aggarwal (2006))

Impact Energy = (mv^2)/2 j , Impact Energy = Work of Deformation

(Sharma and Aggarwal et., al (2006)) Work of Deformation = (0.5F) x eJ

F = is the applied force and e is the deformation.

Work of Deformation is given as = P x e J

P = is the load applied in impact and is equal to the impact load required for shelling the nut.

e = is the maximum deformation of the nut taken to be the difference in the sizes of the shell and the nut.

e = 7.25mm

The torque required for the rotation of the shaft, T = F x r

The minimum power required can be solved by using, P = T x w, w = 2πN

where w = angular speed, T = torque, P = power.

Kinetic Energy and work of deformation can be equated to each other to get the minimum speed required to split a cashew nut. (Ojolo and Ogunsina et,. al(2007))

Mechanical Design

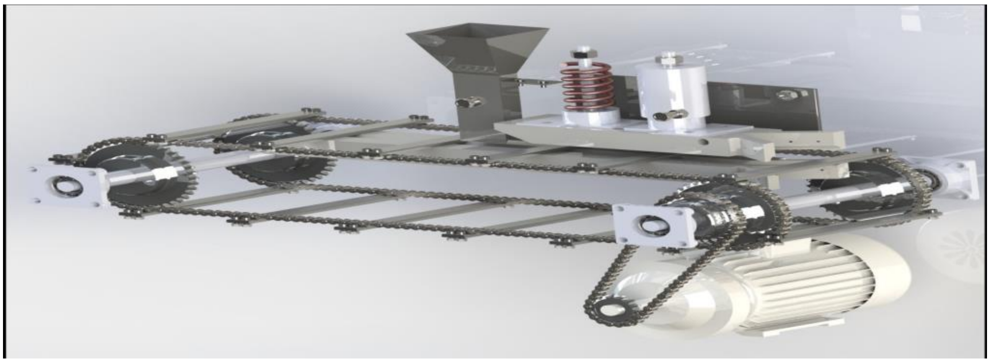

Figure 4: Mechanism of the prototype.

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The machine is run by 1HP gear motor with 30:1 gear ratio. The speed of the gear motor is transmitted to the chain and sprockets of the machine for the distance of the sprockets (center to center distance) refer to Appendix (B). sprocket number 1(16Teeth with 56.8mm diameter) rotates along the driving shaft of the motor and transmitting the power to sprocket 2(26Teeth with 131.7mm in diameter) that is connected by Chain number 1. Sprocket 2 and sprocket 3 are connected in 1 shaft. Chain number 2 is connected to sprocket 3(38 teeth with 156mm in diameter) and scrapers are mounted on the chain number 2 and 3 which rotates in a conveying mechanism that pushes the cashew nut along the v-guides. The v-guides receives the cashew nut from the funnel feed which will be conveyed by the scrapers. The upper v-guide acts as the adjusting mechanism which helps the cashew stay in longitudinal axis, the upper v-guide has 2 springs installed on top of it, the springs work as a device that actuates whenever a cashew enters the v-guide, the actuation also acts as the adjusting guide in preparation for any cashew nut size fed. After the v-guides, the cashew nut goes to the final step of the mechanism which is the splitting which is caused by the blades at the end of both upper and lower v-guides, the blades were designed to be in a Y shape which helps the initial blade to split the shell into 2.

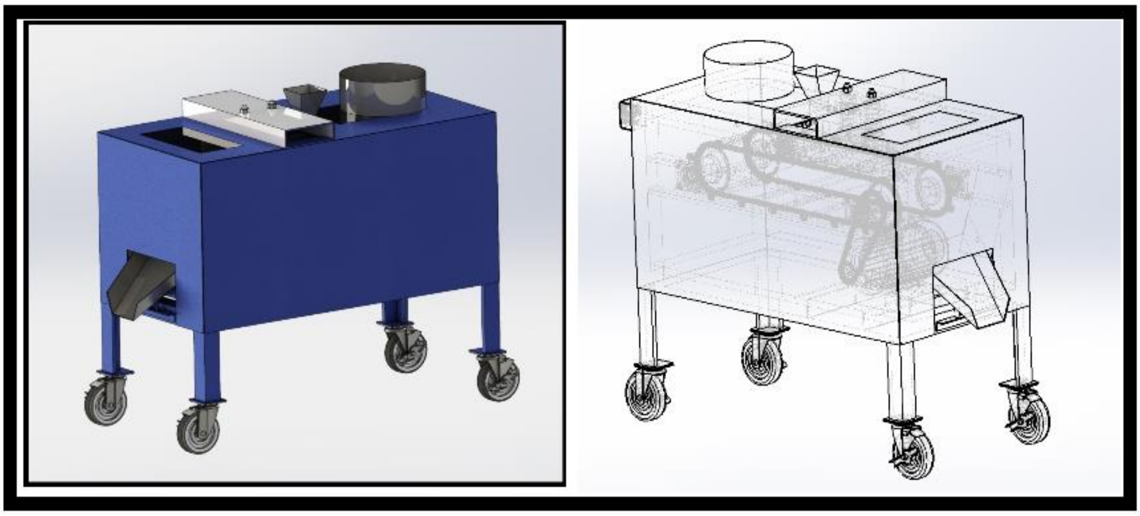

Figure 5: Mechanical Design Isometric View.

The machine is designed to split cashew in a semi-automated manner to reduce the man power needed. The design of the machine helps the manual operators reduce the ergonomics hazard from the traditional method they are using.

The prototype consists of a chassis that supports the motor and the mechanism of the machine. The machine has a stainless sheet metal basin on top of it to secure the cashew nuts, the purpose of the basin is to stack cashew nuts for the operator. The prototype has 2 acrylic glasses placed at the top of the machine, to make troubleshooting easier. The machine has 4 caster wheels which can be lock and unlocked for safety purposes. The prototype is powered by gear motor 1hp in capacity with a 30:1 gear ratio for higher torque a 1hp gear motor is used even though the minimum power required to split a cashew is at 0.2hp, one of our issues are getting the desired components, so in order to get the desired output we just get the higher than 0.2 hp in the market and the most cheapest we can afford so to balance the power the researchers bought a 1hp with 30:1 gear reducer to acquire the closest to minimum speed required of 40.6rpm. The motor is then connected to a 16Teeth sprocket with a diameter of 56.8mm and 60rev/min speed. The 1st sprocket is connected to a 2nd sprocket by a chain to transmit the power to main mechanism, the 2nd sprocket has 26Teeth with a diameter of 131.7mm and 37rev/min speed, the increase in diameter and teeth would cause into slower speed but increase in torque, which is needed to split a cashew nut. The 2nd sprocket is connected to the main driving shaft which is also connected to a flange bearing to support the load and rotating mechanism. The flange bearing used in the prototype is F204 flange Bearing. In the driving shaft there's also 2 sprocket which we can name as 3rd sprockets that consist of 38 teeth sprocket with a 156mm in diameter and a speed of 37rev/min same with the 2nd sprocket because they are connected with a same shaft. The 3rd sprockets were connected by chain to another pair of sprockets with 1:1 ratio. The chains connected to 3rd sprocket has scrapers installed which acts like a conveying mechanism that conveys the cashew nuts from the funnel feed to the blades. The funnel feed is installed at the top back portion of the prototype near the basin for ergonomics safety and is made of stainless sheet metal. The scrapers were made of stainless 304 steel and were bolted to a sheet metal that is weld to the chains. The bolts used were M5 hex socket cap screw for maintenance this helps the user to easily disassemble the scrapers from the steel sheets when changing the scrapers. The v-guides were the main component of the prototype, these guides were designed to have a v shape guide to effectively guide the different cashew sizes, the design was derived by averaging the smallest to largest size gathered from different places near Pampanga. The lower v-guide is fixed to the chassis while the upper v-guide has 2 adjustable springs attached to it so that It would actuate whether a cashew nut with different varying sizes goes through the v-guides. The springs are mounted to a spring guide and enclosed by a spring case, the spring guide is threaded on its top portion for adjustment of the spring pressure and to adjust the distance between the upper and lower v-guide. Adjustment of the spring pressure could change the product's output, it's either you'll get split kernels or whole depends on the spring pressure that the operator set. The springs and spring guide where mounted on parallel to secure the upper v-guide's placement and also to secure the pressure done by the spring at the whole guide. The design of the guides helps the cashew nut stay still on longitudinal axis for the effective splitting, based on the research the longitudinal way of splitting is the most efficient way of getting the best quality of kernel. Both upper and lower v-guide has Y shape blades that causes the cashew nut to split effectively the Y shaped design has higher chance of efficiently acquiring the good quality avoiding the CNSL to touch the kernels. The blades are 30mm in length and 1mm in thickness. After the splitting process the shelled cashew nuts were to fall into the cashew nut ramp were a basket or clean container is placed to catch the products.

Participants

The participants of this study are the Bataan MSME, to help the local laborers with their safety while performing cashew nut de-shelling process. The researchers have provided the machine that they designed and manufactured to be tested by these local laborers and organizations to assess and give their insights for further improvement of the prototype.

Data Gathering Instruments

In order to gather quantitative data that will be used in the research interpretation results. The researchers used a weighing scale to measure the exact amount of cashew nuts needed in every trial they did. For the speed of the motor and scraper the researchers used a tachometer. A Vernier caliper was needed for them to know how the size of cashew nut affect the results of the output product of a machine. Stopwatch was used during the trial to monitor the total time consumed to acquire the efficiency of the machine in terms of production rate. Last is that the researchers used survey questionnaire were utilized to obtain data that are needed for the study.

Data Gathering Procedures

For the researchers to have an idea on how the machine's performance and efficiency, trials were done by them and in each trial were conducted by the workers of Alion Kapit-Bisig SEA-K Association are there as well. During the test different sizes of cashew nuts was used by researchers to evaluate the overall performance of the cashew nut de-shelling machine.

After the demo and testing of the machine the researchers used surveys and asked the benefactors with their feedback and recommendations for them to know on what they need to improve with the machine and how the machine did for them. The questionnaire served as one of the major components with what else is needed to do or work on with the machine.

Data and Results

In this chapter, the researchers analyze and interpret the data gathered in this research study. The results are presented in tables and with corresponding discussions and explanations. The data gathered for production rate were tested by a series of trials.

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Table 1 Production rate for sunlight dried cashew nut

No. Trials	Weight of input	Weight of accepted split cashew nut	Weight of rejected cashew nut	Time	Production rate
1	1000g	800g	200g	0.067hrs	$11.94\frac{\text{kg}}{\text{hr}}$
2	1000g	850g	150g	0.0563hrs	$15.0976\frac{\text{kg}}{\text{hr}}$
3	1000g	800g	200g	0.0517hrs	$15.4738\frac{\text{kg}}{\text{hr}}$
4	1000g	700g	300g	0.0833hrs	$8.4033\frac{\text{kg}}{\text{hr}}$
5	1000g	700g	300g	0.067hrs	$10.477\frac{\text{kg}}{\text{hr}}$
6	1000g	750g	250g	0.0867hrs	$8.6505\frac{\text{kg}}{\text{hr}}$

Table 1 show the production rate of the prototype for sunlight dried cashew nut

The table proves that under man vs machine's production rate is better and during the trial the volunteers show no stress and risk of ergonomics hazard during operation.

Table 2 Comparison between existing, manual operation and the researcher's machine

Description	**Existing machine A** **From India and China**	**Manual process**
Production rate	120kg/hr	3.75kg/hr
Motor power capacity/efficiency	1.5hp	N/A
Machine Dimension	1.45x1.33x1.55m	0.46x0.20x0.25m
Machine weight	300kg	12kg

Table 3 Machine waste ratio and efficiency

No. Trials	Weight of input	Weight of accepted split cashew nut	Weight of rejected cashew nut	Waste ratio (%)	Production efficiency
1	1000g	800g	200g	20%	80%
2	1000g	850g	150g	15%	85%
3	1000g	800g	200g	20%	80%

4	1000g	700g	300g	30%	70%
5	1000g	700g	300g	30%	70%
6	1000g	750g	250g	25%	75%

Table 4 show the waste and efficiency of the prototype

This table shows the waste ratio of the prototype and it appears that the ratio is within the target efficiency of the research. The waste ratio varies from 15-30%.

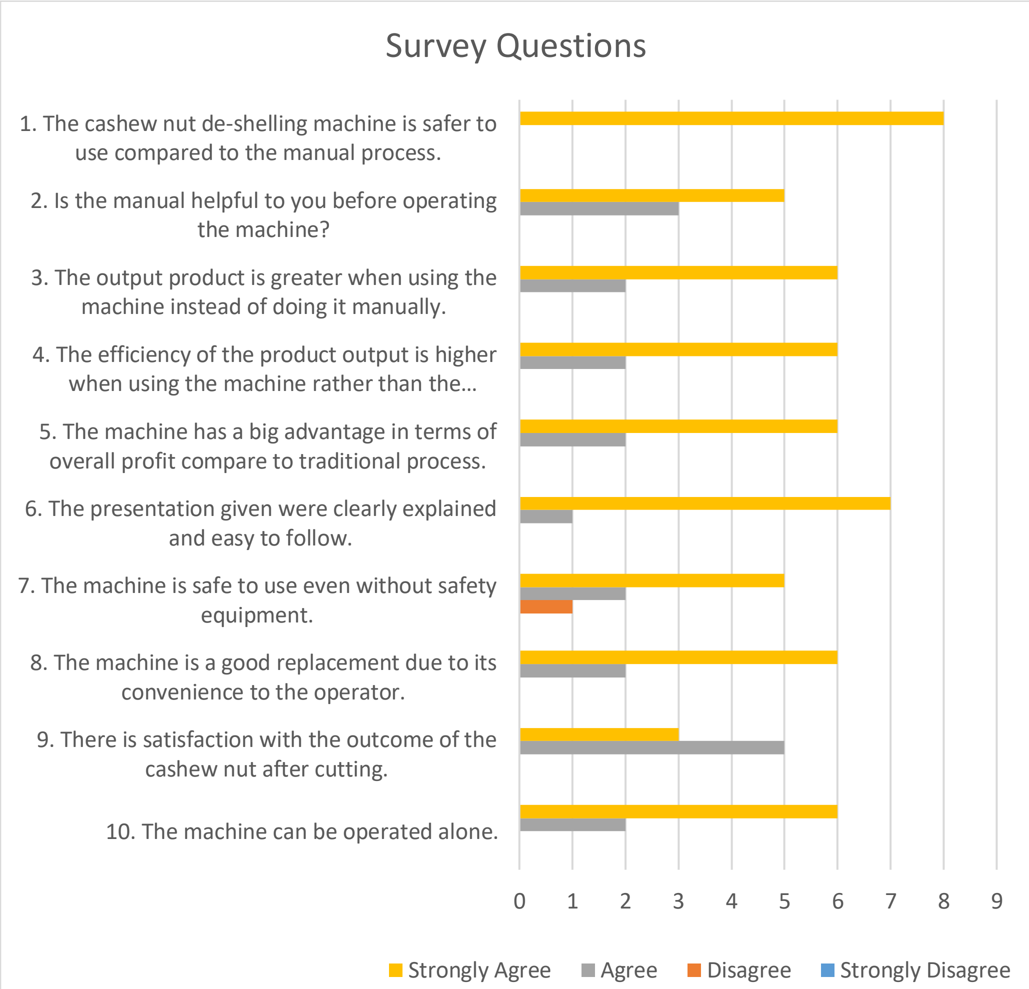

Figure 9: Survey answer percentage

DISCUSSION OF RESULTS

The effectiveness of the prototype was assessed through series of testing through different cashew sizes and different adjustments of the spring pressure. The prototype was also compared to the manual and existing machineries by comparing the production rate, weight, machine dimension, whole kernel efficiency and costing. The researchers also conducted a survey by handling out survey questionnaires.

The prototype's production rate was tested through 6 trials, every trial was timed until 1000g of cashew nuts were shelled. The test was operated by 6 volunteers of Kapit Bisig SEA-K organization in Bataan, Different factors occur that affects the quality, efficiency, quantity and the production rate recorded during this test. The quality and efficiency of the kernel is directly affected by how the v-guides were adjusted depending on how you want the product output to be. On this scenario there are splits and whole cashew nuts. There are two factors that contribute the quantity and production rate of the machine given that the speed of feeding and the choking in funnel feed due to tapered part of the funnel. the production rate may change depending on how fast each individual will do the feeding. Choking of the funnel feeder occur during this test making each trials production rate slower. The prototype was also compared to existing cashew nut de-shelling machine done manually and automatically. Survey questionnaires was also prepared and handed by the researchers answered by 8 respondents volunteers of kapit bisig SEA-K organizations in Bataan. The production rate data under table 1. Has an average rate of 11.6737kg/hr better than the manual shelling and reducing the ergonomics hazards that may happen to the operator during manual shelling. Under table 2. The prototype mostly better than the manual shelling and may someday be better than some of the existing machines if developed further, the cost of the machines from India and philmech are bulky and too pricey for MSME's here in the Philippines. Under table 3. The waste ratio and efficiency the waste per trial may vary depends on what adjustments are made on the spring guide bolts. And due to some hindrances, that happen when conducting the trials, like the choking of funnel feed because of its small outlet for the cashew nuts, adjustments are made after the trials and due to shortage of cashew nuts further trials cannot be conducted. The efficiency of waste per trial vary from 15-30% of 1000g and our production efficiency varies from 70-85% compared to existing bulky machines that has 85-90% shelling efficiency.

CONCLUSION

A semi-automated machine that is aimed to help the workers of Alion Kapit-Bisig Association in terms of production rate, whole kernel efficiency and decrease the risk of ergonomics hazard while performing it.

The machine was able to meet all the objectives that the researchers set, it increases the production rate and fasten the de-shelling of cashew nuts by designing and fabricating a semi-automated cashew nut de-shelling machine that can function with just one worker. The design of the prototype was base from the interviews of the researchers with their benefactors from what they need and want. The design was derived from different machineries around the internet, from different nut shelling machineries and from different aspect of cutting base from the data gathered. The upper and lower v-guide gap plays a big role in the efficiency of cutting the cashew nut. The spring pressure is also crucial in terms of holding the cashew in proper axis. Placing a flat bar MS plate with 5mm thickness before the assembly of the spring guide and upper v-guide could increase the spring pressure. According to the trials done by the researchers the efficiency of the prototype ranges from 70% to 85%. The efficiency varies due to different sizes of cashew and sphericity the machine was able to increase the speed of the production during the manual process the workers can only do 3.75kg/hour while with the prototype average production speed is 11.678kg/hr. It also gave comfort to the workers because it decreases the amount of effort, they have to exert during the de-shelling process of the nut it decrease the chance of numbness of arms during the manual process. The design helps the operator reduce the risk of ergonomics hazard he/she may encounter during the manual de-shelling process. Base on the reviews and surveys the workers were pleased with the prototype that the researchers produced. The machine checked all the requirements that the workers put up and as well as all the expectations of the study.

RECOMMENDATIONS

For further and future study of cashew nut de-shelling machine the researchers recommend enhancement of the speed of the production rate. The researchers would like to suggest to look for alternatives and combine the studies for better results of the product, increase the production and less hazards for the operator.

- Reduce the size of the machine and reduce the motor capacity to minimum to decrease the power consumption of the machine and make it compact.
- Find and use a standard spring force of 170N that can easily be adjusted and appropriate for the design of the machine. The researchers only installed and used a MS plate (5mm thickness) assembly on the upper v-guide and spring guide because it lacks actuation and spring pressure.
- The design of the machine needs further research development in terms of the chassis due to some parts unnecessary with the machine design.
- The researchers suggest to change the V-guide material to stainless steel to lessen the friction loss and increase the impact load.
- Reduce the angle of the Y-blade to achieve better product results.

- The height of the machine can be adjusted to become more compact, the current design has too many space underneath.
- Putting a stainless-steel guard to some components that may hit the cashew nut after shelling process.
- Changing of adjustable nut of the spring guide to adjustable caps or wing nuts.

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APPENDICES

Appendix A. Definition of terms

- Kernel - a softer, usually edible part of a nut, seed or fruit stone contained within its hard shell.
- Pre-Treatment – the treatment of something with a chemical before use.
- Anacardic Acid – chemical compounds found in the shell of the cashew nut.
- Dermatogenic – a consequence of a skin disease.
- Cardol – liquid chemical from the cashew nut shell.
- Hazardous – involving or exposing one to risk.
- Poison Ivy – a climbing plant of cashew nut family that produces an irritating oil causing a usually intensely itching skin rash.
- De-shelling – to remove the shell.
- Roasting – to cook by, exposing to dry heat or by surrounding with hot flames, sand or stones.
- Oil bath – a type of heated bath most commonly used to heat up chemical reactions.
- Steam – a vapor rising from a heated substance.
- Boiling – heated to the boiling point.
- Brittle – easily broken, cracked, or snapped.
- Tedious – tired some because of length or dullness.
- CNSL – cashew nut shell liquid; is a dark brown viscous liquid present inside a honeycomb structure of the cashew nut shell.
- Intensive – concentrated on a single area of subject or into a short time; very thorough or vigorous.
- Contamination – a process of contaminating: a state of being contaminated.
- Caustic – able to burn or corrode organic tissue by chemical reaction.
- Irregularity – the state or quality of being irregular.
- Longitudinal Axis – is a line passing through the centroid of the cross sections.
- Versatile – able to adapt or be adapted to many different functions or activities.
- Tainted – contaminated or pollute something.
- Transverse – situated or extending across something.
- Moisture – water or other liquid diffused in a small quantity as vapor within as solid or condensed on a surface.
- WKO – whole kernel out.
- Prototype – a first, typical or preliminary model of something, especially a machined.
- Stationary – not moving or not intended to be moved.
- Impact load – a force delivered by a blow.
- Kinetic energy – energy with a body possesses by virtue of being in motion.
- Plastically – capable of being shaped or formed.
- Breakage – the action of breaking something or the fact of being broken.
- Obstruction – a thing that impedes or prevents passage or progress; obstacle or blockage.
- Conventional – base on or in with what is generally done or believed.
- Sphericity – is the condition where the variances of the differences between all combination of related groups(levels) are equal.
- Deformation – the action or process of changing in shape or distorting, especially through the application of pressure.
- Torque – a twisting force tends to cause rotation.
- Angular speed – is the change of angular displacement with respect to time.
- Ergonomics – the study of people's efficiency in their working environment.

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Appendix B: Computation of data

Computation of minimum power required to split a cashew nut

$$IMPACT\ ENERGY = \frac{1}{2}mV^2$$

$$Mass_{avg} = 2.9g$$

mass average of cashew nuts.

$$IMPACT\ E. = \frac{1}{2}(0.00029)(V)^2$$
$$= 0.00145(V)^2$$

$$WORK\ OF\ DEFORMATION = 0.5F\ x\ e$$

e = MAXIMUM ELONGATION OF CASHEW NUT

$$WORK\ OF\ DEFORMATION\ IS\ ALSO\ EQUAL\ TO$$
$$= IMPACT\ LOAD\ x\ MAXIMUM\ ELONGATION$$

$$IMPACT\ LOAD_{MEAN} = 80.1N$$

MEAN IMPACT LOAD NEEDED TO SPLIT CASHEW NUT IN LONGITUDINAL METHOD

$$WORK\ OF\ DEFORMATION = 80.1N\ x\ e$$
$$e = 7.25mm\ or\ 0.00725m$$

$$WORK\ OF\ DEFORMATION = 80.1N\ (0.00725m)$$
$$= 0.58J$$

EQUATING WORK OF DEFORMATION TO KINETIC ENERGY

$$0.00145(V)^2 = 0.58$$
$$V = \sqrt{\frac{0.58}{0.00145}} = 20\frac{m}{s}$$

$$V = \omega x r$$

WHERE r IS THE RADIUS OF FRONT SHAFT 3

$$\omega = \frac{20}{0.078} = 256.4\ rad$$
$$\omega = 2\pi N$$

$$N = \frac{256.4}{2\pi} = 40.8rpm$$

Getting the force required to get torque minimum

$$F = m \propto$$
$$F = m\omega^2 r$$
$$F = 0.0029kg(256.4rad)^2(0.078m) = 14.87N$$
$$T = Fxr$$
$$T = 14.87N\ x\ 0.078m = 1.16N - m$$
$$P = T\ x\ \omega$$
$$P = 1.16N - m(256.4rad)$$
$$P = 297.424W$$
$$P = 297.42W\left(\frac{1Hp}{746W}\right) = 0.4Hp$$

0.4Hp is the minimum power required to split a cashew nut

In this computation table shows how to acquire the minimum power required to split a cashew nut. e is the deformation, v is the required velocity for the impact load needed to split a cashew nut, N minimum is 40rev/min, within our design we installed a higher rpm of 60rev/min to increase the production rate, and a 30:1 gear reducer to maximize the required torque, the machine design for the mechanism should be low speed and high torque to acquire the 1 at a time splitting to increase the shelling efficiency. The computed power 0.4Hp is the minimum required to split a cashew nut