DESIGN AND FABRICATION OF CASHEWNUT SHELLING MACHINE

BY

OLADERU OLAITAN EYTAYO
(REG. NO. 93/3996)

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DECLARATION

I hereby declare that this work "Cashew nut sheller" was designed and fabricated by me under the supervision and guidiance of Mrs Z.D.Osunde of the department of Agricultural Engineering, Federal University of Technology, Minna, Niger State during the 1997/98 academic session.

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OLADERU, O.E
93/3996

1/3/99
DATE

CERTIFICATION

This is the bonafide project report prepared and submitted by Oladeru Olaitan Eyitayo at the end of the final year programme in Agricultural Engineering Department.

.... DATE 15/12/98............

Mrs. Z.D. OSUNDE

Supervisor

.... DATE 16/12/98............

EXTERNAL EXAMINER

Prof. J. O. Ohu

.... DATE 1/3/1999............

Dr. M.G. YISA

H.O.D AGRICULTURAL ENGINEERING TECHNOLOGY

(CHIEF EXAMINER)

DEDICATION

TO GOD BE THE GLORY.

This project is dedicated to my mother (Mrs. Beatrice Oladeru) for making this project a success.

ACKNOWLEDGEMENT

God out of his loving kindness made me understand that He starts to work when man's effort has failed . I give Him all the adoration ,praise and worship for giving me the wisdom and understanding to make those tough decisions which have helped me to become the man I am today. I thank you for excepting my mistakes and my shortcomings which are part of my human nature .He is entirely responsible for all the success of this project and the course in general .

I owe my Supervisor,Mrs Z.D Osunde a lot of thanks for her deep interest, encouragement and moral support . Her "keep going" attitude helped me a lot during the stormy periods when things looked as if it was impossible. She gave useful ideas and suggestions that kept me going.I also thank all my teachers from elementary school to university level.

I use this opportunity to thank my mum (Mrs.Beatrice Oladeru), you are really a great and loving mother, if I say I expect all that you have done for me then I have no iota of truth in me .You really surprise me, despite our present condition, you still gave me more than what I needed.I don't know how to thank you for your genuine interest, encouragement, moral and financial support.Idon't know the word that I can use to thank you for your spiritual support you gave me right from the day I was born, through out the trouble times to the present moment. All I can just say is that God will support you in all your endeavours.Thank you.I also thank my only and only sister Yemi Oladeru for her concern, understanding and support .And my father Pa T.A Oladeru (of blessed memory, eternal rest grant him O Lord).

I will never overlook the effort of my aunt, Mrs Tayo Olatilu and her husband for all what they did,I say thank you.

The last but not the least are all my friends and fans too numerous to mention,the foremost

of this people are my room mates Olota Anthony, Sunday Pius Ogbu, Okojie Friday, Toba Adebayo, Adeniran Adewale, Oni Adebayo, Mesele Hezzy, and Adetayo Solomon, I thank you all for your understanding and co-operation.

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ABSTRACT

The physical properties of cashew nut were investigated and mechanical properties relating to shelling were studies which yielded results indicating that the hand structure of the nutshell normally required a force in the range of 520-680N to crack under plane surface loading on a 'raw' nut but if specific conditions were chosen such that blade loading were applied to a 'treated' nut across it's width, the cracking force was reduced to approximately 210N.

The Design consideration on the manually operated sheller utilised the principle of press/twist of the sheller's blade. The shelling rate of the manually operated sheller is 0.52kg/hr while the shelling efficiency is 80% and the whole kernel recovery is 66.7%.

CHAPTER ONE

INTRODUCTION

The Cashew (Anacardium Occidentale) belongs to the family Anacardiaceae is native to the American Tropics from Mexico to Brazil and to the West Indies, but it has since become naturalized in many lowland tropical Areas. It's one of the most nutritious food crop of the tropical world, with it's high protein and fat content. It has appreciable amount of minerals (Calcium, Phosphorus and Iron) and Vitamins compared to other nuts such as almonds walnuts and peanuts.

The tree is spreading fast growing Evergreen up to 12 meters in heights, leaves are leathry and orate with prominent veins. The fruits is a kidney shaped nut on the base of the large receptacle called the 'Cashew apple' which is thin-skinned and edible. The largest African producers of cashews are Mozambique and Tanzania with smaller amount being produced in Kenya, Malagasi Republic, Malawi, Nigeria and Senegal.

There is a great deal of current interest in this Crop since it will thrive in relatively dry areas of low fertility and also requires few expensive inputs. It offers attractive local income and good export potential specifically in the shelled form. As a comparism between the prices of unshelled and shelled Cashew nuts, the local price of raw or unshelled for one kilogram is ₦85.00 whereas that of kernel (shelled nut) also for one kilogram is ₦600.00, depending on their appearance and size. It takes approximately four kilograms of unshelled nuts to make one kilogram of kernels, therefore, it is obvious that good profit can be obtained from the crops, either in the village - level industry or large scale industry.

The art of processing Cashew nuts is to shell them and extract the kernels 'whole' without breaking or damaging them. The method employed by Cashew nut farmers and manufacturers to shell the nuts have mainly included traditional method of shelling, small shelling devices which usually.

are not efficient in their performance and a few cases of highly complex and expensive shelling mechinery, usually through imports from Europe, Israel and U.S.A.

The project is to design and fabricate a semi mechanised cashew nut shelling mechine with locally available materials which must be easily maintained, durable, portable and comfortable in use and competitive in the market.

1.1 JUSTIFICATION

The traditional method of shelling usually result in less white whole kernel recovery and a lot of energy are expended and most farmers are unable to buy the imported sheller, based on these problem an intermediate type of shelling machinery with efficient performance and economically cost are considered necessary in order to reduce waste incure in the traditional method of shelling,energy expended and to help cashew nuts farmers earn attractive income from the shelling industry.

1.2 OBJECTIVES

The specific objectives are :

1. To design cashewnut shelling machine
2. To construct this machine with locally available materials
3. It must be easily maintained, durable, potable and comfortable in use and competitive in the market.
4. The weight must be consistence with practical application.
5. The machine must be cheap, affordable by local farmers .

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 GENERAL

Nigeria's harvest of the multi-purpose cashew nut it's second most important non oil export crop and foreign exchange earner has been suitable for cashew and much of the harvesting is done before the rain starts.

Nigeria cashew nut stock is estimated to be 80,000 metric tonnes per year and worth some $30 million. In view of cashews many uses and its great potential as a revenue -generating crop, its cultivation and processing on a large scale should boost Nigeria's national economic. Apart from foreign exchange earning and locally generated revenue, it serve as additional source of employment for plantation, factory and management staff.

2.2 BOTANY OF CASHEW NUT

The cashew nut is kidney shaped and has sectional view as shown in figure 1,It consists mainly of a nutshell (pericarp) and a kernel which is the main product of the cashew industry. The pericarp consist of a hard outer shell (epicarp), a honey combed structure (mesocarp) in the cells of which is contained a useful but toxic natural resin, known commercially as cashew nut shell liquid (CNSL) and a hard and brittle inner shell (endocarp) which protects the kernel, there is a covering of thin membrane on the kernel known as testa or peel which again protects the kernel.

The kernel (seed) is made of two developed kidney-shape cotyledons and embryo. The average of a whole fruit varies from 3-5g to15- 18g according to variety and cultivations (pedinick 1969). Generally, the kernel accounts for about 22-24% of the whole fruit at processing.

Kernel chemical composition has'high lipid and good protein content as given by Guimaraes and

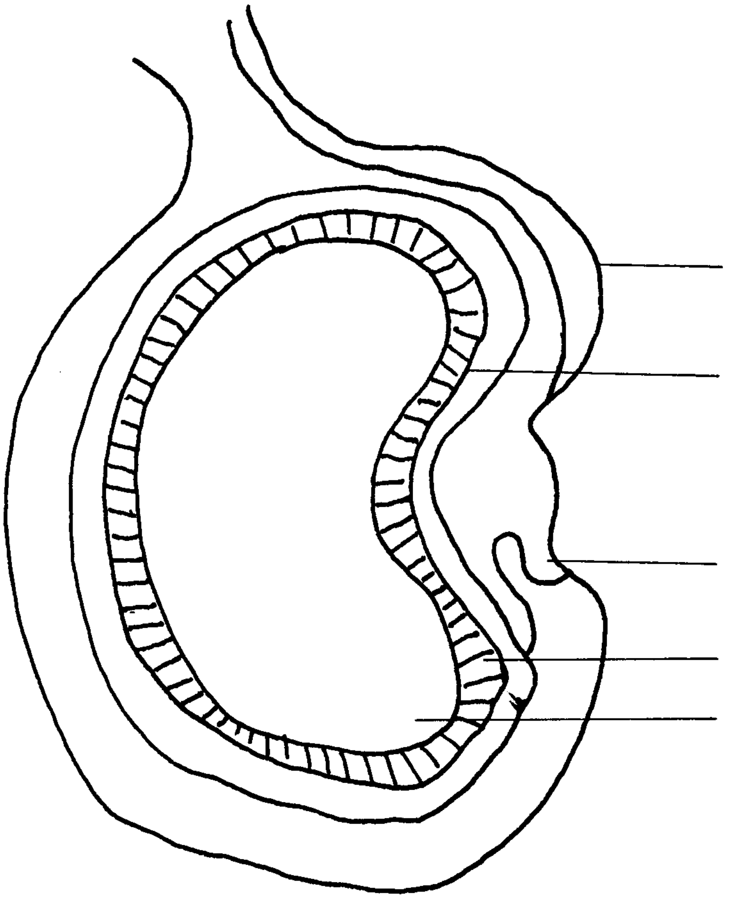


Fig. 1 SECTIONAL VIEW OF CASHEWNUT

Pechnick (1969).

Table 1 CASHEW NUT KERNEL CHEMICAL COMPOSITION

Composition	Percentage
Moisture	2.0
Crude protein	20.9
Ethered extract	47.0
Carbohydrates	27.2
Crude fiber	1.2
Mineral salts	1.7

Non saturated fatty acids prevail (over 80%)

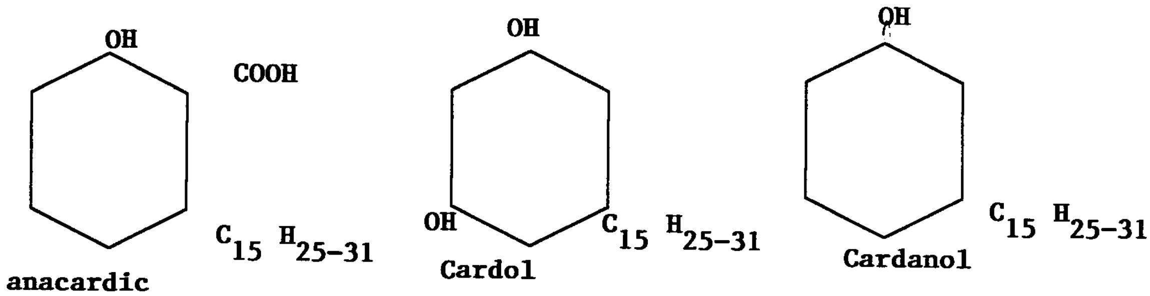
The most recurrent fatty acids are Oleic, Stearic, Palmitic and Linoleic acids (Pechnick and Guimaraes 1969). The 9-10 amino acids needed for man nutrition are present. The peel, standing for 2.5% of the fruit weight, is another by-product and can be used in the animal feed industry or for tannin extraction.

2.3 CASHEW NUT SHELL LIQUID (CNSL)

The cashew fruit mesocarp or nut is a spongy tissue containing a corrosive resin, known as CNSL (cashew nut shell liquid). The cashew nut shell liquid is of 30-40% of the whole pericarp or shell.

CNSL from the pericarp maybe extracted by surfacing in a hot bath, but with a very low yeild, or by hot squeezing, with 90% yeild. The remaining 10% is extracted by means of solvents. CNSL composition when cold extraction is used, is 90% anacardic acid (3-n-pentadecadienyisalicylic acid) and 10% cardol (3-n-pentadecadienylresorcinol)

During extraction, the anaeardic acid loses the -COOH radical, thus it decarboxylates giving Cardanol. Formulae for these three compounds follow:



2.4 NUTRITIONAL QUALITIES OF CASHEW KERNEL

Like all other seeds, the cashew kernel is mainly constituted by a lipidic and a protein fraction. Besides starchy substances and mineral salts contained in ash. Cashew kernel composition without peel is given in table 1.

It is clear that the cashew kernel has high lipid (46%) and medium protein (19.5%) content. Conversely, crude fiber content is low, which is a possible feature. Mineral salt content is similar to that for other Oleaginous seeds. While phosphorous is relatively high, indicating varying amounts of phospholipids. Phosphorous content measured in kernel of various origins is quite constant equal to 1.96%.

Cashew nut oil is pale to orange yellow and is darker when a high percentage of peel is attached to the kernel. Data on cashew kernel oil show its composition to be halfway between peanut and olive oils. The cashew contains relatively high percentage of stearic and oleic acid and the saturated/unsaturated acid ratio is 4:1, according to nutritionists ideal (5 being the ideal value) for a correct diet.

2.5 ECONOMIC IMPORTANCE

The most important product of cahsew trees is the nut which has many uses. Roasted cashew nut are used as dessert. But cashew liquid (CNSL) is converted to resins used in brake lining of jet plane and the clutch facings of motor cars.

The united state of America, United Kingdom and other European countries are much more interested in the cashew nut liquid which they convert into different types of resins and with advances in chemical technology, these are also used to manufacture plastics, printing ink, germicides, insecticides, wood and fabric preservatives.

Cashew butter, similar to peanut butter is used in confectionary and bakery products. The nut also contains a golden yellow edible oil of excellent quality which has been found to contain high protein. It is also used in the manufacture of jam, syrup, fruit juice, wines, brandy and vinegar.

The amber-like cashew gum which exudes from the bark of the cashew tree is used in book binding as an adhesive.

2.6 CASHEW NUT PROCESSING

The processing of cashew nuts involves series of unit operations such as cleaning, sorting, roasting, shelling, parking e.t.c. before it finally get to the final consumer. But the main processes engage in by the cashew nut farmers before it get to the processing industry is the removal of the cashew nut shell liquid (CNSL) which is an irritant and will contaminate the nut blister human skin if not handled properly.

The traditional method of treatment is to roast the nuts over an open fire, this removes the CNSL which is a valuable source of natural Phenols.

Another technique is to roast the nuts in vats of hot (190-200°C) oil removes the CNSL from the nuts and allow for its collection and sale. Other techniques have been developed which include cooling to fix the CNSL, and steaming of the nuts and later oven dry at 210°C. (Astedy 1988)

2.7 SHELLING

Shelling of cashew nut is the act of removing the kernel from the cashew nut. Shelling is perhaps the greatest bottleneck along the processing line especially because of the deplorable condition of both the local method of shelling and the automatic shelling machine.

The achievement of production target is highly dependent on the capacity of the method of shelling adopted. After shelling, separation of kernel from the shell is carried out either by winnowing or blowing.

As a result of consumers and commercial buyers increasing preference for white whole kernels, the general target in any cashew nut processing plant is to get a high percentage of white whole kernels. Other grades are dessert wholes, butts, splits and pieces. All these are in 15 different categories of internationally accepted sub-classification namely: W180, W210, W240, W320, W450, Dessert split, Lwp, Lwp (Dessert), Swp (Dessert), Dessert whole, Fancy butt, Scorched Butt, White split and Chips (Lincholstroblu 1994) the kernels according to these grades are packed (manually).

2.7.1 LOCAL METHOD OF SHELLING

Today, in Nigeria cashew nut processing is still carried out traditional methods in what may not be defined as real factories. The material is prepared for shelling either by being moistened or dried in the sun. Then the nuts are roasted on a perforated open pan or put in a rotating drum treated over a fire. In some cases an autoclave is used before shelling or this operation is done without roasting.

Shelling is often carried out at home by individual workers paid on the basis of whole kernels yeild. Shelling is done by hand with a hammer or with pedal-operating stears or using mortal and pestle.

ADVANTAGES OF LOCAL METHOD OF SHELLING

1. The method is very simple.
2. Its easy to construct, operate and maintain.
3. Local material are mainly used.

DISADVANTAGE OF LOCAL METHOD OF SHELLING

1. The method is purely inhygenic, the nuts can easily be contaminated while cracking.
2. It is time consuming.
3. Much energy is expended.
4. Its efficiency is relatively low.
5. High labour intensive.
6. Low white whole kernel yeild.

2.7.2 MECHANICAL METHOD OF SHELLING

There are many mechanical systems of shelling cashew nut, but most recent one is the OLTREMARE mechanical system. But generally, shelling of cashew nut mechanically involves four (4) stages of operation.

The cashew nut are first WASHED in the washing machine to remove plant debris, small stones and particles which constitute impurities. The nuts are Humidifiedfor a period of 6-72 hours to increase the moisture content, there is no fixed regulation on how to carryout humification because the operation is highly affected by the nature of the nuts, place of harvest and initial moisture content.

Each lot of the humidified (large, medium and small) nuts are ROASTED at a temperature of 190°C to 200°C by passing through cashew nut shell liquid (CNSL) oil bath and allowed to cool for 24 hours to facilitate SHELLING. During shelling, the nut is cracking and the separation of kernel from the shells is retrieved by a pneumatic mechanism, the moisture content of kernels at this stage is between 6% to 7%.

ADVANTAGES OF MECHANICAL METHOD OF SHELLING

1. The machine gives room for hygine.
2. It requires little labour.
3. It is not time consuming.
4. Suitable for medium and large scale production.
5. Cashew nut shell liquid is recover.

DISADVANTAGES OF MECHANICAL METHOD OF SHELLING

1. It is expensive when compared to local method.
2. Ow white whole kernel recovery.
3. Can be affected by the environmental condition leading to wear and tears and corrosion of the body.
4. High maintenance cost.
5. Require skill labour.

CHAPTER THREE

METHODOLOGY

Information on properties of material for which a machine is to be design is very important in any Engineering design if the machine is to perform efficiently for the purpose for which it is designed. In designing a shelling machine for Cashew nut, certain properties of cashew has to be know such as the physical properties which will help the designer to have an idea of it shape, size, shell thickness as well as kernel weight.

Mechanical properties of cashew nut is also important in designing a meaningful shelling machine. The nature as well as the hardness of the Cashew nut shell has to be understood for the designer to know the exact force capable of cracking the shell without breaking or cracking the kernel.

3.1 PHYSICAL PROPERTIES OF CASHEWNUT

Apart from the general characteristics of a cashew nut already described in chapter two, its main physical dimensions are defined as show in fig. 2 and its density, shell thickness kernel weight as well as shell weight have also being investigated as presented in table2, in which the results were obtained from 200 nuts taken 40 each from 5 sacks. The sacks were taken randomly out of 20 sacks at Cashew nut processing industries Plc. Eleyele, Ibadan, Oyo State, Nigeria.

The sample were of the western part of Nigeria variety and which has been stored for a period of seven (7) months.

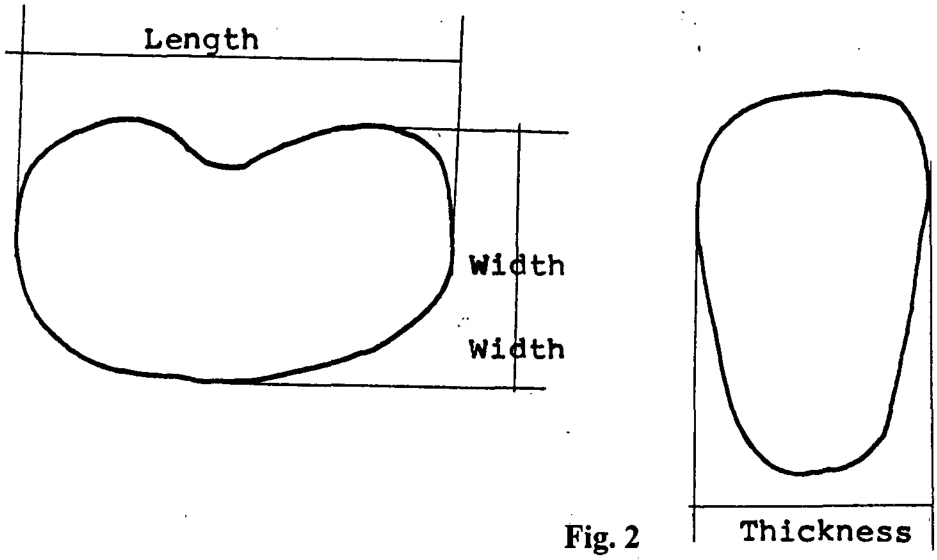


Fig. 2

Table 2: Physical characteristics of cashew nut samples of the western part of Nigeria variety.

	Physical parameter	Maximum	Minimum	Mean
1	Nut length (mm)	33.00	27.70	32.40
2	Nut width (mm)	30.10	21.12	20.00
3	Nut thickness (mm)	23.45	17.90	25.00
4	Nut density (g/cm^3)	2.01	0.80	1.06
5	Shell thickness (mm)	2.56	2.00	2.34
6	Kernel weight (g)	2.00	1.15	1.50
7	Shell weight (g)	3.05	2.00	2.70

3.2 MECHANICAL PROPERTIES

Mechanical properties are those having to do with the behaviour of material under applied force. A study on the breakage strength of the shell was carried out on raw nut (nut without conventional preshelling treatment) and treated nut (nut given conventional preshelling treatment) using force/deformation measuring machine at cashew nut processing industries Plc. Eleyele, Ibadan, Oyo State, Nigeria. The machine consists of a base, a measuring scale which is graduated in kilogram force (kgf), a clamp, a press edge (lever), a support and electric motor.

The Cashew nut is placed on the base and is held in place from the top by a clamp. It is ensure that the measuring scale is in zero kgf before switching on the machine. As soon as the machine is switched on, the point edge will press the cashew nut and at the same time the scale will be reading. This continues until the nut crack and at that point the reading on the scale is recorded in kgf and later converted into Newton using conversion factor of 9.806605. The two distinct results are presented below.

Firstly, 'Raw' nuts were subjected to compressive loads applied by plane surface until nut shell breakage occured in three different directions (i.e. the major, minor and intermediate diameter) using force/deformation measuring machine. This was to obtain an indication as to the magnitude of the force required to break the nut shell in a simple way. The result indicated a force with magnitude in the range of 550-650N is required to break the nut shell since human (Adult) can exert maximum force of 80N while in standing position and 250N in sitting position using one hand (Woodson, Tillman, Tillman, 1992). It's seen to be too high and which must be reduced substantially before having any practical use.

Secondly a treated nut was subjected to compressive loads across width (i.e. intermediate diameter) using force/deformation measuring machine. The result indicated a force with magnitude 210N gives the maximum cracking force considerably less than that in the previous testing by plane surface and being much more practical for actual use since man can generate maximum force of 250N while in sitting position using one hand (Woodson, Tillman, Tillman 1992). All the test was carried out on 100 cashew nuts taking 20 each from

5 sacks for raw nuts and also the same amount for treated nuts. The 5 sacks are selected randomly from 20 sacks of raw nut and also 20 sacks of treated nut.

In addition to the second result, it was considered essential to investigate further that if the cracked nutshell was to be opened up by certain means, such as a twisting action of the upper blade immediately after the cracking action. According to Tunde (1989) investigation, it reveal that maximum torque has a magnitude of approximately 3.5N and also previous work done at Cashew nut processing industries Plc. Eleyele Ibadan, Oyo State by Olaoye (1992) revealed that torque of 3.52Nm will be required to open the cracked nut shell.

From the study of mechanical properties of cashew nut as stated above, it can be concluded that the new methodology employing two sequential process including the blade loading across the nut width for the cracking of the nut shell and the blade twisting for the opening of the cracked nutshell form the basis of the shelling method in the machinery to be developed under this project.

3.3 DESIGN CONSIDERATION

The design consideration commenced with a study of two existing manually operated sheller which were the foot operated press blade type and the two hand operated press separation blade type.

A preliminary testing of these shellers was carried out and the test result indicated that the hand operated press-separation blade type gave better performance than the foot operated press type. The good features of this sheller was it's two continuous actions of pressing and separating the blade to open up the nutshell after cracking resulting in high shelling rate and whole kernel recovery.

The single hand sheller to be developed combined the two action of pressing and twisting of the blade of the two hand operated press separation blade type which enable the single hand operated sheller to crack and open up the nut shell as required.

The difference between the single hand operated sheller and the two hand operated press separation blade lies in their mode of operation the single hand . . . as it names implies uses are hand press the nut as well as twisting the cracked nut to open up and the single hand operated sheller has one press/twist lever whereas the two hand operated press separation blade type uses both hands and has two press/twist lever.

3.4 CONSTRUCTION CONCEPT

The machine was constructed to shell cashew nut in order to recover whole white kernel. The nuts are considered to have been roasted and allowed to cool for 24 hours to improve shelling efficiency.

The feeding of the nut to the machine is done by hand, the machine is considered to be able to work on a farm with or without Electricity and as such source of power is human power.

3.5 MATERIAL SELECTION

The primary goal in designing a machine is that the strength of the part have a factor of safety greater than one (1) and to meet this goal, the designer must know the properties of the materials to be used for different parts, such properties includes; strength of the material under loading and unloading conditions; physical properties of the material thermal properly ; mechanical property; chemical property; and also availability of the material and their workability (Ojo, 1996).

The material selection problem is further complicated by the fact that the material properties are influenced by the manufacturing process and by the geometry of the component, types of forces acting on it and as such it is important that the performance of the component in service rather than the behaviours of material in component that counts.

Economy selection between material cannot be based solely on the cost of materials procedure for materials selection can be summarized as follows:

1. Analysis of the material selection.
2. Development of alternative solution to the problem of material selection.
3. Evaluation of different solutions.
4. Decision on the optimum material.

Reliability of material can be defined as the probability that it will perform the intended service for the expected life without failure. But material reliability is difficult to measure because it's not only dependent upon the material interest nature and properties. But is also largely a function of its production and processing history. The environment in which the components will operate plays an important role in determining the material requirement, the coefficient of thermal expansion of all materials involved in a part may have to be similar to avoid thermal stress.

After considering these properties, it is considered fit to have the sheller component (such as base, frame blade, press/twist lever upper blade holder and holder casen) constructed of mild steel while the spring is of oil tempered wire.

3.6 MACHINE COMPONENT

The sheller has mainly eight component parts which are as follows:

1. Base
2. Spring
3. Frame
4. Upper blade holder
5. Press/twist lever
6. Upper Blade
7. Lower Blade
8. Holder Casen

BASE

The Base support all other components of the sheller, it's made of mild steel of 10mm thickness, the thickness was chosen on the basis of the strength require of the Base to be able to withstand the impact of the press/twist lever. Also the Area of the Base was chosen so as to reduce the weight of the sheller as well as making the sheller compqct

Area of Base = length x Breadth

= 300mm x 200mm

= 60,000mm^2

= 0.06m^2

Volume of Base = Area x thickness

= 60,000mm^2 x 10mm

= 600,000mm^3

= 6 x 10^{-4}m^3

Mass of Base = Density of mildsteel x Volume of Base

$= 7830 \times 6 \times 10^{-4}$

= 4.7kg

SPRING

The spring is an oil tempered wire type that is cold drawn to size and quenched and tempered. The choice was based on the force to be exerted (210N), the cost when compared with music wire is economical, but is ordinarily not considered suitable where long fatigue life is required.

Spring Design

P = F = load required (force)

Fs = factor of safety

S_{uit} = Minimum tensile strength

S_{syp} = yield strength in shear

D = mean coil diameter

d = diameter of wire

k = Shear stress correction factor

c = Spring index

n = no of active coil

G = Shear stress in modulus

Ss = permissible stress

As = Actual stress

The spring design is based on spring design procedure (Spott m.f 1988): Design of machine element).

No 6 wire was chosen from table 4.1 (Design of machine element spott m.f 1988) based on the force (210N).

The diameter of wire (d) = 0.1920in = 4.8768mm

S_{uit} = 195,000 Psi = 1.3444782 x 10^9N/m^2

from table 4.6Ssyp = 0.45 x S_{uit}

$$= 0.45 \times 1.3444782 \times 10^9$$

$$= 6.0501519 \times 10^8 N/m^2$$

$$\therefore \text{permissible stress (Ss)} = \frac{Ssyp}{Fs}$$

The factor of safety chosen within the range of factor of safety is accepted if the permissible stress is greater than. Actual stress (otherwise choose another factor of safety) (Spott M.F 1988).

$$Ss = \frac{Ssyp}{Fs}$$

$$Ss = \frac{6.05015519 \times 10^8 N/m^2}{1.5}$$

$$Ss = 4.03334346 \times 10^8 N/m^2$$

Actual Stress (As) = $\frac{K8FD}{\pi d^3}$ (Machine design schaum series, 1989)

where

$$K = \frac{4c-1}{4c-4} + \frac{0.615}{4} \text{ (Spott, 1988)}$$

C = D/d (machine design schaum series, 1961)

D = 20mm

$d = 4.8768mm$

$$C = \frac{20mm}{4.8768mm}$$

$C = 4.1$

$$\therefore K = \frac{4(4.1) - 1}{4(4.1) - 4} + \frac{0.615}{4}$$

$$K = \frac{15.404}{12.404} + 0.149962$$

$K = 1.392$

$$As = \frac{K8FD}{\pi d^3}$$

$$As = \frac{1.392 \times 8 \times 210 \times 20 \times 10^{-3}}{\pi(4.8768 \times 10^{-3})^3}$$

$As = 1.28358255 \times 10^8 N/m^2$

Note

When Actual Stress is less than permissible stress design is all right (Spott m.f 1988)

Spring Deflection

The deflection $y = \frac{8Fc^3n}{D.G} = \frac{8fD^3n}{d^4G}$ (Spott 1988)

no of active coil is base on magnitude of force to be exerted on the spring. Chosen n is 6.

$$y = \frac{8 \times 210 \times (4.1)^3 \times 6}{4.8768 \times 10^{-3} \times 79300 \times 10^6}$$

$y = 0.0018m$

$y = 1.8mm$

Spring Rate

$$\text{Spring rate (T)} = \frac{G.d}{8c^3n} = F/y$$

$$T = \frac{4.8768 \times 10^{-3} \times 79300 \times 10^{6}}{8 \times (4.1)^{3} \times 6}$$

$$T = \frac{386730240}{3308.208}$$

$$T = 116900.2 N/m$$

Spring to be selected

No 6 wire

$d = 4.87in \approx 5mm$

$n = 6$

$D = 20mm$

FRAME

The is the support that carries the upper blade holder, spring, upper blade, press/Twist lever and holder casing. It is made of mild steel square pipe of 38.1mm by 38.1mm. It's welded to the base in a vertical position. The height of the frame was obtained by adding the upper blade holder heights, Distance of travel of the upper blade holder to touch the cashew nut, the height of cashew nut and cashew holder casing height. The 38.1mm by 38.1mm square pipe of 2.5mm thickness was chosen base on the rigidity required of the frame.

Volume of frame = 4 Breadth x thickness x length

$= 4(38.1) \times 2.5 \times 250$

$= 95250mm^3$

$= 9.5250 \times 10^{-5} m^3$

Mass = Density x Volume

$= 7830 \times 9.5250 \times 10^{-5}$

$= 0.75kg$

UPPER BLADE HOLDER

It anterior end is attached to press/twist lever while the posterior part is attached to the upper blade. The dimension of the upper blade holder (18.5mm) was chosen based on the blade size which in turn is based on the average width size of cashew nut (20mm). The height was obtained based on the distance between the press/twist lever and the Cashew nut after considering the distance it will travel before it cut the nut shell.

The upper blade holder is made of circular mild steel rod of 18.5m and the length is 145mm

Volume $= \pi r^2 h$

$= \pi(9.25)^2 \times 145(mm^2 \times mm)$

$= 38976.4mm^3$

$= 3.8976 \times 10^{-5}m^3$

mass of holder = density x volume

$= 7830 \times 3.8976 \times 10^{-5}$

$= 0.31kg$

PRESS/TWIST LEVER

This is the handle for compressing the spring and for twisting the upper blade in order to open the Cashew nut from the top.

When force has to be applied to a lever the diameter of the handle must be large enough so that the user's hand and finger surface contact is maximized, but not so large that a firm grip cannot be maintained.

Woodson Tillman and Tillman (1992) anthropometric data investigation shows that 75 per cent of Adult (human) has hand length of 8.2in (208.28mm) while hand breadth at thumb is 3.8in (96.52mm). This dimension reveals that human (Adult) can have a firm grip of material with diameter not exceeding 50mm and the length of the material should not exceed 400mm when the user is in sitting position.

Based on the above consideration the press/twist lever is made of hollow circular pipe made of mild steel of 30mm diameter and of 250mm length circular pipe was chosen for easy gripping.

$$\text{Volume} = \pi r^2 h$$
$$= \pi(15)^2 \times 250$$
$$= 176737.5\text{mm}^3$$
$$= 1.767375 \times 10^{-4}\text{m}^3$$

$$\text{Mass} = \text{Density} \times \text{Volume of Pipe}$$
$$= 7830 \times 1.767375 \times 10^{-4}$$
$$= 1.38\text{kg}$$

UPPER BLADE

It is attached to the blade holder for opening of the nut shell from the top. It's made of mild steel of 1mm thickness and the length is based on the average cashew nut width size (20mm) and allowance is given in case of a large nut (3mm) making the length to be 23mm.

$$\text{Area} = \text{length} \times \text{height}$$
$$= 40\text{mm} \times 10\text{mm}$$
$$= 4 \times 10^{-4}\text{m}^2$$

Volume = Area x thickness

$= 400mm^2 \times 1mm$

$= 400mm^3$

$= 4 \times 10^{-7}m^3$

Mass = Density x Volume

$= 7830 \times 4 \times 10^{-7}$

$= 3.132 \times 10^{-3}$

= 0.003kg

LOWER BLADE

The lower Blade is for opening of the nut from the bottom and it's attached to the nut Housing, it's also made of the same material as upper blade and having the same dimension.

HOLDER CASING

It hold the spring in position and it's through it that the upper blade holder moves up and down. The dimension was chosen base on the addition of the dimension of upper blade holder moving within it and the spring diameter (that is wound round the upper blade holder) and an allowance was given for easy movement.

Based on these, the casing is made of circular pipe of mild steel of 25mm diameter and of 30mm length for easy movement of the upper blade holder. The length was chosen based on the no of turn required on the upper blade holder.

Volume $= \pi r^2 h$

$= \pi(12.5)^2 \times 30\ (mm^2 \times mm)$

$= 14728.13mm^3$

$= 1.472813 \times 10^{-5} m^3$

Mass $= \text{density} \times \text{volume}$

$= 7830 \times 1.472813 \times 10^{-5}$

$= 0.12 kg$

The upper blade holder casing is two in number, therefore the total mass of the two is 0.24kg.

CASHEW NUT HOUSING

This is made from mild steel pipe of 30mm diameter, it hold the nut in position and underneath is the lower blade (for cutting the nut from the bottom). The dimension was chosen on the average minor diameter (2.5mm) and major diameter (32.40mm) as well as the intermediate diameter (20.0mm) of Cashew nut. The pipe was cut into two and each one serve as a nut housing.

Volume of nut housing $= \pi r^2 h$

$= \pi \times (15)^2 \times 2.5\ (mm^2 \times mm)$

$= 17673.75 mm^3$

$= 1.77 \times 10^{-5} m^3$

Volume of each nut housing $= 8.8 \times 10^{-6} m^3$

Mass of nut housing $= \text{density} \times \text{volume}$

$= 7830 \times 1.77 \times 10^{-5}$

$= 0.14 kg$

The mass of each nut housing $= \frac{0.14 kg}{2}$

$= 0.07 kg$

HOLDER CASING SUPPORT

This is made of circular mild steel rod of 18mm diameter. It attached the holder casing to the frame. The dimension was chosen based on the size of the Holder casing.

Volume $= \pi r^2 h$

$= \pi(9)^2 \times 60$

$= 15270.12mm$

$= 1.5270 \times 10^{-5}$

Mass of support $=$ Density x Volume

$= 7830 \times 1.5270 \times 10^{-5}$

$= 0.12kg$

3.7 MODE OF OPERATION

The press/twist lever is placed in position (release position) with the upper blade holder. The nut is then fed into the nut casing (under which there is a lower blade). The press/twist lever is then press down to cut the shell of the nut while the lower blade cut the nut from the bottom at the same time by the time the press/twist lever is pressed, the upper blade holder travel 50mm down and by the time it has traveled 2.5mm into the nut and at the same time the lever blade also travel 2.5mm into the nut from the bottom. The Blade cuts the nut shell without cutting the kernel.

The press/twist lever is then used to twist the nut to left and right in order to open up the nut. The press/twist lever is then released in order to come back to it's normal position. The feeding is done manually by hand. The total weight of the sheller is approximately 7.62.

COST OF MACHINE

The total cost of the sheller is two thousand three hundred and sixty six Naira only (₦2,366.00) the cost of each part are given as shown in table 3.

S/N	DESCRIPTION	MATERIAL	QUANTITY	SIZE	PRICE(₦)
1	Base	Mild Steel	1	300mm x 200mm	500.00
2	Frame	Mild Steel	1	250mm long 38.1 mm x 38.1mm	120.00
3	Spring	Oil temperature	1	5mm diameter	300.00
4	Upper blade holder	Mild Steel	1	145mm long	50.00
5	Blade	Mild Steel	4	40mm x 10mm	100.00
6	Press/Twist lever	Mild Steel	1	30mm diameter 250mm long	200.00
7	Holder Casing	Mild Steel	2	25mm diameter	50.00
8	Bolt & Nut	Mild Steel	2		90.00
9	Electrode	Mild Steel	36 pieces		180.00
10	Nut Housing	Mild Steel	2	40mm x 25mm	60.000
11	Frame head	Mild Steel	1	70mm x 20mm	20.00
12	Transport				200.00

Cost of Sheller materials = ₦1820

Workmanship is 30% of the cost of Sheller

Workmanship = 30/100 x ₦1820 = ₦546

Total Cost of Sheller = 1820 + 546 = ₦2366.00

CHAPTER FOUR

TESTING

After fabrication, performance test was carried out on the shelling machine, this was aimed at assessing the performance in term of shelling rate, shelling efficiency and whole kernel recovery.

4.1 PREPARATION OF CASHEW NUT PRIOR TO SHELLING

The Cashew nut are first washed in order to remove plant debris, small stones and particles which constitute impurities. The nuts are humidified for a period of 7-72 hours to increase the moisture content. There is no fixed regulation on how to carry out humidification because the operation is highly affected by the nature of the nuts, place of harvest and initial moisture contents.

Each lot of humidified (large, medium and small) nuts are roasted at a temperature of 190°C - 200°C by passing through cashew nut shell liquid (CNSL) oil bath and allow to cool for 24 hours to facilitate shelling.

4.2 TEST PROCEDURE

Thirty roasted cashew nut was used for the test and this was weighed before shelling commenced. The nuts are placed in the nut housing while the press/twist lever was in release position. The press lever was then press which make the upper blade holder to move down and the upper blade at the posterior end of the upper blade holder cracked the nut shell (without cracking or cutting the kernel).

The sheller was shelling two nuts at a time, the shelling operation was stopped after 5minutes of operation .the total kernel obtained was packed and weighed and also the whole kernel collected from the total kernel was weighed. The following are the measurement taken before and after shelling.

Total weight of cashew nut used =126g = 0.12kg

weight of Cashew nut shelled = 100.8g = 0.1008kg

weight of kernels obtained = 43.2g = 0.0432kg

weight of whole kernels obtained = 28.8g = 0.0288kg

4.3 RESULT

From the performance test carried out on the shelling machine below are the outcome of the test. A total weight of 0.126kg of Cashew nut was used and shelling was carried out for 5 minutes and out of 30 roasted nuts available, 24 nuts were shelled within 5 minutes.

Shelling rate = weight of kernel obtained per unit time

= 0.043kg/5mins

This implies that

5 minutes = 0.043kg

1 minute = 0.043/5

$$60 \text{ minutes} = \frac{0.043 \times 60}{5}$$

= 0.516kg

therefore the shelling rate = 0.52kg/hr

$$\text{Shelling efficiency} = \frac{\text{weight of cashew nut shelled}}{\text{total weight of cashew nut used}} \times 100$$

$$= \frac{0.1008\text{kg} \times 100}{0.126\text{kg}}$$

$$= 0.8 \times 100$$

$$= 80\%$$

$$\text{whole kernel recovery} = \frac{\text{weight of whole kernel obtained} \times 100}{\text{weight of kernel obtained}}$$

$$= \frac{0.0288 \times 100}{0.0432}$$

$$= 0.66 \times 100$$

$$= 66.7\%$$

4.4 DISCUSSION OF RESULTS

The target of any Cashew nut plant (or industry) is to have higher whole kernel recovery. The shelling efficiency as well as the whole kernel recovery are better when compare to local method of shelling and pedal operated sheller but the local method have higher shelling rate than the shelling rate of the machine (sheller).

CHAPTER FIVE

CONLUSION AND RECOMMENDATION

5.1 CONCLUSION

Cashew nut shelling machine was designed and fabrication and a performance test was carried out using roasted Cashew nut. The result was however satisfaction despite the little twisting problem noticed, because it is about 70 times or more better than the local method of shelling in term of whole kernel recovery and energy expended.

5.2 RECOMMENDATIONS

1. The shelling machine should be used for Cashew nut roasted in Cashew nut shell liquid.
2. Effort should be made to solve the twisting problem (i.e. the lever should be easy to twist).
3. Way of increasing the shelling rate should be developed.

REFERENCES

1. Asiedu (1988) Pocessing tropical crop, a technological approach. London, Macmillan press.

2. Hall A.S. and lauglin, H.G.(1961) Machine design (Theory and problems) Schaum's outline Series.

3. Lincholstroblu (1994) The world cashew economy SPA Bologna Italy.

4. Ojo O. (1996) Design and fabrication of a manually operated ground nut oil extractor, H.N.D thesis (unpublished) department of agricultural Engineering, Federal Polytechnic, Ado-Ekiti.

5. Olaoye (1992) Cashew nut processing, Longman London.

6. Pechnick and Gulmaraes (1969) Fruits and vegetables, Longman London

7. Spotts, M.F (1988) Design of machine elements. Prentice hall of India private Limited, New Delhi.

8. Tunde S. (1989) Physical and Engineering Properties of Agricultural crops B.Eng thesis (unpublished), department of Agricultural Engineering, University of Ibadan.

9. Woodson, Tillman,Tillman (1992) Human factors in Engineering Design, London. Macmillan press.