DEVELOPMENT OF AN IMPROVED PALM NUT CRACKER

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BARCHELOR OF ENGINEERING (B. ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

FEBRUARY, 2010.

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communications, published and unpublished work were duly referenced in the text.

[signature]	18-02-2010
Amoo, Ayodeji Stephen	**Date**

CERTIFICATION

This project entitled "Development of an Improved Palm Nut Cracker"by Amoo, Ayodeji Stephen, meets the regulation governing the award of Degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project work is dedicated to God Almighty, the maker of Heaven and Earth, for granting me the privilege to be alive to write this project.

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My gratitude goes to Almighty God, for the gift of life and His love, mercy, divine provision, protection, health and wisdom.

I am most grateful to my able supervisor Mr. M.A Sadeeq, for His unrelenting effort and support in seeing that this work becomes a reality. My sincere appreciation goes to my H.O.D Engr. Dr. A. Balami. And to all my lecturers who have impacted knowledge in me; one way or the other, may God in His infinite mercy bless and protect you all.

My profound gratitude goes to my beloved parents Engr. And Mrs. R.O. Amoo, for their financial, spiritual, moral support, to mention but a few, may God bless them.

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ABSTRACT

This project work entitled the "Development of an Improved Palm Nut Cracker", was done by changing the shape of the hopper, from a rectangular shape to a trapezoidal shaped hopper for easy loading of the product. The cracking device (Hammer), was made four (4) as against three (3) of the formal design. To give room for safety (which is one of the major ethics of engineering profession), belt cover was designed for the system. And as a result, the efficiency of the system was increased to 84%, as against 63% of the former design. Therefore, since this machine has been improved upon, it has solved to a large extent, the problems encountered in the former design. I would recommend that this improved machine, should be produced on a large scale basis; and this would also go a long way in busting the economic strength of the investors, farmers owners of the machine and so on; of the machine; owing to the fact that the time gained could be used to carryout other activities

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ABBREVIATIONS OR SYMBLS OR NOTATIONS

"NCAM" = National Centre for Agricultural Mechanization

"mm" = Millimeter

"m^2" = Square meter

"m/s^2" = Meter per second square

"g/cm^3" = Gram per centimeter cube

"kg/m^3" = Kilogram per meter cube

"π" = Pie

"ω" = Angular velocity

rad/s = Radian per seconds

"1hp" = 746w $\approx$ 750w

"W" = Watts

"J" = Joules (unit for energy)

"Pks" = Palm kernels

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CHAPTER ONE

1 INTRODUCTION

1.1 Background to the Study

Palm nut, is an agro-product obtained after the orange-red portion of the palm kernel fruit seeds have been removed. When palm kernels are dried, cracked, and the nuts fried and crushed; an oily substance with enormous industrial potentials; is obtained. In Nigeria, this oily substance has various uses; which varies from region to region. In the western region of Nigeria, the oily substance serves as a major raw material in the manufacture of black-soap "*Adiagban*", and it is also used in the manufacture of both hair and body lotion. While in the Northern region of Nigeria, the oily substance extracted after the fried nuts have being crushed, is used in the manufacture of 'Lade'. But all these usage, are dependent on cracking of the palm kernel, in order to obtain the nuts (Haynes, 2000)

Although, many services had been employed in palm kernel cracking (manual or mechanical methods).The manual methods, is full of drudgery and time consuming, and hence resulting in reduction in output efficiency. While in the case of the machine methods, different models have been designed with low output efficiency (Haynes, 2000).

Therefore, the need to modify and improve on the considered machine, so as to increase the machine performance efficiency; is very necessary so as to ensure the continuous production of our native black soap, hair and body lotion production etc. Which will in turn bust economic power of the farmer, investors, states and so on, that would invest in it production.

1.1.1 Oil palm

The Native land of palm oil is West Africa, where local people grow it and extract oil by old traditional methods in their villages. In West Africa they use more often raw palm oil as an integral part of their traditional cuisine. Now palm oil trees are grown in the tropics of Africa, Latin America and South-Eastern Asia.

A Hybrid palm tree was raised with crossing between *Elaeis oleifera*, a Latin-American palm tree, and *Elaeis guineensis*, a West-African palm tree. This hybrid has more high qualities in comparison with ordinary vegetable culture.

The palm fruits grew in large clusters, and sometimes fruit amount could reach 2000. Reddish palm oil is extracted from fruit seeds. During processing, pulp is separated from seeds and with mechanical pressing there extracts impure palm oil, then with special technologies there precede fractionating, peeling and odor-control treatment. As a result they receive refined, de-odorized reddish palm oil.

The seeds are also processed, by cracking the seeds and separating the kernels that are used in further processing for palm kernel oil extracting. Palm kernel oil is also in widespread use. In South-Western Asia, an oil palm tree was first made public, in 1848. It was introduced to Indonesia from Nigeria by the Dutch, where it was used as a decorative plant. In Malaysia the seeds of an oil palm tree *Elaeis gineensis* were imported by the British in 1875. Soon exotic palm trees became popular in Malaysia, and in 1886 the inspired British brought the next lot of seeds for sowing. The palms were planted along avenues; nobles decorated their possession with them. Fortunately, some farmers discovered in these colored palms and some other features: hardiness and high-quality oil, extracted from the fruit. In 1909 the Agriculture Department of Britain worked out long-term programs in cultivating palm plantations for oil extracting (Trade group Ltd, 2008).

In 1917, 40 years after the palm import to Malaysia, there, they planted the first palm plantation. By that time because of the First World War there were reduced deliveries of fat and oil. And so money investment to the vegetable oil production promised a lot. The Malaysian farmers paid much attention to the palm oil production, in spite of their long-term rubber production.

United Plantation Company is a producer of palm oil called "Zlata Palma" became one of the first companies, which owners decided to invest their money and property to the palm oil production. After them, many entrepreneurs took up the initiative. But during the Second World War many plantations became the fields of battle, and the palm oil production was paused. During the next 4 years of the Japanese occupation, when adults and children suffered from shortage of essential vitamins and fat, they ate every day raw palm oil, all it nutritious qualities became obvious. Due to the war, palm oil production was very low, but after the next decades, throughout 1960s and 1980s, Malaysia, after the declaration of Malaysian Independence in 1957 increased production level of the world palm oil and became the leader among the world palm oil delivers (Trade group, 2008).

1.1.2 Favorable Conditions

They are best suited to a humid tropical climate in which the weather condition is always bright and sunny. There is a direct relationship between the amounts of sunshine received and yield, when there is sufficient moisture for growth. Minimum monthly rainfall for optimum yield is around 150mm, and the best climatic conditions are those in which there are no dry season and sunshine. That is, it is evenly distributed and it exceeds 2000 hours per annum.

1.1.3 Vegetable and Kernel Oils

The oil palm is an important producer of vegetable oil. It is generally regarded as the highest yielder of oil, of all the oil producing plants. The fruit has a red-orange pericarp and mesocarp, a shell and kernel. The palm oil of commercial importance is contained in the mesocarp of the fruit while a different kind of oil called kernel oil, is present in the kernel. Its oils are used domestically in certain areas. The palm kernel oil is a major industrial raw material, after the moisture content of the kernels have been removed.

1.1.4 Palm Kernel Cracking

Palm kernel cracking raw material that is mainly used for the production of soap, is palm kernel oil, and it is obtained from kernel after the mesocarp oil (that is vegetable oil) has been collected from the fruits. The hand shelled nut enclosed (that is the outermost layer) is dried to loosen the seed from the hand shell, while the cracking of palm kernel is the breaking into two or more of the palm kernel nuts. After the cracking has taken place, the separation of the fragment of the shells and kernels will follow using any available methods of separation.

However, the cracking of palm kernel is said to be a large limiting factor in the production of palm kernel seeds. Cracking is still largely practiced in Nigeria, traditionally by using the primitive method and these makes it difficult to control the breakage of kernel .And this method, is full of drudgery and is often a function of the experience and intelligence of the operator. Even though, this manual process often contribute to the source of injury for the operators who often get hit by the shrapnel's from the shattered shell or striking of his/her finger in between the cracking metals or stones.

Therefore, this study is carried out, to direct the attention and the development and modification of palm nuts crackers to substitute the manual cracking in order to remove all difficulties and discouragement that may be involved in the cracking operations and to get increased cracking capacity of the production of nuts by means of medium scale oil palm process mills.

1.2 Statement of Problem

Agro-products (palm kernel) processors, still face some difficulties in the usage of the existing palm nut crackers, owing to the quest for an increase in efficiency of the machine as against that of the former design with an efficiency of 63%, and also the positioning of some components such as the hopper and hammer mill contributes to the overall drop in the optimum performance of the machine.

1.3 Objectives

To develop an improved palm nut cracking device with an increase in its performance efficiency.

1.4 Justification

Palm kernel cracking in Africa, has being a major concern to both crackers, farmers, and also medium scaled oil palm processing mills. This is because, in the former; cracking of the kernel nuts, is done through manual means (with the aid of stones, metals etc).And this often result in various types of injuries to the farmers/crackers.

Although, there had being various efforts (on the part of both the farmers, investors in palm kernel oil business etc), in designing machines for this purpose. Among these cracking efforts, is the design of palm kernel crackers (which gave hopper problem to the operators) and the cracking components/devices, gave low performance efficiency as well.

More so, this leads to low patronage of investors and interested persons in the production of palm kernel oil, in commercial quantities. Sequel to the increasing demand for black soap (which gave a better body cleaning result, when compared to the commercial soap), and therefore, the need to strengthen palm kernel oil (which is a major raw material, in the production of black soap) production, is now paramount. And this is the sole aim of the development of an improved palm nut cracker.

1.5 Scope of the Study

The scope of the study is limited to the modification, design, and fabrication of "an improved palm nut cracker.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Brief History of Palm Oil

The oil palm *(Elias Guineesis)* is a native of tropical Africa with a natural distribution between Lat. 13° N and 12°S . The oil palm also requires warm temperature. Elevated sites in which oil palms are commercially grown is around 15° N in *Horidurs*. The roots of the oil palm grow from the boles of the stem base. Secondaries arise upwards and downwards from the primaries and these bear the tertiary and quaternary root that forms the main absorption centres for water and nutrients.

It has a straight rough trunk, formed from the leaf bases and the central stem tissue. It grows 30-40cm in height every year depending on the climatic conditions, and even more under evenly distributed wet conditions. Old oil palms reach 15mm or more in height and may live for at least 60 years. In the commercial estates, they are usually replanted after 25-30 years because of declining yield and because the increasing height makes harvesting more difficult. The commercial oil palm has three genetics forms depending on the shell thickness of the kernel.

The durra has a thick shell with a fibred ring, the *pisifera* is shell-less and the tenera is a hybrid between the above two and has a medium shell thickness with a fibrous ring in the mesocarp around the shell. Seeds do not germinate well without heat treatment. Prior to 1960, the germination of seed was by the (wet heat) technique at 38° C and 20-22 per cent moisture content and germinated seeds removed as germination occurred. Since 1965, the dry or pre-heating technique has been used.

2.2 Nuts Screening and Cracking

The already cleaned nuts are required in mills with large operating capacity required to be dried in a nut-silo. And it has also been verified that the moisture content of the kernel should be less than 17%, if especially they are to be sufficiently shrunk away from the shell so as to achieve easy cracking (Hartley, 1977).

However, a meaningful cracking could as well be achieved in mills without silos. If especially the heating in the nut silos is too much, this could result to deterioration in the quantity of the kernel. Moreover, small nuts are more difficult to crack than the large ones therefore; it entails proper drying and is of great importance.

Extending the rate of drying can also heads to a high percentage of broken kernels and they are very sensitive to fungus attack. Furthermore, too dry nuts need to be a little bit wet. (Application of water) to increase the moisture content (Octise, 1961). Nut screening is not all that easy that anybody can just jump into the business. If high efficiency is to be enhanced, the interaction between the capacity and the hole size should be taken into consideration. In essence, screens of lower capacity must be installed or introduced. (Ollie, 1967).

2.3 Separation of Nut from Fibers

The hydraulic press is used for the extraction of the mesocarp oil i.e. mechanical extraction, compare to the local method which produces very clean and neat which is free of fibre. It is very important to first separate the nuts from the fibred in order to accomplish an effective cracking.

Mainly mechanical fibre separations are mostly in small mills, where a low capital cost is impressive. A type consists of a screened drum which is rotating and it's allows the separation of fibre to take place and fall through the screen but retains the nuts inside (Trade group, 2008).

2.4 Cracking Devices

There are varieties of palm kernel cracking devices and they are also in different designs and they are available around the world which all joins hand together at improving on the manual cracking method.

Before any attempt are been made to introduce method of palm nut cracking, a trial should be made to get the correct traditional method involved. As it is known that any technology not based on a good understanding of traditional processing tends to have a low acceptance rate in the market (Trade group, 2008).

Nuts are been cracked open with the aid of manual operation by placing the nut on a bigger stone or a hard surface. In a smaller form but heavy stone or metal harmer is used to strike at the nut, therefore its introduced or impact energy on it causing the hard Nut-shell to break into two parts. The method is not only irritating, it consume time and in most cases is a wasteful effort if care is not taken and is of low productivity compare to commercial purpose.

2.4.1 Iron Plate Mills

The plate mill is a modification of the buhr-stone type. The plates are cost with corrugations which force the material outwards as in the buhr-stone type. The plates are made of a suitable iron to produce by chilling the maximum hardness with adequate toughness. They are easily interchangeable, and are usually made with corrugations on both sides as to be reversible.

The fineness of grinding is controlled by the nature of the corrugations and by the clearance between the two plates, which are mounted on a horizontal shaft. The corn is fed from the hopper over a small oscillating screen which removes any large foreign bodies, and hence, by the way of an anger like device to the centre of the inner plate. The outer plate is usually feather - keyed to the rotating shaft, and may be set at a variable distance from the fixed plate by means of a hard wheel. A spiral spring between the plates prevents them from touching when no grain is passing through provided they are properly adjusted. A wooden break-pin, a strong, or a quick release device is provided as a safety measure in case, if hard objects are mistakenly drop into the mill. This type of mill performs coarse grinding or kibbling of wheat, barley and maize very efficiently (Haynes, 2000).

2.4.2 Hammer Mills

There are various types of mill, but the harmer mill is becoming increasingly popular for farm grinding. In it a rotor mounted on the main shaft carries a series of bars or harmers arranged radially like the hub and spokes of a motorcycle wheel. The rotor and harmers revolve at high speed inside a circular or semi-circular screen. The material being ground is struck by the harmers until it is broken up sufficiently to pass through the holes in the screen, where it is collected by a fan and blown into a centrifugal separator for bagging off. A typical harmer mill, with part of the casing revolved, the two types of harmer are in general use i.e. rigid and swinging. The farmer is clamped firmly to the rotor arms by at least two bolts; the latter is mounted on a single hardened pin, and takes up a medical position during the process of working.

Under the influence of centrifugal force, the mill is equipped with swinging hammers. The hammers themselves are made from length of flat, wear-resisting steel bar. It is most important that the hammers should not be very hard and brittle, or they may break when working. PRODA (1985) constructed one, such hammer mill type nut cracker reported to achieve a 0.5 ton/hr capacity (45% performance efficiency) of output (Haynes, 2000).

2.5 Kernel and shell separation

The method commonly used and well known is the introduction of hand picking method after cracking is been done. The nuts are being cracked mechanically, after which the mixture of the shells and kernels are being spread on the floor and the children some women including some able men nowadays, would be picking the kernels with mere hand. It is mostly done in the night in the village after the evening meal to while away the time. The other methods been known are explained below discussing the kernel and shell separation (Haynes, 2000).

2.5.1 Specific Gravity Table Separator

The specific gravity table consists of an oscillating desk covered with fabric, wire or perforated metal, and with the upper end and one side adjustable for height. Air is blown up through the seed on the desk, at such a speed that the seed just tends to rise off the surface.

The action of gravity tends to material flow towards the lower, whereas the oscillation tends to take it to the higher side. Agitation of the mixture by the air flow causes the heavier seeds to sink to the bottom of the layer (McLaughlin, 2003).

2.5.2 Pneumatic Separators

Some simple cleaning and grading machines achieve separation by aspiration alone. The air blast in the aspiration leg is strong enough to weigh the kernel in the air stream, the heavier fractions falling to the bottom, light fractions being taken off at an intermediate position, and the lightest material being blow out with air stream. The factors governing separation are a combination of weight and air resistance.

Although, they are suitable as pre-cleaners, but cannot be expected to achieve such fine cleaning and grading as they are more complex and expensive machines, which employ a different separation processes (McLaughlin, 2003).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Material Selection

The materials used for the project were source locally at various markets in Ilorin, Kwara State. This was focused at reducing the overall cost of the machine to the minimum affordable cost. The materials were gathered based on the following factors:

1) Production cost (low price of raw materials)
2) Maintenance cost
3) Availability of raw materials
4) Durability (strength, rust and wear resistance)

3.1.1 Materials

1) Angle iron (50 x 50 x 3)mm
2) Mild sheet (4mm thick)
3) Metal sheet (9mm)
4) 2 bearings (28mm diameter)
5) A pulley
6) Bolts and nuts
7) Flat bar (2mm)
8) Electrodes
9) Shaft ($\varphi 30 \times 575$mm)
10) Paints.

3.1.2 Constructional features

The constructional features of the project include:

1) The cracking housing (drum)
2) The shaft and bearings
3) The spout (outlet)
4) The extension pipe of the hopper
5) The hopper
6) The rotor
7) The main frame

3.1.3 Operating Procedure and Maintenance

1) The machine should be placed on a leveled ground.
2) It may be bolted down to reduce the vibration.
3) Check and tighten loose bolts and nuts before the operation.
4) Check the electric rotor and make sure it is well connected.
5) Avoid over feeding of the machine.
6) Check belts and see that the bearings are properly lubricated.
7) Do not oil, grease or adjust the machine during the cause of operation.
8) The machine should not be operated without the extended Hopper or the revolving disc nakedly exposed.
9) The machine should only be operated by those who are responsible and have operating knowledge.
10) Clean the machine after use.

3.2 Methods

3.2.1 Design of Hopper

The hopper is Trapezoidal in shape, to allow easy movement due to gravity palm nut.

Assuming we adopt the angle of inclination of the coefficient of sliding friction of sugarcane which is 20^0 (Adebisi, 1992).

$$\text{Tan } 20^0 = \frac{x}{170} \quad (3.1)$$

x = 61.87mm

75 + 2(61.87)

75 + 123.74

198.74

For this we use 200mm as the top width of the Hopper.

3.2.1.1 Volumetric Capacity of the Hopper

Volume = base area × length (3.2)

Area of the trapezoid = ½(A+B) H (3.3)

Where:

A =base length = 75mm

B = upper length = 200mm

H = height of the upper = 170mm

Area = 0.5 (75 + 200) 170

= 0.5 x 275 x 170

= 23,375mm^2

Volume = 0.5(23,375 x 75) + 0.5(23,375 x 200)

= 0.5(23,375 x 275)

= 3214, 062.5mm^3

= 0.003214m^3

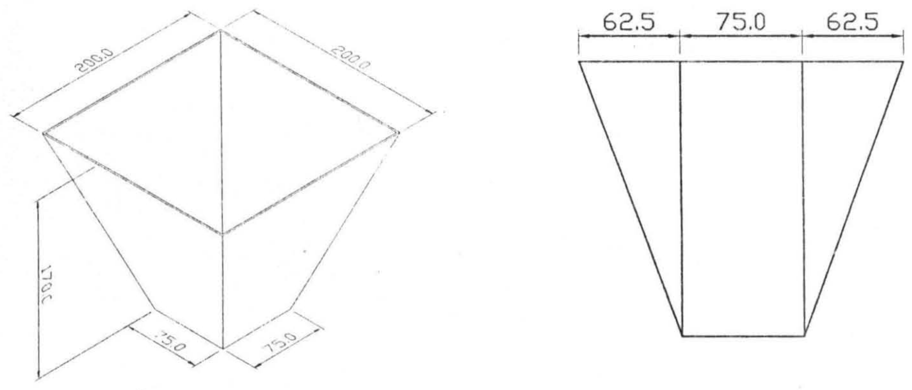

Fig. 3.1: Diagrammatic Representation of the Hopper

3.2.2 Drum Design

To design the external drum of the cracking machine through which the cracking operation is taking place, one major thing to consider is the thickness of the selected material as this can affect the efficiency of the machines and durability of the selected materials.

To calculate for the thickness, volume and other parameters must be considered.

$$\text{Volume} = AH \quad (3.4)$$

Where: A = Area of the drum

$$A = \pi r^2 \text{ Or } \frac{\pi D^2}{4} \quad (3.5)$$

D = diameter of the drum

H = thickness of the metal selected.

Similarly volume can be given as follows compare with the cracking products.

$$F = m \times g \quad (3.6)$$

Where m = mass of the selected material.

g = acceleration due to gravity.

f = required cracking force.

But mass can be given as volume multiply by density.

$$M = V \times \delta \quad (3.7)$$

Where:

V = volume.

δ = density.

$$F = v \times \delta \times g \quad (3.8)$$

Relate equation (3.4) with equation (3.8)

$$F = A \times H \times \delta \times g$$

$$H = \frac{F}{A \times \delta \times g} \quad (3.9)$$

The formula for the thickness is derived as given in equation (3.9) above

Where:

H = thickness of the material

F = breaking force required.

F = 197.75N

A = the area of the drum which is given as $A = \frac{\pi D^2}{4}$

Where D is assumed to be 45mm

$$A = \left(\frac{\pi \times 45^2}{4}\right) = 159043 mm^2$$

$A = 1590.43 \times 10^{-6} m^2$

g = acceleration due to gravity is given as $9.8 m/s^2$

δ = the density of the Palm Kernel.

The bulk density of the various sample of palm kernels are shown in table 4.2. The average bulk density decreases from $0.60 g/cm^3$ for a freshly cracked shell to $0.53 g/cm^3$ for a ten year post cracked exposed shell. The reduction in values of bulk density can be attributed to decrease in dry matter as a result of possible deterioration of the shell. This observation appears to be true since palm kernels is an organic material which can be susceptible to deterioration brought about by the influence of micro-organisms and other abiotic factors. The decrease in bulk density observed in palm kernels implies possible in strength and load carrying capacity of the material with time since density is directly related to strength of a constructional material.

From the table 4.5 below, the solid density of the freshly cracked palm kernel was chosen since the kernel would be dried before cracking.

$\delta = 1.37 g/cm^3$ chosen from the table.

$\delta = 1.37 g/cm^3$ converting the unit to kg/m^3

$$\delta = 1.37\left[\frac{(1/1000)}{(1/100^3)}\right] = 1.37 \times 10^3 kg/m^3$$

Recall from equation (3.9)

$$H = \frac{F}{A \times \delta \times g}$$

Where:

$F = 197.75N$ (chosen from the table)

$A = 1590.67 \times 10^{-6} m^2$

$\delta = 1.37 \times 10^3 kg/m^3$

$g = 9.8 m/s^2$

$$H = \frac{197.75}{1590.67 \times 10^{-6} m^2 \times 1.37 \times 10^3 kg/m^3 \times 9.8 m/s^2}$$

$H = 0.0091m$

$H = 9mm$

If the Area of the plate $= 1590.67 \times 10^{-6} m^2$ and $A = \pi r^2$ or $\frac{\pi D^2}{4}$

The circumference = πD which is the length of the plate

Circumference = $\pi \times (45)$ mm

Circumference = 141.37

Length of the plate = 142mm

Breadth of the plate = 11mm

Thickness of the plate = 9.4mm

3.2.3 Design of the Cracking Unit

To design for the cracking unit, the space between the internal disk attached with cracking device and external drum must be considered perfectly as this can greatly affect the cracking efficiency of the machine. According to Engr. Obiakor and Engr. Babatunde in a book titled Agrimech in National Centre for Agricultural Mechanization (NCAM), they chose the space to be 5mm in order to ensure accurate and perfect operation of the machine base on the above, since the external drum diameter has been chosen as 45mm, then the diameter of internal disk attached with cracking device can be given as below:

$D - d = S$

Where:

D = External drum diameter

d = internal drum diameter

S = space between the two drum

Thickness = External diameter − Internal diameter

Internal diameter = External − thickness

Internal diameter = 45 − 9

Internal diameter = 36mm

Internal disk diameter = D − S

Internal disk diameter = 36 − 5

Internal disk diameter = 31mm

The thickness of material chosen for cracking device (hammer) is also 9mm since cracking efficiency is based on the thickness of material majorly.

3.2.4 Calculation of the Power Transmitted by the Machine Through the Belt and to Select Electric Motor Required.

The speed selected for the machine is equal to 1000rmp. Then, converting this speed to m/s, the below formula can be used.

$$\omega = \frac{2\pi N}{60} \text{ rad/s} \qquad (3.9.1)$$

But $V = r\omega$

$$V = \frac{r \times 2 \times \pi \times N}{60} \text{ m/s} \qquad (3.9.2)$$

Where 2r = Diameter (D)

$$V = \frac{\pi D N}{60} \text{ m/s}$$

$$V = \frac{\pi \times 0.12 \times 1000}{60} \text{ (m/s)}$$

$$V = 6.28 \text{ m/s}$$

The power, $P = \frac{work\ done}{time}$

Where:

Work done = force × distance

$$\text{Power} = \frac{force \times distance}{time}$$

But: $\frac{distance}{time}$ = speed (v)

Power = FV

Power = force x velocity (m/s)

Where: F = 197.75N **(chosen from the table)**

V = 6.28m/s

Power = 197.75 × 6.28 (W)

Power = 1241.87w

Recall that 750w = 1hp

Converting this to 1hp

750w = 1hp

1241.87w = xhp

Power (hp) = $\frac{1241.87w}{750w}$

Power (hp) = 1.65hp

Therefore, the selected electric motor should be between 2hp and 2.5hp.

Electric 2hp, 1460 rpm specification (φ = 60mm)

3.2.5 Belt Speed Design

The diameter of the pulley selected for the machine is to be calculated. The speed selected to have higher efficiency of 1000r.m.p. according to the performance and testing carried out by (Obiakor and Babatunde, 1999)

Recall:

$$N_1D_1 = N_2D_2 \quad (3.9.3)$$

$$\frac{N_1}{D_2} = \frac{N_2}{D_1}$$

Where:

N_1 = speed of the machine in r.p.m

N_2 = speed of the electric motor in r.p.m

D_1 = diameter of electric motor in (mm) = 60mm

D_2 = diameter of machine in (mm) =?

$D_2 = \frac{60 \times 1460}{1000}$

D_2 = 87.6mm

For machine sake = 90mm

$\theta = \pi - 2\sin^{-1}(\frac{R-r}{2c})$ given as standard for groove angle.

Where;

R = 90

r = 60

c = 300

$\theta = \pi - 2\sin^{-1}(\frac{90-60}{2(300)})$

$= \pi - 2\sin^{-1} 0.05$

$= \pi - 2(2.87)$

$= \pi - 5.74$

$= 180 - 5.74$

$= 174.26^0$

$\theta = \frac{174.26 \times \pi}{180} = 3.04$ rad

3.2.6 Belt Tension Design

μ = coefficient of friction, it is usually selected between 0.18 – 0.3 for rubber belt moving on cast iron pulley (Gupta, 2006)

μ = 0.2 (selected)

$\frac{T_1}{T_2} = e^{u\theta}$ (3.9.4)

$\frac{T_1}{T_2} = e^{0.2 \times 3.04}$

$\frac{T_1}{T_2} = e^{0.608}$

$\frac{T_1}{T_2} = 1.84$

$T_1 = 1.84T_2$ (3.9.5)

$Mt = \frac{9550 \times kw}{rev/min}$ (3.9.6)

$Mt = \frac{9550 \times 3.75}{974}$

$Mt = 36.77Nm$

$(T_1 - T_2)R = Mt$

$(T_1 - T_2)R = 36.77$

$\frac{36.77}{90/1000} = T_1 - T_2$

$\frac{36.77}{0.09} = T_1 - T_2$

$T_1 - T_2 = 408.54N$ (3.9.7)

Substitute équation (3.10) into (3.12)

$1.84T_2 - T_2 = 408.54$

$0.84T_2 = 408.54$

$T_2 = 486.36N$

Recall in equation (3.10)

$T_1 = 1.84T2$

$T_1 = 1.84 \times 486.36$

$T_1 = 894.90N$

$T1 = 894.90N$, $T2 = 486.36N$

3.2.7 Designed for Belt Length

In order to select the appropriate belt length that will drive the pulleys at the required tension without ship or snap, it is necessary to calculate the length of the open belt.

$$L = \frac{\pi}{2}(d_1 + d_2) + 2c + \frac{(d_1 - d_2)^2}{4(c)} \text{ (open belt)} \quad (3.9.8)$$

Where:

L = Length of the belt (mm)

d_1 = Machine Pulley diameter = 90mm

d_2 = Motor Pulley diameter = 60mm

C = Centre length between the two shaft = 300mm

Therefore:

$$L = \frac{\pi}{2}(90 + 60) + 2(300) + \frac{(90-60)^2}{4(300)}$$

$$L = \frac{\pi}{2}(150) + 600 + \frac{900}{1200}$$

L = 235.65 + 600 + 0.75

L = 836.4mm

L = 840mm

3.2.8 Calculation of the Value for Bending Moment

Volume of blade $= \frac{\pi d^2}{4} \times 20$

$= 1924, 225.5mm^3$

$= 0.001924 \times 2850 \times 9.81$

= 148N

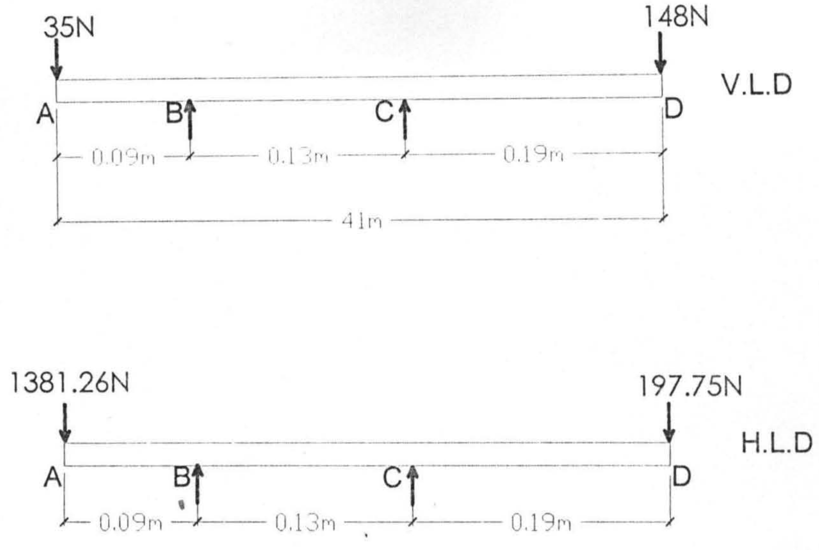

Fig.3.2: Diagram for Calculating the Bending Moment

3.2.9.1 Calculation on Vertical Load (V.L.D)

Taking moment about point B

$35 \times 0.09 + C\,(0.13) = 148 \times 0.32$

$0.13C = 47.36 - 3.15$

$C = \frac{44.21}{0.13}$

$C = 340N$

Taking moment about point c

$35 \times 0.22 = 148 \times 0.19 + 0.13B$

$7.7 - 28.12 = 0.13B$

$-20.42 = 0.13B$

$B = \frac{-20.42}{0.13}$

$B = -157.07N$

3.2.9.2 Calculation on Horizontal Load (H.L.D)

Taking moment about point B:

$1381.26 \times 0.09 + 0.13C = 197.75 \times 0.32$

$124.3134 + 0.13C = 63.28$

$0.13C = -61.0334$

$C = -469.49N$

Taking moment about point c:

$1381.26 \times 0.22 = 197.75 \times 0.19 + 0.13B$

$303.8772 - 37.5725 = 0.13B$

$266.3047 = 0.13B$

$B = \frac{266.3047}{0.13}$

$B = 248.50N$

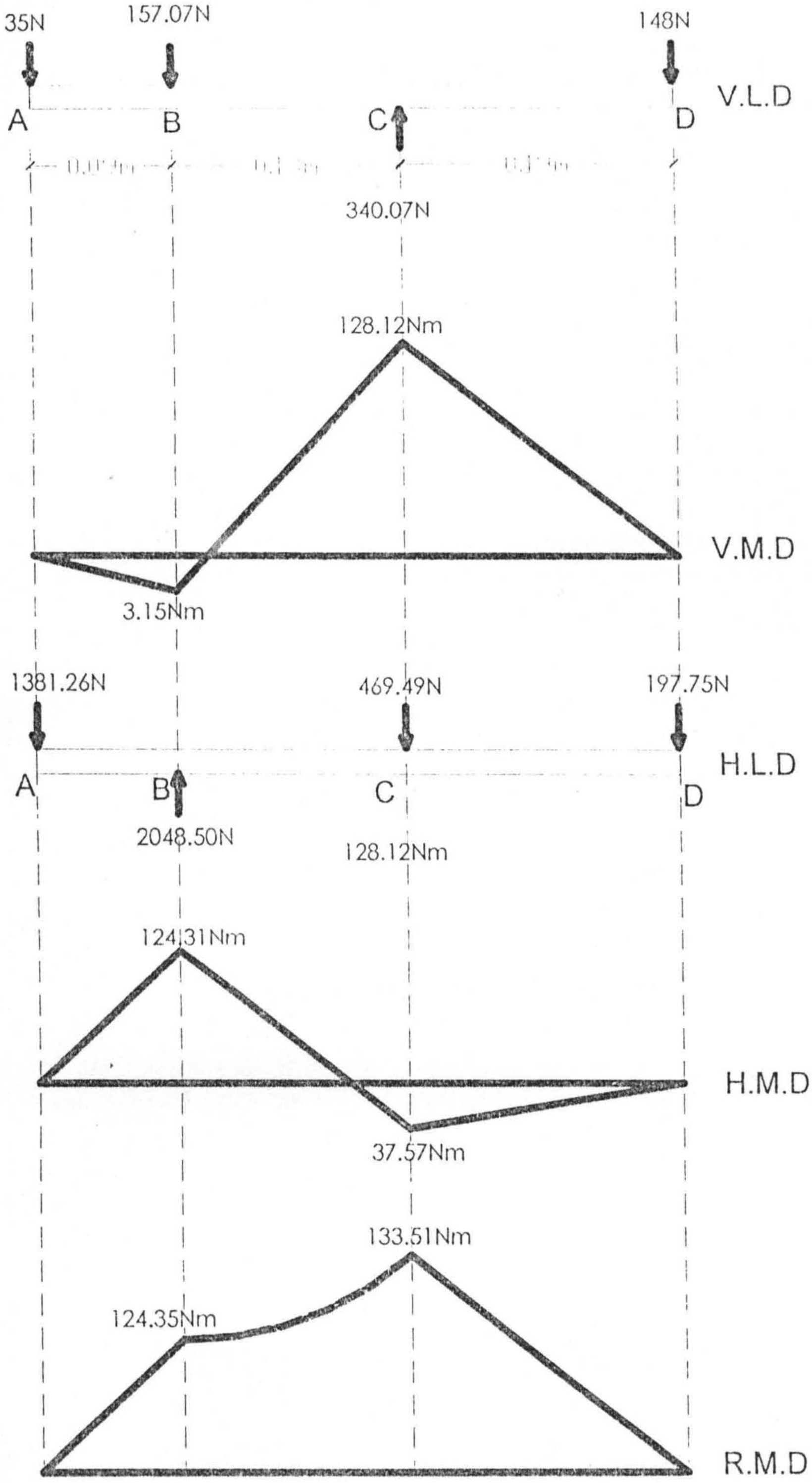

Fig. 3.3 Shear Force and Bending Moment Diagram

3.2.9.3 Shaft Design

The objective here is to design for shaft diameter, to ensure satisfactory strength and rigidity. This shaft is subjected to twisting and bending load, ASME code equation for calculating diameter of such solid shaft is given (spots, 1971).

$$d^3 = \frac{16}{\pi sd}\left[\sqrt{(K_b M_b)^2 + (K_t M_t)^2}\right] \quad (3.9.9)$$

Where:

d = the required shaft diameter, m

sd = Allowable bending stress for steel, N/m^2

M_b = maximum bending moment, Nm

K_b = combine shock and fatigue factor to bending moment

K_t = combine shock and fatigue-factor to tort ional moment

M_t = maximum tort ional moment, Nm

ASME code specified 1.5 – 2 for Kb and 1.0 – 1.5 for Kt both for rational shaft.

$Sd = 55 \times 10^{-6}\ N/m^2$

Mb = 133.51 Nm

Mt = 36.77 Nm

Kb = 1.5

Kt = 1.0

Substitute these values into equation (3.14)

$$d^3 = \frac{16}{\pi \times 55 \times 10^{-6}}\left[\sqrt{(1.5 \times 133.51)^2 + (1.0 \times 36.77)^2}\right]$$

$$d^3 = \frac{16}{\pi \times 55 \times 10^{-6}}\left[\sqrt{40{,}106.07023 + 1352.0329}\right]$$

$$d^3 = \frac{16}{\pi \times 55 \times 10^{-6}}\left[\sqrt{41{,}458.10213}\right]$$

$$d^3 = \frac{16 \times 203.613 \times 10^{-6}}{\pi \times 55}$$

$$d = \sqrt[3]{\frac{16 \times 203.613 \times 10^{-6}}{\pi \times 55}}$$

$$d = \sqrt[3]{1.8854 \times 10^{-5}}$$

d = 0.02662m

d = 26.62mm

Consider a factor of safety of 1.1

=26.62 × 1.1

= 29.28mm

d = 30mm

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Sampling Method and Material Separation

The nuts of ten era class were handpicked from the oil palm processing centre after the nuts has been properly washed and dried and it is separated from the fibres. The nuts sample was kept in the sun for five days to reduce the moisture contents in order to enhance proper cracking of the nut and reduce the rate of damages on the nut.

4.2 Moisture Content Of The Kernel Nuts

The kernels were graded into small, medium and large sizes. Each grade was weighed by using a weighing balance and put into a known weight of a drying pan to give the initial weight of the kernels as W_1 as shown in the Table 4.1.

The pan and kernels were put in the hot box oven set at $105^{o}c$ for 24 hours. The kernels were brought out after 24 hours into desiccators to cool for 5 minutes. The cooled sample from desiccators was weighed again to a constant weight to obtain weight of dried kernels as W_2 .

Weight of moisture removed = $W_1 - W_2$

$$\% \text{ of moisture content removed} = \frac{W1-w2}{w1} x100$$

TABLE 4.1: MOISTURE CONTENT OF THE KERNEL NUTS

Category (Size)	**No of Nuts**	**Initial Weight (hg)**	**Final Weight (kg)**	**Mass of Moisture removed**	**% of Content**
Small	60	0.2103	0.196	0.0143	0.68
Medium	60	0.459	0.4314	0.0276	0.601
Large 30	30	0.3308	0.3036	0.0272	0.822

4.2.1 **Calculation**

The three relevant performance criteria were calculated thus;

1. Cracking efficiency, $E = \frac{N - N_u}{N} \times 100\%$ (4.1)

2. Capacity Q (ton/hr) = $\frac{3.6WT}{t}$ (4.2)

3. Kernel Breakage factor, $F = \frac{Wd}{Wu + Wd}$ (4.3)

Where: W_T = Total weight of sample

t = Cracking for each sample in seconds

W_d = Weight of damage kernels

Wu = Weight of undamaged kernels

N = Number of nuts in a sample

Nu = Number of uncracked and partially cracked nuts

The results of the calculations of the performance criteria at the moisture contents determined above are presented in the Table 4.2 below.

Table 4.2: Results and Shelling Efficiency Table

S/No.	Total No. of Nuts in the sample N	No of Cracked Nuts (undamaged Kernels)	Uncracked and number of partially Cracked nut Nu	Number of Cracked Nut (Damaged Kernels)	Shelling Efficiency %
1.	60	45	10	5	83
2.	60	47	10	3	83
3.	60	41	13	6	78
4.	60	49	8	3	86
5.	60	52	6	2	90

Average Shelling Efficiency = $\frac{83+83+78+86+90}{5}$

=84%

Table 4.3: **Determination of the Cracking Capacity of the Machine and Kernel Breakage Factors**

S/No.	Cracking Time t (Seconds)	Total Weight Wt	Weight of Damage Kernel Wd (Kg)	Weight of Undamaged Kernel Wu (Kg)	Machine Capacity Q (Ton/Hr) $\frac{3.6}{t}$ wt	Kernel Factor, $\frac{w_d}{Fw_u}$
1	18	1.321	0.072	0.223	0.158	0.266
2	17	1.325	0.069	0.219	0.170	0.256
3	18	1.341	0.075	0.214	0.161	0.286
4	16	1.335	0.066	0.216	0.185	0.250
5	17	1.326	0.070	0.223	0.170	0.257

Table 4.4: COMPRENSSION TEST RESULT FOR THE SEED IN CHOOSING THE FORCE REQUIRED

Variety Axis of Loading	Load at diff Pt (N)			Energy at Pt (J)			Steam Pt (%)		
	Peak	Break	Yield	Peak	Brake	Yield	Peak	Brake	Yield
Dura Major	15.04	404.14	378.95	0.9012	1.0075	0.343	14066	15.404	7.871
intermediate	54.17	473.42	361.21	0.4199	0.4393	0.1711	9.478	9.835	5.306
Tenera Major	481.71	319.61	127.75	2.0015	2.2473	0.0919	31.509	34.121	6.648
intermediate	136.42	75.89	109.46	0.0369	0.0433	0.0231	5.0991	6.0471	3.498
Pisitera Major	293.26	260.12	79.82	0.6668	0.8171	0.0387	34.094	39.382	7.215
intermediate	297.54	273.93	162.26	0.2967	0.3249	0.0554	22.25	23.874	8.617
	Load at diff Pt (N)			Energy at Pt (J)			Steam Pt (%)		

(Babatunde and Obiakor, 2000)

4.3 Density of Palm Kernels (g/cm^3) and duration of post cracked exposure.

The density that was used in the calculation was chosen from the test in the table 4.5 below in a book (Agrimech, 2000) in which they are been numbered from 1-10 and they are been grouped into three categories of bulk density and solid density. The density used in the calculation is the summation of the first density divided by the total number which gives us the average.

$$\text{Average} = \frac{\Sigma \text{solid density}}{\text{Total number}}$$

$$= \frac{13.74}{10} = 1.37 g/cm^3$$

Table 4.5: Density of the Palm Kernels

Densities of Palm Kernels

(g/CM^3)

Duration of Post-Cracked Exposure						
Replicam	Bulk Density	Solid Density	Bulk Density	Solid Density	Bulk Density	Sold Density
1	0.56	1.41	0.55	1.24	0.52	1.17
2	0.59	1.38	0.56	1.3	0.53	1.27
3	0.59	1.43	0.59	1.42	0.52	1.25
4	0.61	1.37	0.59	1.3	0.52	1.16
5	0.58	1.38	0.59	1.33	0.54	1.18
6	0.61	1.37	0.57	1.37	0.54	1.29
7	0.58	1.35	0.58	1.32	0.55	1.3
8	0.6	1.35	0.55	1.32	0.54	1.28
9	0.61	1.32	0.59	1.33	0.54	1.28
10	0.59	1.38	0.56	1.37	0.53	1.3
Average	0.6	1.37	0.57	1.33	0.53	1.25

4.4 Performance Tests and Results

The palm kernel nut cracker was tested to determine the output capacity, nut cracking efficiency and kernel breakage factor all of which were considered including the criteria for determining at various cracking condition. A sample containing 300 nuts that was selected differently was randomly weighed out of the rate.

The sample was run through the palm kernel cracker and the time was been taking for cracking recorded on a stop watch. This experiment was repeated at the same speed 1, 600rpm. The output was then separated into uncracked, partially cracked nuts, unbroken kernels, shattered kernels and shell. Each of these components were weighed. Furthermore, the uncracked and partially cracked nuts were counted. Similar runs were made using each of obtained by replacement of the cracking rotors on the shaft in the cracking unit.

CHAPTER FIVE

5. 0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

This project work entitled the Development of an Improved Palm Nuts Cracker, was done with the sole aim of solving the various problems encountered by the manufacturer and users of the former/ unmodified palm kernel nuts cracking machines. Problems like lower hammer efficiency, hopper problem, risk of belt accidents etc. Was solved by using four (4) hammers, to increase hammer efficiency, using a Trapezoidal shaped hopper as against the rectangular shaped hopper of the former/ unmodified palm kernel crackers, using a metal casing to cover the belt and pulley arrangement (to minimize belt accidents), which was absent in the unmodified palm kernel crackers. And by this, the sole aim of the project was achieved (that is, development of an improved palm nut cracker).

5.2 Recommendations,

I want to recommend that this machine should be produced on a large scale basis, because it would go a long way in solving the, various problems encountered by the users of the former/unmodified palm kernel crackers (that is, hopper problem, lower hammer efficiency, risk of belt accidents etc). This would go a long way in easing the efforts/workload, reduction in the time required for the completion of cracking operations etc. This in turn, enables the operators to use the time gained, for other activities, and thereby, busting the economic power of the owners/farmers (because time they say is money).

Also, safety which is one of the ethics of engineering practices was encouraged in the design and addition of belt cover (to minimize accidents), as against that of the unmodified palm kernel crackers; that does not have any belt cover. Therefore, based on the above fact, I would hereby recommend that this modified palm kernel cracker, should be purchased by the various farmers, Agro minded people, investors in palm kernel business etc.

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APPENDICES

Table A: The Palms (in Alphabetical Order): V-Z

Veitchia arecina – Veitchia palm (solitary – Vanuatu)	Palm heart harvested locally for tourist restaurants (destructive)
V. joannis – Joannis palm, niusawa is local name (solitary – Fiji)	Seed and palm heart edible (destructive)
V. vitiensis – Kaivatu is local name (solitary – Fiji)	Palm heart (destructive), seed, and inflorescence all edible
Voanioala gerardii – Forest coconut palm, voanioala is local name (solitary – Madagascar)	Edible palm heart (destructive)
Washingtonia filifera - California fan palm, desert palm (solitary - California, Arizona – not adapted to humid tropics)	Edible fruit
W. robusta - Mexican fan palm (solitary - Mexico, Baja California)	Edible fruit
Welfia spp. (solitary – Central America – requires tropical climate)	Reduced to rarity in parts of their ranges due to harvesting of edible cabbage (destructive)

Table B: Palms with edible vegetative parts		
Destructive cabbage:		
Acanthophoenix rubra	Acrocomia aculeata	Alloschmidia glabrata
Archontophoenix spp.	Areca listeri	A. macrocalyx
Areca spp. (Phillipines)	Arenga pinnata	A. undulatifolia
Astrocaryum mexicanum	Attalea cohune	A. maripa
Borassodendron borneense	Borassus aethiopium	B. flabellifer
B. madagascariensis	Caryota no	C. rumphiana
C. urens	Clinostigma harlandii	Cocos nucifera
Corypha utan	Cryosophila williamsii	Dypsis spp. (Madagascar)1
Euterpe edulis	Geonoma spp.	Gulubia cylindrocarpa
Hyphaene petersiana2	Iriartea spp.	Kentiopsis pyriformis
Licuala valida	Livistona spp.	Marojejya insignis

Mauritia flexuosa	Phoenix acaulis	Prestoea spp.
Pritchardiopsis jeanneneyi	Ravenea albicans	R. sambiranensis
Rhopalostylis sapida	Roystonea spp.	Sabal mexicana
S. palmetto	Syagrus comosa	S. oleracea
S. romanzoffiana	Trachycarpus fortunei	Veitchia arecina
V. joannis	V. vitiensis	Voanioala gerardii
Welfia spp.		
Non-destructive cabbage		
Arenga microcarpa	Arenga obtusifolia	Astrocaryum jauari2
Bactris gasipaes	Calamus spp.	Caryota mitis
Chamaerops humilis	Cyphosperma tanga3	Daemonorops spp.
Eleiodoxa conferta	Eugeissona insignis	E. utilis
Euterpe oleracea	E. precatoria3	Oncosperma horridum
O. tigillarium	Pinanga duperreana3	Plectocomiopsis geminiflora
Salacca affinis	S. vermicularis	
Other non-destructive uses:		
Inflorescence:	Chamaedorea elegans	C. tepejilote
Rhopalostylis sapida	Veitchia vitiensis	
Immature leaf:	Coccothrinax argentea	Livistona australis
Nannorrhops ritchiana		
Pollen:	Eugeissona utilis	

1 Some of these species may be clustering palms; for those that are clustering, harvesting of palm hearts would not be destructive.

2 This species, although multi-trunked, is not clustering and, therefore, the harvesting of a "branch" would be considered destructive.

3 Growth habit for these species is unknown; therefore, it is also unknown if harvesting palm heart of these species is destructive or non-destructive.

Table C: Palms with edible fruit		
Eaten raw:		
Acrocomia aculeata	Aiphanes spp.	Allagoptera arenaria
A. brevicalyx	A. campestris	A. leucocalyx
Aphandra natalia	Astrocaryum acaule	A. aculeatum
A. campestre	A. murumuru	A. tucuma
A. vulgare	Attalea allenii	A. butyracea
A. cohune	A. crassispatha	A. maripa
A. martiana	A. spectabilis	Bactris brongniartii
B. concinna	B. plumeriana	Borassodendron borneense
Borassus aethiopium	B. flabellifer	Brahea aculeata
B. edulis	B. dulcis	Butia capitata
B. eriospatha	B. yatay	Calamus paspalanthus
C. rotang	Calamus spp. (SE Asia)	Calospatha scortechinii
Carpoxylon macrospermum	Chamaerops humilis	Clinostigma harlandii
Cocos nucifera	Corypha utan	Cryosophila nana
Daemonorops cristata	D. didymophylla	D. fissa
D. periacantha	D. scapigera	Daemonorops spp. (SE Asia)
Desmoncus cirrhiferus	Dypsis baronii	D. madagascariensis
D. utilis	Eleiodoxa conferta	Eugeissona brachystachys
E. insignis	E. tristis	Euterpe catinga
Gulubia cylindrocarpa	Hyophorbe spp.	Hyphaene dichotoma
H. petersiana	H. thebaica	Juania australis
Linospadix monostachya	Maximiliana regia	Nannorrhops ritchiana
Neoveitchia storckii	Nypa fruticans	Oenocarpus bataua
O. mapora	Phoenix acaulis	P. canariensis
P. dactylifera	P. farinifera	P. pusila
P. reclinata	P. sylvestris	P. zeylanica
Phytelephas macrocarpa	Pinanga mooreana	Polyandrococos caudescens
Ravenea sambiranensis	Sabal palmetto	Sabal pumos
Salacca spp.	Serenoa repens	Syagrus cardenasii
S. comosa	S. coronata	S. flexuosa

S. oleracea	S. schizophylla	S. smithii
Syagrus spp. (South America)	Washingtonia filifera	W. robusta
Fruit eaten cooked:		
Bactris gasipaes	B. guineensis	B. major
B. maraja	Cocos nucifera	Mauritia flexuosa
Mauritiella aculeata		
Fruit eaten pickled:		
Calamus rotang	Eleiodoxa conferta	
Fruit made into fresh drink:		
Euterpe oleracea	Leopoldinia piassaba	O. distichus
Phytelephas macrocarpa		
Fruit processed into jelly:		
Butia capitata		
Fruit fermented into wine:		
Bactris guineensis	B. major	B. maraja
Cryosophila nana	H. petersiana	Oenocarpus bacaba

Table D: Palms with edible seeds.		
Chewed as stimulant:		
Acrocomia aculeata	Aiphanes spp.	Allagoptera leucocalyx
Arenga obtusifolia	A. pinnata	Attalea cohune
Balaka longirostris	Borrasodendron borneense	Borassus aethiopium
B. flabellifer	Cyphosperma tanga	Eugeissona brachystachys
Gastrococos crispa	Hyophorbe spp.	Hyphaene dichotoma
Jubaea chilensis	Jubaeopsis caffra	Latania spp.
Nannorrhops ritchiana	Parajubaea cocoides	P. torallyi
Pelagodoxa henryana	Phytelephas macrocarpa	Ptychococcus spp.
Salacca spp.	Sclerosperma spp.	Veitchia vitiensis
Actinorytis callaparia	Adonidia merrillii	Areca catechu
A. concinna	A. guppyana	A. ipot
A. macrocalyx	Areca spp. (SE Asia)	Calamus tonkinensis
Heterospathe elata	H. elmeri	Loxococcus rupicola

Oncosperma spp.	Pinanga spp.	

Table E: Palms with edible sap		
Destructive:		
Drunk fresh:		
Mauritia flexuosa1		
Dried into sugar:		
Jubaea chilensis		
Boiled into honey:		
Jubaea chilensis		
Fermented into wine:		
Attalea butyracea	Jubaea chilensis	Pseudophoenix ekmanii
P. vinifera		
Non-destructive:		
Drunk fresh:		
Arenga pinnata	A. wightii	Borassus aethiopium
B. flabellifer	Caryota urens	Calamus vanauatuensis
Cocos nucifera	Corypha utan	Hyphaene petersiana
Oenocarpus bataua	O. distichus	Parajubaea cocoides
P. torallyi	Rhopalostylis sapida	
Dried into sugar:		
Arenga pinnata	Borassus flabellifer	Nypa fruticans
Phoenix dactylifera	P. reclinata	P. sylvestris
Fermented into wine/alcohol:		
Acrocomia aculeatea	Arenga pinnata	Bactris guineensis
B. major	B. maraja	Borassus flabellifer
Caryota urens	Cocos nucifera	Phoenix sylvestris
Raphia hookeri	R. vinifera	
Fermented into vinegar:		
Bactris guineensis	B. major	B. maraja
Borassus flabellifer	Caryota urens	Cocos nucifera
Boiled into honey/syrup:		
Phoenix canariensis		