DESIGN, CONSTRUCTION AND TESTING OF A MANUALLY OPERATED GROUNDNUT OIL EXTRACTION MACHINE

BY

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PGD/AGE/1998/1999/033

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY

MINNA, NIGER STATE

SEPTEMBER, 2008

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PGD PROJECT REPORT
SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
MINNA, NIGER STATE
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POSTGRADUATE DIPLOMA IN AGRICULTURAL AND BIORESOURCES ENGINEERING
(FARM POWER AND MACHINERY OPTION)

SEPTEMBER, 2008

CERTIFICATION

This is to certify that this project was carried out by LEGBO, John Bakke, PGD/AGE/1998/1999/033, in the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State.

--	14/10/08 --
DR. B. A. ALABADAN	**DATE**
SUPERVISOR	

--	14/10/08 --
DR. MRS. Z. D. OSUNDE	**DATE**
HEAD OF DEPARTMENT	

DECLARATION

I hereby declare that this project has been conducted by me under the guidance of my Supervisor, who is the PG Co-ordinator of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State. **DR. B. A. ALABADAN**.

I have neither copied someone's work nor has someone else done it for me.

-- 14/10/2008 ------------------------------

Legbo, John Bakke **Date**

PGD/AGE/1998/1999/033

ACKNOWLEDGEMENT

I wish to express my profound gratitude to our **GOD Almighty**, who guided me through the period of my course. I am particularly indebted to my supervisor, Dr. B. A. Alabadan, for his unprejudiced criticism and encouragement.

I equally wish to recognize the encouragement and invaluable assistance accorded to me by Engr. Dr. Balami, Mr. John Jiya Musa, Mr. Paul Zhiri, Alhaji Abdulmalik Bala Bosso, Kehinde Bello, Mal. Ishaku and staffs of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna and Kaduna Polytechnic, Kaduna.

Finally, it is extremely necessary to register my heart felt appreciation to my entire family, friends, colleagues, associates and countless individuals, who have in one way or the other been instrumental to the actualization of this project.

DEDICATION

This project is dedicated to my Late mother **MRS. VICTORIA ADI LEGBO.**

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ABSTRACT

The machine was designed to mechanize the existing traditional method of groundnut oil production, to reduce drudgery, timeliness and increase output. From 2kg of groundnut paste at 25°C, 80ml of oil was extracted, and from the same 2kg of paste at 100°C, 90ml of oil was extracted. The machine is operated manually and the oil filtrates through a cheese clothe into a plastic basin underneath the machine. The machine has a capacity of processing 2kg of groundnut paste in 30 minutes.

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CHAPTER ONE

1.0 INTRODUCTION

Groundnut, Arachis hypogaea is a tropical leguminous plant, thriving well under a variety of horticultural practices and environmental conditions. Its protein content being as high as between 21 – 36% oil content depending on variety (Holaday and Pearson 1974), all these makes it an essential consultant of dietal needs. It processed products in all forms of its presentation are high income generating; this is justified by its large scale utilization and consumption as high quality edible oil. food drink, animal feed, roughages biomass, filler and as an organic amendment for fertilizer production (Harris, 1982; Sanda, 1977).

The most important step in processing oil seed (Groundnut) and materials is preparation. Groundnut preparation consist essential of sun drying, cleaning, decorticating, roasting and size reduction. The moisture content for groundnut should be between 10% - 11% and other factors are presence of foreign materials, degree of maturity, tempering time between harvesting and placing in storage and ambient tempering of atmosphere at the time of placing in storage (Edwald, 1976).

Groundnut is eaten raw, roasted, cooked or processed into several products, like cake, margarine and oil which are ingredients in bakery products, ice-cream and pharmaceuticals. The processing of groundnut into cake "kuli kuli" and oil involves various operations as shown in figure 1.

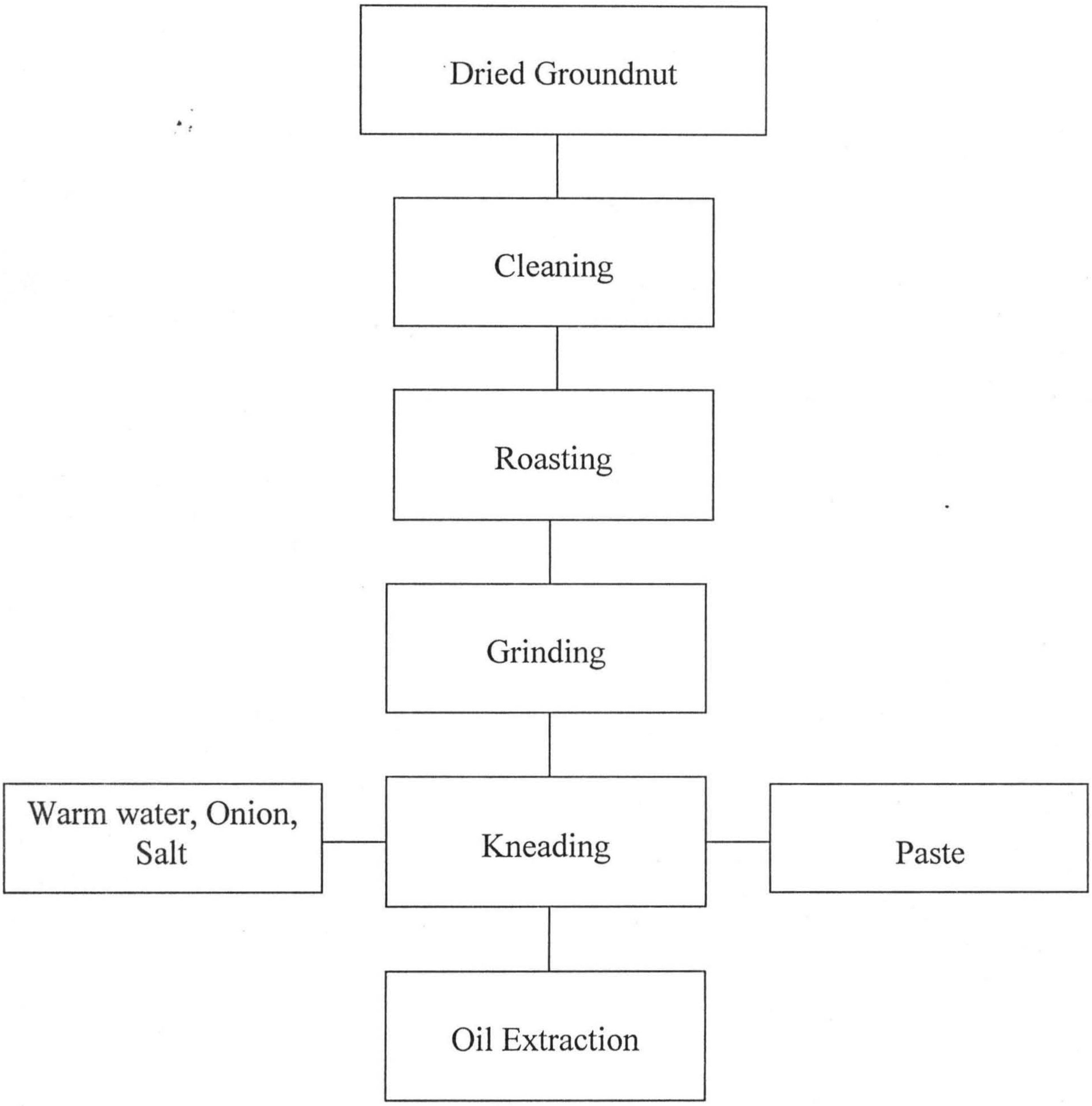

Figure 1: Flow Chart of Groundnut Processing for Oil Extraction

(Savanna Journal of Agricultural Mechanization Vol. 2 No. 1)

Manual operations in cleaning, roasting, milling (Grinding), kneading and extraction are not only identified as the most difficult and time consuming activities in groundnut oil production, but are also report to have health hazards among oil producers (Alabadan et al 2002).

Apart from discouraging many groundnut oil producers from continuing with this trade especially at old age, these difficult tasks also limit the capacity and oil yield of those determined to continue with the trade.

It is against this backdrop, that I have decided to embark upon this project titled, design, construction and testing of a manually operated groundnut oil extraction machine.

1.1 OBJECTIVES

The objectives of this project are as follows:

i. To carryout a study on the traditional method of groundnut oil production.

ii. To design, construct and evaluate a groundnut oil extraction machine.

1.2 JUSTIFICATION

The justification of this work is principally to mechanize, the existing traditional method of groundnut oil extraction to reduce drudgery and improve good quality and quantity groundnut oil for the much needed profitable market.

1.3 SCOPE OF STUDY

The scope of study is limited to the design, construction and performance test of manually operated groundnut oil extracting machine using locally sourced construction materials.

CHAPTER TWO

2.0 LITERATURE REVIEW

In the advent of human endeavour, the sole aim is victory and consequently survival. It is unproven phenomenon that groundnut (Arachis hypogea) thrives best in the Savanna Zone of Nigeria, most especially in Kano State. It is also grown in Sokoto, Borno and Kaduna States. Nigeria is also known as one the largest groundnut producing Countries in the world. The groundnut produced are either consumed locally in various forms and some are exported.

It has been observed that many farmers sold out their groundnut seeds at a give away price to the middlemen instead of extracting oil from them. The few among them especially women who extract oil from groundnut do it locally, hence, only small quantity of oil is usually, extracted. The modern method of oil extraction from groundnut seeds is therefore adopted to increase and improve both the quantity and quality of oil yield.

The importance of groundnut seeds can not be overemphasized. They can be eaten raw, or dried, they can be boiled, roasted or dry fried. They are rich in fat and protein. A good percentage of it is used for oil production which is exported; it is used for making soaps and vegetable fat.

2.1 THE NEED FOR IMPROVED METHOD OF GROUNDNUT OIL EXTRACTION

Improved equipment are available for small – scale oil production for the various oil seeds produced in this country, classified into three groups, these are expellers, ghanis and plate presses Expellers and ghanis are used for seeds and nut because of the great pressure required to extract oil screw operated plant presses are however seed for oil extraction from monocarps, while hydraulic press due to high pressure generation, are used to press seeds and nuts as well. Among this equipment only the machines marketed by Union of Appropriate Technology Assistance (UNATA) of Belgium were identified to popularization among small – scale rural groundnut oil producers in this country.

A set of these machines comprises of a decorticator, winnower, soller mill, oil press and a cooker. High cost of acquiring the set, the non-conformity of the cake utility after oil extraction with the need of most Nigeria consumers, and the reproduction of some of the units in the set by some of the problems identified to be the major obstacles in pushing this technology to end users. Hence, the need to develop improved groundnut oil extraction technology based on established indigenous groundnut processing for groundnut oil production for small – scale oil producers in Nigeria (NAERLS, 1990).

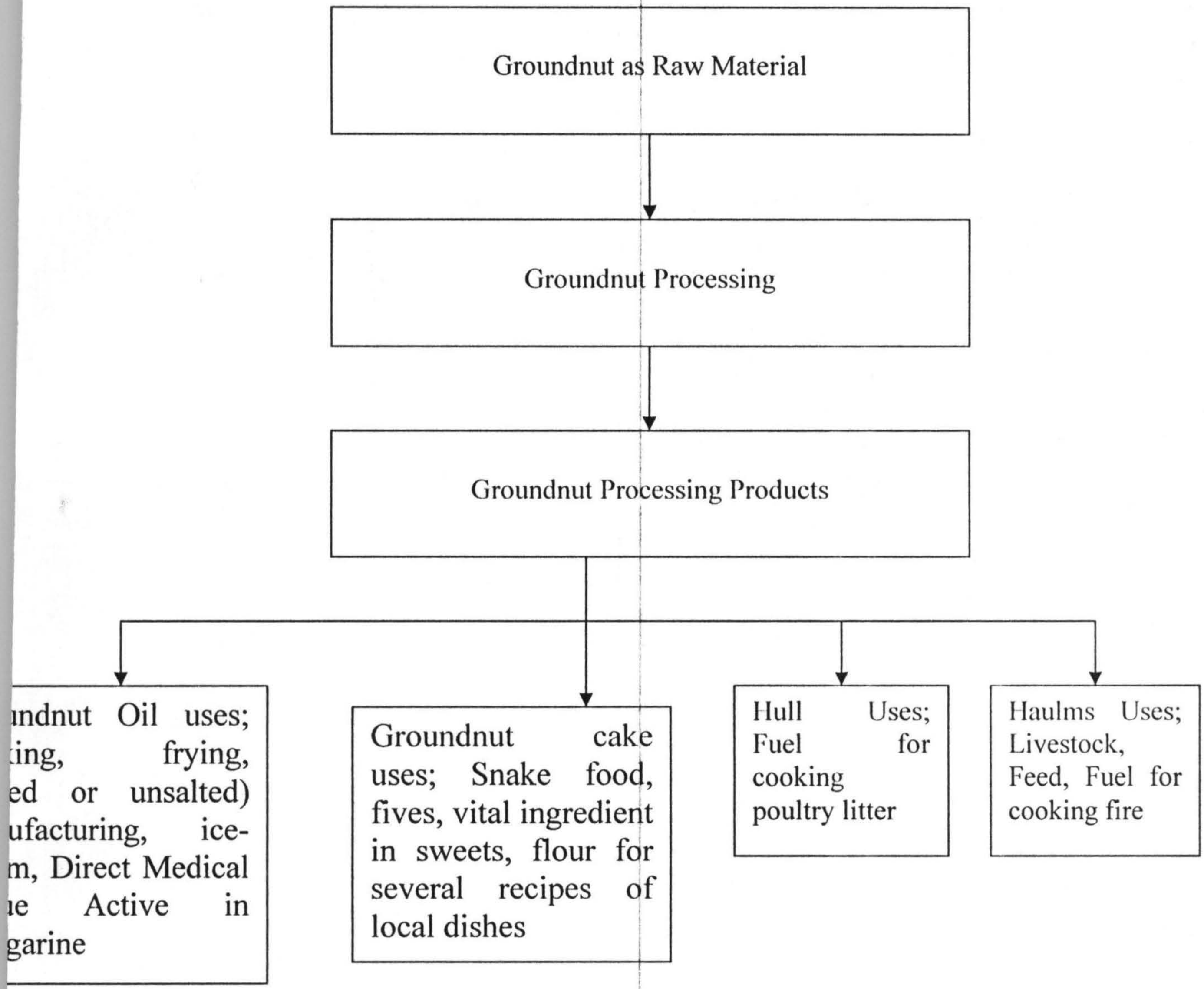

Figure 2: Flow Chart of Groundnut Products and their Utilization among Nigeria Consumers (Savanna Journal of Agricultural Mechanization Vol. 2 No. 1).

2.2 METHOD OF GROUNDNUT OIL EXTRACTION

Groundnut is one of the most popular and widely leguminous crops grown in the Savannah Zones of Nigeria. The crop is endowed with a high percentage of extractable oil, that is 40 – 55 percent oil content (TPI, 1971). The production of groundnut oil and other products such as "Kuli-Kuli" haulms, hull, etc that are obtainable from groundnut processing is an important income source for women in many communities in Nigeria (UNFEM, 1987).

There exists little variation in the basic traditional system of groundnut oil production. The system involves a number of processes carried out in succession. Groundnut is shelled and cleaned or alternatively, shelled is obtained directly from market. It is then thoroughly dried and roasted (grilled). The roasted seed is then manually dehauled (skinned) or by the use of rolling planks.

The dehauled and clean groundnut seed is then grounded using grinding stone. The resultant paste is kneaded (stirred) using a special wooden pestle and mortar. Warm water (25°C – 32°C) is added a little at a time while the paste is being stirred to form a meal. This continues until the meals viscosity increases and its coloration darkened (to dark brownish). At this stage, oil release begins. The quantity of oil obtained at this first point of collection depends on the expertise of the operator (Kneader).

The only dark brownish meal is then removed from the pestle and mortar and place on grinding stone in batches. Each bath is thoroughly pressed and squeezed with bare hands against the stone several times until the maximum amount of oil that can be extracted from the meal is obtained. The resultant production is an oily thick meal forming a cake. The cake is manually formed into different shapes, i.e. Balls, rings, plates, pellets, etc. and fried to remove the remaining oil (third point for oil collection). The fried product is a food snack popularly known as Kuli-Kuli and sold in the market.

2.2.1 HYDRAULIC PROCESSING OF GROUNDNUT OIL

Cornelius et al (1971) stated in their own study that the invention of hydraulic press, started in 1967 by Joseph Bramah. Its invention resulted in a great revolution of the oil seed industry until the introduction of the continuous high pressure screw press. They further enumerated that hydraulic press comprises of two main types, the open and close type.

The open type, oil seed is wrapped in the press cloth and subjected to pressure between a series of horizontal steel plates with a [illegible]0mm ram and a maximum pressure of 2,500kg/cm^2 and the residue oil in the cake is about 5%.

The close type cage press confines the oil containing materials with a strong perforated steel – cage during the pressing operation and thus largely dispense with the use of press cloth. It is practically subjected to high pressure than the open presses. They are particularly suitable for the expression of crops like palm kernel and other oil seeds which are high in oil contents.

2.2.2 EXPELLER PRESSING OF GROUNDNUT OIL

Dendy et al (1973), said for expeller pressing, groundnuts are crushed and feed continuously into an expeller, consisting of a screw which rotates within a sturdily built cylinder. The crushed groundnut mass is fed into the larger end of the expeller chamber and pressure is exerted as the screw turns, forcing the mass towards the smaller end (discharge end). Friction and pressure cause the mass to heat, which facilitates oil extraction the groundnut oil passes through the perforated screen walls, and is collected beneath the expeller chamber, while the press cake is extruded from the discharge end. The optimum moisture content of the groundnut mass for oil recovery by expeller pressing is 6 percent. The resulting press cake normally contains 5 percent oil.

2.2.3 SOLVENT EXTRACTION OF GROUNDNUT OIL

(Woodroof 1983), reported that (Scott 1980) described the solvent method of oil extraction from groundnut to produce high quality protein for industrial use.

The process for solvent extraction of groundnut oil is similar to solvent extraction of Soya Bean oil. Generally, the groundnuts destined for oil are shelled and winnowed to remove the fibre rich shells, and whitened by removing the tannin – containing red skins. Next, the nuts are cracked into pieces and conditioned to 10 – 11 percent moisture content at 50°C, and then flaked by passing through rolls. Sometimes the groundnut flakes are cooked before they are conveyed into the extractor. In the extractor, the oil is removed by means of a solvent.

The solvent laden flakes are then passed through a desolventizer which recovers the solvent. The deflated and desolventized cake may undergo further treatment before it is used as feed. The crude oil is clarified by passing it through a filter press. After clarification, the oil may be dehydrated and sent directly to the oil refinery. Steinbock (1982), stated a combination of mechanical and solvent extraction occasionally gives better results than either process used separately.

2.3 TRADITIONAL WEST AFRICA METHOD OF OBTAINING GROUNDNUT OIL

This method has been adopted long ago for oil extraction from groundnut seeds. In Nigeria, the traditional method is achieve as follows: Shelled Groundnut seeds are cleaned, roasted and fried for sometime in a frying pan. After roasting, it is allowed to cool for sometime and thereafter the testa is removed. The cleaned roasted groundnut is then milled using a grinding stone. After milling, it changes into a paste which is stirred continuously via mortar and a pestle. In the process of stirring, some water and salt is added little by little to the paste.

Stirring could also be carried out using a plate which is deep and wide a little bit with a strong stick of reasonable length.

As the stirring process continues, at a certain point in time, the paste will start to change into cake and will then start to float at the top of the cake. The oil is then collected carefully using small cup from the mortar into another container.

When no more oil oozes out of the cake, it is then pressed with hand on the walls of the mortar and finally the cake is removed out. The cake is either used for animal feed or human consumption. This method is time consuming, labourious, low output, and great loss of oil.

2.4 TRADITIONAL METHOD OF OBTAINING GROUNDNUT OIL IN NIGER STATE

(Kolo, 2005), reported that groundnuts are shelled by hand. The kernels are roasted over a fire on a metal sheet. The kernels are lightly rolled between flat stones, then winnowed to remove the testa. The steps is important because the testa is bitter and will affect the flavour of the fried by-product. The roasted kernels are either ground in a local maize mill or crushed between two stones to form a paste.

The former process is preferred since it is quicker and reduces labour requirement. Water and salt are added to the paste in a large bowl and the mixture is stirred and kneaded by hand. The amount of water added is not measured, but gauged using experience. After about fifteen minutes, the mixture darkens and forms a resilient paste which is difficult to knead.

At this time, oil separates from the mixture. The mixture is continuously kneaded for about five or more minutes. The groundnut paste (which, at this stage, can be formed into a cohesive ball) is then removed. The oil is poured into a separate container and needs no further treatment before consumption. The remaining groundnut paste is rolled into thin.

CHAPTER THREE

3.0 DESIGN METHODOLOGY

The machine is designed to extract oil from groundnut dough or paste after roasting, grinding and kneading of the groundnut seeds using a separate roaster and burr-mill machine.

The materials used in the construction of the machine were sourced locally based on availability, design and the usefulness of the machine.

The machine frame is made of thick mild steel angle iron to provide for rigidity. The paste container is also made of 1.5mm thick, mild steel sheet shaped into a square with a frustum at the bottom to allow for the escape of the extracted oil.

The main body of the machine is made of mild steel sheet of 2.0mm thick with the walls lagged, using a good lagging material to increase and retain the temperature of the chamber during the oil extraction operation. Both the top and bottom of the main body is left open to house the paste container.

A metal screw (press screw) is mounted on a press bar with a press plate at one end to compress the groundnut paste during the oil extraction operation in the paste container. The press bar also made mild steel rod of 0.015mm diameter is hinged on two support arms, each support arm is attached against the two opposite walls of the machine.

3.1 DESIGN CONSIDERATIONS

The important considerations in the design, construction and testing of the groundnut oil extraction machine include among other (Corbette, 1981):

(i) Low cost, so that most of oil producers can afford to acquire it

(ii) It should be portable and easily fixed to and removed from ground surface for stationery operation.

(iii) Local artisans should be capable of fabricating the machine

(iv) The power required forits operation should be much less than that required to operate the pestle and mortar.

(v) Should be as simple as possible, preferably with no or few adjustments to enable potential users operate it with no difficulty.

(vi) Should have a capacity of between 5 and 10kg per bath (anything higher than that should be difficult to operate manually).

(vii) It should be manually operated (Hand operated).

3.2 MACHINE DESCRIPTION AND PRINCIPLES OF OPERATION

3.2.1 MACHINE DESCRIPTION

The groundnut Oil extraction machine consist of the following basic units: Press bar, machine frame, Paste container, Press plate and support arm

The machine is manually operated by hand. In operating the groundnut oil extraction machine, the already mixed paste is put into a cheese cloth, and below the paste container is a perforated mash wire with openings. The turning bar or press handle is rotated in the clockwise direction, until it presses the paste and oil is then expressed through the perforated base of the chamber into a container which collected the oil.

The machine frame carries the entire components of the machine. The frame is made of mild steel angle iron of 45mm x 45mm to allow for rigidity. The press handle is made of a piece of shaft, which is also mild steel of 30mm in diameter and 150mm long. It is used in rotating the press plate. The press plate is being threaded and produces a linear motion which rotated. The press screw and Nut are welded to the frame to enhance rigidity. The walls of the machine are being lagged to maintain a constant temperature.

.2.2 PRINCIPLES OF OPERATION

The groundnut oil extraction machine is a stationery processing unit operated by one person by way of rotating its handle in a transverse plane in either clockwise or anticlockwise direction. The unit consists of five functional sections. Press handled, paste chamber, support arm, machine frame and press plate.

The paste chamber is cylindrical with an open designed to replace the traditional mortar pressing mechanism consist of handle and press plate, which is supported by two arms mounted at the shaft. The machine is supported during operation by supports and anchors attached to its frame. The support arms are not fixed permanent, but can be removed from the anchors before operation. Kneading of paste is accomplished by the rotating and pressing plate up to the point of oil release.

3.3 MACHINE COMPONENT DESIGN AND CALCULATIONS

Machine design helps in the selection of the material, shape, computing the dimensions, strength, reliability and specifying the manufacturing requirement of the machine component parts or the complete machine (Adgidzi, 2004).

3.3.1 GROUNDNUT OIL EXPULSION

To determine the amount of oil to be extracted from groundnut paste per batch in the paste chamber, let us assume, the mass of paste to be processed as 17kg.

3.3.2 CAPACITY DESIGN OF THE PASTE CHAMBER

Mass of paste in container = volume of container

X Density of paste (M = V x D) .... (1)

Where, Mp = Mass of Paste (kg)

Vp = Volume of paste (m^3)

Dp = Density of paste (kg/m^3)

Volume of the paste container (cube)

$$V = L \times B \times H \quad (2)$$

Let assume the dimension of the paste container to be 0.3m x 0.3m x0.3m =

Density of groundnut paste = 640.80kg/m^3 (Henderson, 1981).

Hence, mass of paste in container

$$M = \text{Density} \times \text{Volume} \quad (3)$$

$$M = 640.8 kg/m^3 \times 0.027 m^3$$

$$M = 17.3 kg$$

The design of the trapezium shaped bottom welded to the tower end of the paste container to provide a gentle slope in the flow of the extracted oil from, the peanut paste into a plastic container underneath the machine.

Area of trapezium $$A = \tfrac{1}{2}(a + b) \times h \quad (4)$$

Where,

A = Area (m)

a = Length (m)

b = Breath (m)

h = Height (m)

Hence, $A = \frac{1}{2}(0.3 \text{ x } 0.3) \text{ x } 0.2$

$= \frac{1}{2}(0.9 \text{ x } 0.2)$

$= \frac{1}{2} \text{ x } 18$

$A = 0.36\text{m}^2$

Volume of trapezium = Area x thickness of material .... (5)

$V = 0.36\text{m}^2 \text{ x } 1.5\text{m}$

$V = 0.54\text{m}^3$

3.3.3 DESIGN OF MACHINE PRESS SCREW (POWER SCREW)

A manually driven power screw in the power unit are the square, ACME and buttress thread (Sligley, 1989).

However, this machine uses an ACME thread with a 15° profile angle, is easy to manufacture in all workshops.

The total load on the power screw was determined using this equation.

$WTL = \text{WP} + \text{WR}$ .... (6)

Where, WTL = Total load on power screw (N)

$W\text{p}$ = Weight of paste (N)

$W\text{pp}$ = Weight of rods (N)

WR = Weight of rods (N)

From equation 6, WTL $= Wp + Wpp + WR$

Wpp = Mass x gravity due to acceleration

Wpp = Mass x gravity due to acceleration25kg x 9.81 = 166.77N

WR = Mass x gravity (N)

= 15kg x 9.81 = 147.2

WR = 147.2N

WTL = $167 + 245.3 + 147.2$

= 559.45N

WTL = 559.5N

The allowable stress on the power screw was given by (Maitra and Prashed, 1985).

$\gamma A /\ \ 0.45\,\gamma y$ ....(7)

Where, y = Yield strength = 0.65N/mm

γUt = Ultimate stress = 700N/mm^2

However, stress = F ....(8)

As = Fd ....(9)

Where, As = Cross - Sectional Area of Screw m^2

Fd = Designed force on screw N

Since $As = \Pi 4\left(d^2/_3\right)$ .... (10)

$Fd = \text{WTL} + 0.3\,\text{WR}$ .... (11)

$Fd = 559\,\text{N} + 0.3(147.2\text{N})$ .... (12)

$Fd = 559.5\text{N} + 147.2\text{N} = 707\text{N}$

Also from equation 7; $\gamma A1 = 0.45 \times 0.65$

$\sigma AL = 0.2925\ \text{N/mm}^2$

Hence, d^3 = Minor diameter of screw

$$d^3 = \sqrt{\frac{4fd}{\sigma\ \text{AL}}} \quad \text{.. (13)}$$

$$d^3 = \sqrt{\frac{4 \times 707\text{N}}{0.2925 \times 3.14\text{N}}}$$

$$d^3 = \sqrt{\frac{2828N}{0.91845}}$$

$$d^3 = \sqrt{3079}$$

$$d = 14.548\text{mm}$$

3.4 POWER REQUIREMENT

The power required to operate the machine was determined from the Equ Shigley, 1976).

From, $H = \text{Tf}\omega$ .... (14)

H = Power required (watts)

T = Torque Nm

Σ = angle velocity, Radian/Sec

Also, $\Sigma = 2\frac{\pi N}{60}$ .... (15)

Where N = speed, rpm

However, the maximum speed of a human strength for cranking (Woodson et al, 1982).

For an ACME thread the torque to move load was given by Grammer (1976) as:

$$Tf = \frac{Fd \text{ x } d^2(\text{Cos}\Theta \text{ Tan a} + \mu s)}{2(Cos\Theta\ \mu s \text{ Tan a})}$$

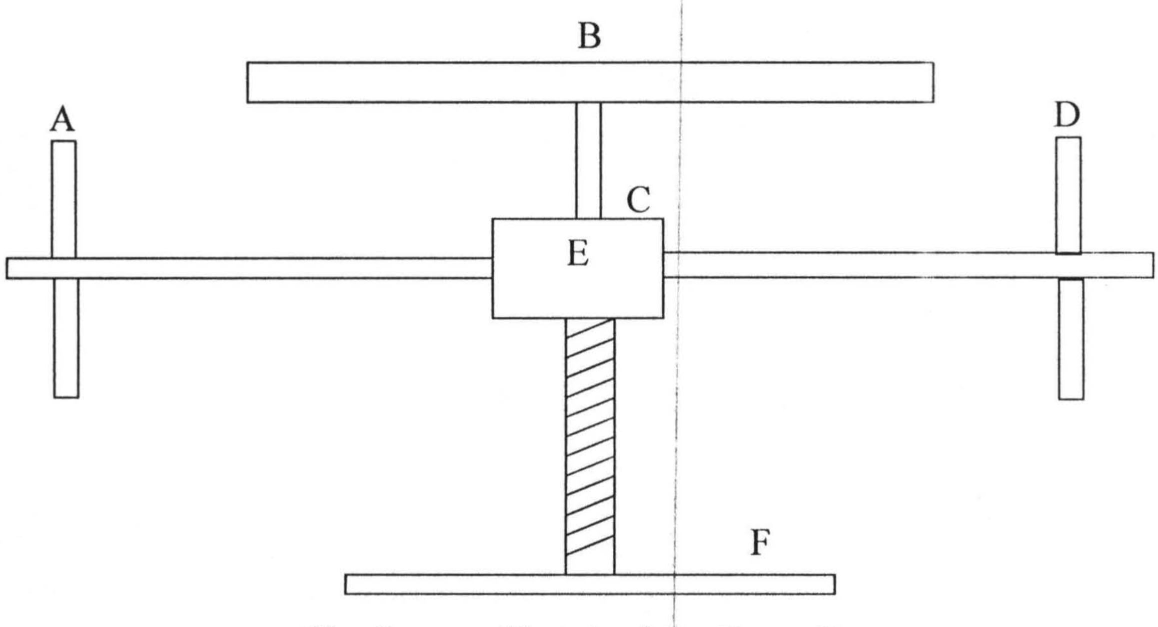

Fig. 3: Sketch of the Press Bar

Where, A = Support Arm (Left)

B = Press crew handle

C = Press Screw

D = Support Arm (Right)

E = Press Screw Nut

F = Press Plate

G = Press Bar

3.3.5 CALCULATION OF THE COMPONENT WEIGHTS

The support arms are welded to the two opposite walls of the machine body.

To determine the axial loads on the press bar

1. Mass of grounded paste per batch = 17kg
2. Weight of groundnut paste per batch $= 17 \times 9.81 = 166.77N$
3. Mass of press screw with handle = 16.0kg
4. Weight of press screw with handle $= 16.0 \times 9.81 = 156.96N$

Mass of press plate = 25kg

Weight of support arms $= 10kg \times 9.81 = 98.1N$

Hence, $Fa = 167 + 157 + 245.3 + 98 = 667.3n$

$$Fa = 667.3N$$

To represent free body diagram of the press bar

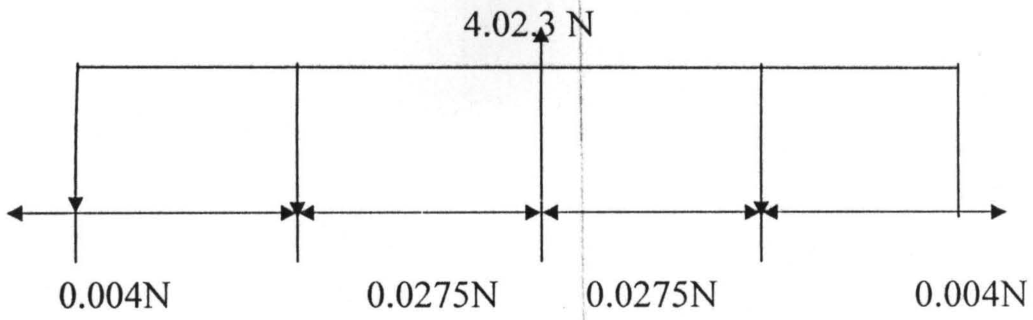

Fig. 4: Free Body Diagram of Press Bar

Where TF = torque required, Nm

Fd = Load to be moved, N

Θ = Half of the profile angle (15°)

μs = Coefficient of friction, 0.12

d2 = Pitch diameter

α = Helix angle 4.25°

$$TF = 7.07\text{N} \frac{(0.9914 \text{ x } 0.00743 + 0.12)}{2(0.0647 - 0.12 x 0.0743)}$$

$$TF = 7.07 \frac{(0.1936)}{2(0.0647)}$$

$$TF = 10.5772 \text{ Nm}$$

Hence, $H = 10.5772 \text{ x } \frac{2 \text{ x } 3.14 \text{ x } 250}{60}$

$$H = 10.5772 \text{ x } 26.1666 \text{ watts}$$

$$H = 276.7700 \text{ watts}$$

$$H = 277\text{W} = 0.277\text{kw}$$

$$H = 0.3713 = 0.4\text{hp}$$

Woodson (1992) gave the maximum torque applied by a human Cranking perpendicular to the plane of crank as 4.52 Nm. Thus maximum power by a human being is:

$$Hm = \text{Tm x } 2\pi\text{n} = 0.16\text{hp} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

Since H < Hm. It implies that the machine can be cooperated manually.

3.3.6 DESIGN OF MACHINE PRESS BAR

The machine press bar acts as a support bar on which the press screw passes through in the middle. The machine press bar is hinged at both ends on two support brackets. It is necessary to consider the forces acting on the press bar for the sake of design and safety. The Load acting on the press bar are as a result of (1) Axial Load (Fa) due to the weight of the press screw, press plate, support arms, the press exerted on the paste during the oil extraction operation. (2) Shearing force as a result of the downward movement of the press screw during the oil extraction.

3.3.7 DETERMINATION OF THE REACTION ($RA \alpha$ RC)

Consideration of the figure above, the vertical force should be:

$$\sum fy = 0$$

$$RA + \text{Rc} - 402.3 = 0$$

$$RA = 402.3 - \text{Rc}$$

$$\sum MA = 0$$

$$Rc = (0.055 + 0.004) + 402.3\,(0.0275) + 0.00275$$

$$+\ 0.004 = 0$$

$$0.059RC = 11.06325 + 0.0315$$

$$0.059RC = 11.09475$$

$$Rc = \frac{11.09475}{0.059} = 188.04\text{N}$$

$$Rc = 188.04\text{N}$$

Hence,

$$RA = 402.3 - 188.04$$

$$RA = 214.25\text{N}$$

3.3.8 BENDING MOMENT AT HORIZONTAL LOADING

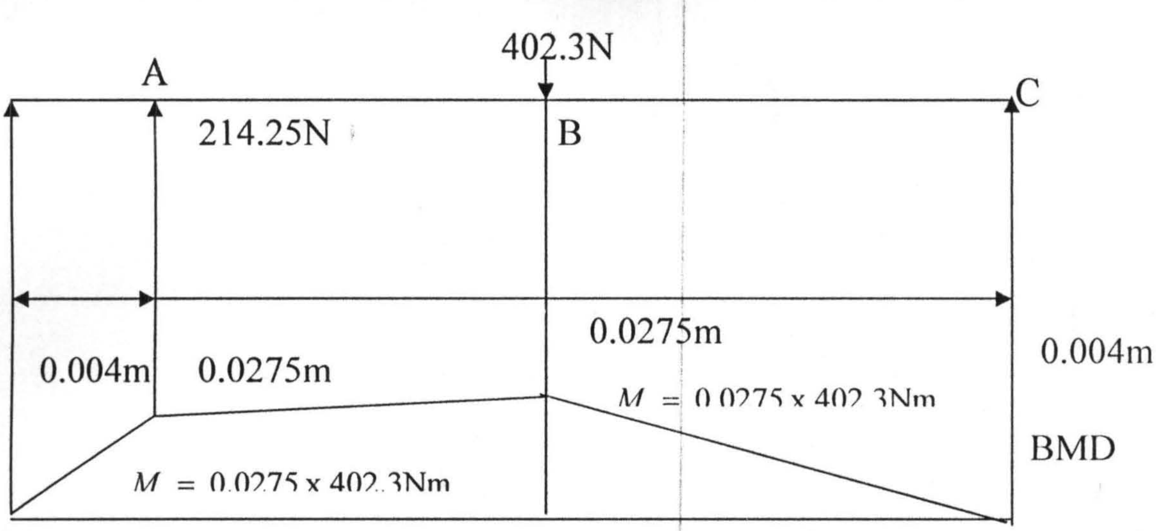

Fig. 5: Bending Moment at Horizontal Loading

$\sum MA$ = When x = 0.004

$= 214.25(0.004) = 0.857N$

$\sum MB$ = When x $= (0.004 + 0.0275) = 0.0315N$

$= 214.25(0.004) - 402.3(0.0315)$

$= 214.25(0.004) - 402.3(0.0315)$

$= 0.857 - 12.67N$

$X = -11.813N$

$\sum c$ when x $= (0.004 + 0.055) - 0.059$

$= 214.25(0.004) - 402.3(0.0275 + 183.04)$

(0.059)

$= 0.857 - 11.063 + 11.0944$

$= -10.2063 + 11.0944$

$X = 0.8882\text{N/M}$

3.3.4 DETERMINATION OF PRESS BAR DIAMETER

Hall, et al (1980) gave the ASME Code equation for determining the diameter of a solid shaft having axial loading as:

$$d^3 = \frac{16}{\pi \text{Ss}} \sqrt{(\text{KbMb})^2 + (\text{Kr} + \text{Mr})^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

Where, d = shaft diamter, m

Kb = Combined shock and fatigue factor applied to bending moment (Load gradually applied = 1.5)

Mb = Bending moment N/M

Kr = Combined shock and fatigue factor applied to torsional moment for rotating shaft and gradually applied = 1.0

Mr = Torsional Moment, N/M = 0.35N/M and Maximum bending moment, $Mb = 11.82\text{Nm} = 12\text{Nm}$

Substituting the valves into the equation.

$$d^3 = \frac{16}{\pi(55 \times 10^6)} \sqrt{(1.5 \times 12)^2 + (1.0 \times 0.29)^2}$$

$$d^3 = 9.2 \times 10^{-8} \sqrt{324 + 0.0841}$$

$d^3 = 9.2 \times 10^{-8} \quad \sqrt{324.0841}$

$d^3 = 9.2 \times 10^{-8} x 18.0023$

$d = 3\sqrt{1.6562}$

$d = 0.012\text{m}$

Addition of factor of safety 1.5 (Sligley, 1989).

$d = 0.012 \times 1.5$

$d = 0.018\text{m}$

$d = 18\text{mm}$

3.4.1 DESIGN OF MACHINE MAIN BODY

The main body is a container that houses the paste container to allow for smooth escape of the extracted oil into a collection trough and into a plastic basin without wastage. The main body is constructed in a form of cube and properly lagged to maintain a reasonable temperature during oil extraction operation.

$A = \text{Length x Breath x Height}$

$$Area \text{ of Cube A} = \left(\tfrac{1}{2} n(n = 1)^2\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

Substituting into the equation

$A = 0.5\text{m x } 0.5\text{m x } 0.5\text{m}$

$A = \left(\tfrac{1}{2}\ 0.5\left(0.5 + 1\right)^2\right)$

$= \quad 0.25 \times 0.375$

$A \quad = \quad 0.1406 = 0.14m^2$

3.4.2 DETERMINATION OF PRESSURE ON THE PASTE CONTAINER WALLS

The static pressure (Ps) exerted by the paste on the walls of the paste container, is a factor to be considered.

Hence, $Ps = \frac{\text{Force}}{\text{Area}}$

$$= \frac{\text{dvg}}{\text{A}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

When, Ps = Static Pressure, Pa or N/M^2

A = Area of Paste Container, M^2

F = Force, N

d = Density of groundnut paste, Kg/m^3

V = Volume of Paste in container, M^3

g = Acceleration due to gravity, m/s^2

since pressure acts in all directions

area of the paste container bottom, $A = L \times B$

$A \quad = \quad$ Length x Breath ……………………………… (21)

$A \quad = \quad 0.3 \times 0.3 = 0.92m$

Area of the paste container = $A\,\frac{1}{2}(n+1)^2$

$$A\left(=\left(\frac{1}{2}(0.3)\right)(0.3+1)\right)^2$$

$$= ((0.15)(1.3))^2$$

$$A = (0.195)^2 = 0.3802\text{m}^2$$

$$\textit{Total}\ \text{Area} = 0.3802 + 0.9$$

$$\textit{Total}\ \text{Area} = 1.28\text{m}^2$$

Hence, from equation .... (20)

$$Ps = F/A = \frac{dvg}{A}$$

$$Ps = \frac{640.8 \times 0.027 \times 9.81}{1.28}$$

$$= \frac{169.728}{1.28}$$

$$Ps = 132.6\ \text{N/m}^2$$

$$Ps = 133\text{N/m}^2$$

3.4.3 WORKING STRESS OF PASTE CONTAINER

Assuming the container walls has a thickness of 1.5mm, the allowable stress was given by (Green, 1992).

$$\sigma^{\circ}\frac{Pb1}{2t}$$

Where, $\sigma° =$ Allowable or working stress, N/m^2

$P =$ Pressure in the container, N/m^2

$B1 =$ Length or breath of container, m

$t =$ Thickness of the walls, m

Substitution into equation 2.3

$$\sigma° = \frac{pB1}{2t}$$

$$\gamma° = \frac{133\ \text{N/m}^2}{2(1.5)m} \text{ x } 0.3\text{m}$$

$$\gamma° = 13.3\ \text{N/m}^2$$

3.4.4 DESIGN OF MACHINE FRAME

The machine frame is necessary to support the components of the machine and to also provide a base for the machine rigidity, the frame is like a column subjected to loading from the main body, paste container, support arm, press bar, press screw with the press plate and the groundnut paste in the paste container.

The total load to be carried by the frame was calculated to be:

1. Weight of main frame (wMF)

= Volume x Thickness

$V = L \text{ x } B \text{ x } H \text{ x } t$

$= 0.5 \text{ x } 0.5 \text{ x } 0.5 \text{ x } 2.5$

$= \quad 0.3125m^3$

Mass $= \quad$ Volume x Density of steel

$= \quad 0.3125m^3 \times 7790\ Kg/m^3$

$= \quad 2434.37kg$

$Weight = 2434 \times 9.81$

$= 23881.22$

$Weight = 23.88kN$

3.5 MATERIAL SELECTION

The material selected for the construction is mild steel because mild steel has good structural properties and could withstand shcok and vibration. However, other factors include:

(i) Low cost – The material selected are easily affordable and can be obtained at a low cost.

(ii) Availability - The material selected is readily available in the local market.

(iii) Durability – The materials selected are durable and could be replaced easily.

3.5.1 MACHINE FABRICATION PROCEDURE

The machine component parts were fabricated in the Department of Agricultural Engineering, Kaduna Polytechnic Workshop, using appropriate equipments, machine and tools. The procedures carried out in the fabrication of the machine component are highlighted below in a table.

Table 1: Showing Components, Fabrication Procedures and Machine or Tools Used.

S/NO	COMPONENT	FABRICATION PROCEDURE	MACHINES OR TOOLS USED
1.	PRESS HANDLE	Measure out the dimension on mild steel rod, 1.5mm thick and length 70mm, threaded and cutting of marked outlines.	Steel tape Try square Hand Hacksaw Lathe machine.
2.	PRESS HANDLE	Measure out on a hard mild steel 70mm thick by 40mm length. Cutting of marked out lines. Provide thread for screwing and pressing.	Hacksaw, Lathe machine, Hammer.
3.	PRESS NUT	The screw was also thread, on the lathe machine, thickness of 1.5mm and length 500mm.	Try square, steel tape, Nuts and bolt Hacksaw.
4.	SURPPORT ARM	Mild steel of 1.5mm shaped to an angle of 45° and cut to a reasonable shape of angular bar and measure with a try square.	Hacksaw Try square steel rule compasses.
5.	PRESS BAR	Mild steel rod of 1.5mm, length of 600mm, at 300mm at both ends. Clampdown the bar to the press plate.	Lathe machine, steel rule tape Try square, Hacksaw.
6.	PRESS PLATE	Mild steel plate of 45mm x 45mm, saw out the length of the plate and measured out to required dimension.	Hacksaw, Try square stee rule.
7.	PASTE CONTAINER	Measure out the dimension on a mild steel place of 1.5mm thick, 350mm x 300mm. Marking out of the measured dimension.	Tee square scriber, steel rule folding machine.

3.5.2 MACHINE MAINTENANCE

Proper care and maintenance of the paste container ensures quality oil production under hygiene condition and increase its services life. Always use clean water in the processes.

Basic maintenance includes lubricating the bearings from time to time, proper care of the nuts and press plate, press handle and support arms.

3.6 COST ANALYSIS

This refers to the sum of money committed into carrying out every bit of operation in the construction of the machine as well as the cost of material used.

Cost analysis according to (Calvin 91991) can be defined as “the signs of skilful analysis of a system to obtain a reasonable and accurate prediction of manufacturing cost of parts and hence to equipment produce.

Cost of production can be broadly classified into three namely:

i Maintenance cost

ii Labour cost

iii. Overhead cost

iv. Total cost

3.6.1 MATERIAL COST

This is concern with the cost of the material used in constructing the machine. The quantity, quality, specification and component required for the construction below.

TABLE 2: Cost of Material

S/NO	MATERIAL	SIZE	QUANTITY	UNIT PRICE	TOTAL COST
1.	Galvanized steel sheet	2mm Gauge	1	1500	1500
2.	Mild steel plate	2mm Gauge	1	500	500
3.	Mild steel rod	2mm Gauge	1	600	600
4.	Twist drill	4mm diameter	1	150	150
5.	Tap		1	100	100
6.	Sieve cloth		1	150	150
7.	Electrode	Gauge 12	30	70	1400
8	Paint		2 litres	300	300
9	Angular Bar	45mm x 45mm	3	500	1500
10	Screw	17mm	4	80	320

3.6.2 LABOUR COST

This is the money spend in paying technicians for production of some parts of the machine and personal labour put into the production. It is estimated to be 15% of the material costs.

$$\frac{15}{100} x4650 = \text{N}697.50$$

3.6.3 OVERHEAD COST

This is the money spend in collecting data, information and transportation of materials from the market to the workshop. It is estimated to be 20% of the material cost.

$$\frac{20}{100} \text{x } 4650 = \text{N}930.00$$

3.6.4 TOTAL COST

The total amounts of money spend on the production of the machine. It is the summation of the material cost, labour cost and overhead cost.

$$\textit{Total} \text{ cost (TC)} = \text{Material Cost (MC)} + \text{Labour}$$

$$\textit{Cost} \text{ (LC)} + \text{Overhead Cost } (\text{Oc})$$

$$Tc(N) = \text{N}697.50 + \text{N}4650.00 + \text{N}930.00$$

$$\text{Total cost (Tc)} = \text{N}6{,}277.50$$

CHAPTER FOUR

4.0 TEST, RESULTS AND DISCUSSION

The manually operated groundnut oil extractor was tested using the groundnut paste, after stirring, roasting, winnowing and kneading. The test was conducted in the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna.

4.1 PERFORMANCE TEST OF THE MACHINE

The apparatus and materials used in carrying out the test were as follows:

i. Groundnut paste (10kg)

ii. Manually operated groundnut oil extractor

iii 50 litres of water

iv. Weighing scale

v. Measuring cylinder

vi. Thermometer

vii. Cheese clothe

4.2 TEST PARAMETERS

The test parameters taken into consideration are:

i. To determine quantity of oil extracted

ii. To determine quantity of paste per kilogram after oil extracted

iii. The effect of various temperatures on the quantity of oil extracted

4.3 TEST PROCEDURE

The Runner variety of groundnut was used for the test, because it is very popular in West Africa. Before grinding, roasting, winnowing, groundnut was sun dried. This was done so as to reduce the moisture content and also to facilitate removal of the skin (testa) from the nuts. I used 45 minutes for the drying of the groundnut and the moisture content was reduced to 11.5% using moisture (Kenı ethe) meter.

The manually operated extraction machine components were cleaned and coupled. Some quantity of water was boiled in a bucket.

In operating the machine, the already mixed sample of paste is put into the pressing chamber after covering the base of the chamber with netting of $1mm^2$ and cheese clothe. The turning bar is rotated in the clockwise direction until it presses the paste to a flat level and the rotation is stopped. Oil is then expressed through the perforated base of the chamber, into a basin, which collects the oil.

The screwing and kneading operations were done simultaneously. The total operation was carried out in 2 hours.

4.4 RESULTS

The results of oil extraction of the groundnut paste at various temperatures is contained in table 4 below.

TABLE 2: DETERMINATION OF OIL EXTRACTED AT VARIOUS TEMPERATURES

Samples	Time (Secs)	Qty of Water (Ml)	Temp. °C	Wt of Sample B/F Pressing (W`1)	Wt of Sample after Pressing (W`2)	W_1-W_2 Volume (Kg) of Oil Extracted
A1	10	100	25	2	1.65	0.35
A2	10	100	25	2	1.70	0.30
A3	10	100	25	2	1.75	0.25
Total				6	5.10	0.90
Average				2	1.70	0.30
B1	10	100	50	2	1.50	0.50
B2	10	100	50	2	1.55	0.45
B3	10	100	50	2	1.60	0.40
Total				6	4.65	1.35
Average				2	1.55	0.45
C1	10	100	100	2	1.40	0.60
C2	10	100	100	2	1.35	0.65
C3	10	100	100	2	1.45	0.55
Total				6	4.20	1.80
Average				2	1.40	0.60

TABLE 3: STATISTICAL ANALYSIS OF RESULTS OBTAINED FROM MODERN METHOD OF GROUNDNUT OIL EXTRACTION AT 25°C

No of Replicate	Weight of Paste (g)	Weight of Cake (g)	Weight of Oil (g)	$\bar{X}-X$	$\Sigma\left(\bar{X}-X\right)^2$
1	2	1.65	0.35	0.05	2.50
2	2	1.75	0.25	-0.05	2.50
3	2	1.70	0.30	0.00	0.00
			$\bar{X} = 0.90/3$ $X = 0.30$		5.00

$\bar{X} = 0.30$

$\Sigma\left(\bar{X}-X\right)^2 = 5.00$

$$\text{Variance } S^2 = \frac{\Sigma\left(\dot{X}-X\right)^2}{n-1} = \frac{5.00}{3-1} = \frac{5.00}{2} = 2.5$$

$$\text{Standard deviation } = \sqrt{\frac{\left(\dot{X}-X\right)^2}{n-1}}$$

$$= \sqrt{2.5}$$

Standard deviation $= 1.58$

TABLE 4: STATISTICAL ANALYSIS OF RESULTS OBTAINED FROM MODERN METHOD OF GROUNDNUT OIL EXTRACTION AT 50°C

No of Replicate	Weight of Paste (g)	Weight of Cake (g)	Weight of Oil (g)	$\bar{X}-X$	$\Sigma\left(\bar{X}-X\right)^2$
1	2	1.50	0.50	0.05	2.50
2	2	1.56	0.45	-0.05	2.50
3	2	1.60	0.40	0.00	0.00
			$\frac{1.35}{3}$ $X = 0.45$		5.00

$\bar{X} = 0.45$

$\Sigma\left(\bar{X}-X\right)^2 = 5.00$

$$\text{Variance } S^2 = \frac{\Sigma\left(\dot{X}-X\right)^2}{n-1} = \frac{5.00}{3-1} = \frac{5.00}{2} = 2.5$$

$$\text{Standard deviation } = \sqrt{\frac{\left(\dot{X}-X\right)^2}{n-1}}$$

$$= \sqrt{2.5}$$

Standard deviation $= 1.12$

4.5 DISCUSSION OF RESULTS

Judging from the results obtained from the various test carried out, it has been observed that the groundnut that has low water addition will yield more oil, heating the groundnut at proper level is also necessary. The percentage oil yield increases until it reaches, sample C, at a temperature of 100°C, and it begins to fall.

This is simply because water at that temperature is not good for mixing groundnut paste.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

A simple, small scale and manually operated groundnut oil extraction machine was designed, constructed and tested for groundnut oil extraction.

From 2kg of groundnut pastes at 25°C, 80ml of oil was extracted, and from the same 2kg of paste at 50°C, 83ml of oil was extracted, also from 2kg of paste at 100°C, 90ml of oil was extracted.

In conclusion, the result above indicates that the higher the temperature, the more oil that can be extracted from the groundnut paste. The power required to operate the machine is within the recommended human energy (0.8kw).

5.2 RECOMMENDATIONS

Having tested the machine some problems were observed during the operation as follows:

1. The hole size of 0.20cm perforation on the paste chamber was found to be too large for the oil outlet.

2. The pressing handle was found to buckle during the operation of the machine.

3. The hot water chamber on the machine will require a heating device or element to facilitate the boiling of water within the system.

4. The press plate should properly fit into the pressing chamber to avoid oil spillage during operation.

In view of the problems highlighted above, there is the need for further research and development on the machine.

REFERENCES

1. Alabadan B. A., Ajisegiri, E.S.A. and Olayemi, I.A. (2002). Determination of Human Energy Requirements for the various stages of Groundnut Processing.

2. Adgidzi, D (2004). Lecture Note on Design of Machine Elements (Unpublished). Department of Agricultural and Bioresources Engineering, Federal University of technology, Minna, Niger State.

3. Cornelius et al (1971). Aqueous Extraction. An Alternative Oil Seed Milling Process. In Journal of American Society of Agricultural Engineers.

4. Corbett, S. (1981). VITA News – A New Oil Press Design: but is it any better? ITA Publishing. Washington D.C.

5. Ewald, (1976). Design and Development of a kneader. Nigerian Society of Agricultural Engineers (NSAE) Proceedings. 18:145-250.

6. Grammer, S. V. (1976). Processing Tropical Crops. A Technology Approach. Macmillan Education Ltd. Houldmils Basingstoke pp. 124-143.

7. Green (1992). Lecture note on Design of Structural Elements (Unpublished). Department of Agricultural Engineering, Silos College, England.

8. Holaday, C. and Pearson, J. (1974). Effects of Genotype and Production Area on the Fattacid Composition, total oil and total protein in Peanuts Journal of Food Science. Vol. 3:12069.

9. Harris, R. V. (1982). Groundnut Processing Methods and Products. Africa Groundnut Council, Processing of the International Symposium in Africa on production World Seeds Market and Intra-Africa Trade in Groundnut and Products Banjul, The Gambia 7-11 July. Page 33.

10. Kolo, E. W. 92005). Seminar on Small-Scale Oil Processing, Production and Technological Development. College of Agriculture, Ahmadu Bello University, Zaria, Nigeria.

11. Maitra and Prasad, (1985). Physicochemical Properties of Peanuts, in Peanut Culture and uses, AM. Peanut Res. and Educational Association. Stone Printing Co., Roanoke, VA.

12. NAERLS, (1994). Construction and use of a Multipurpose Paste Stirrer. Extension Bulletin No. 78.

13, NAERLS (1990). National Agricultural Extension and Research Liaison Services. Survey and Identification of Local Smiths with Potentials for Simple Oil Extraction Equipment Fabrication.

14. Sanda, M.A. (1997). Improved Tools and Methods of traditional groundnut oil extraction system. An M.Eng. thesis submitted to the Department of Agricultural Engineering, Zaria, Nigeria.

15. Scoot, (1980). Design and Fabrication of Beni-Seed Oil Extraction Machine. Institute for Agricultural Research Bulletin Ahmadu Bello University, Zaria, Nigeria.

16. Steinbock, (1982). Design and Fabrication of Agricultural Machinery. John Willey and Sons Inc. New York, U.S.A.

17. United Nations Development Fund for Women (UNIFEM, 1989). Oil Extraction. Food Cycle Technology Source Book No. 1 UNIFEM New York.

18. Woodroof, J.G. (1983). Peanuts Production, Processing and Products. AVI Publishing Inc. West Connecticut, USA.

19. Woodsoon, A. (1992). Application of Solvent Extraction. In Journal of America Oil Chemical Society, 33:457.