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Abstract- This paper presents the design, construction and testing of a hand operated hydraulic oil press for groundnut oil extraction. The device consists of a pressure cylinder, pressure plates, hand operated hydraulic press and oil collector. The maximum design pressure of the device is put at 16.2N/mm^2 with groundnut holding capacity of approximately 1kg per batch. Materials for the construction of the device were selected to meet the design, safety, cost and service requirements of the device. Stainless steel was used for pressure cylinder, pressure plates and collector to avoid contamination of the oil while mild steel was used for constructing the frame. Other tools like steel rule/measuring tape and hacksaw for taking measurements and cutting of materials while vanier caliper for measurement of internal and external diameters of the pressure cylinder, plates and collector. The drilling and lathe machines were employed for drilling finishing, boring, and turning operations. The joining of parts was achieved using electric welding. Roasted groundnut seed is place between the layers of the pressure plates and the driven hydraulic press is used to compress the groundnut in the pressure cylinder to extract the oil which is then collected through the collector.

Keywords: *hydraulic oil press, oil yield, extraction efficiency, improve capacity and efficiency.*

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DESIGNCONSTRUCTIONANDTESTINGOFHYDRAULICOILPRESSFORGROUNDNUTOILEXTRACTION

Strictly as per the compliance and regulations of:

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Abstract- This paper presents the design, construction and testing of a hand operated hydraulic oil press for groundnut oil extraction. The device consists of a pressure cylinder, pressure plates, hand operated hydraulic press and oil collector. The maximum design pressure of the device is put at 16.2N/mm^2 with groundnut holding capacity of approximately 1kg per batch. Materials for the construction of the device were selected to meet the design, safety, cost and service requirements of the device. Stainless steel was used for pressure cylinder, pressure plates and collector to avoid contamination of the oil while mild steel was used for constructing the frame. Other tools like steel rule/measuring tape and hacksaw for taking measurements and cutting of materials while vanier caliper for measurement of internal and external diameters of the pressure cylinder, plates and collector. The drilling and lathe machines were employed for drilling finishing, boring, and turning operations. The joining of parts was achieved using electric welding. Roasted groundnut seed is place between the layers of the pressure plates and the driven hydraulic press is used to compress the groundnut in the pressure cylinder to extract the oil which is then collected through the collector. The pressure cylinder consists of holes in which the extracted oil flows out of the cylinder. The press is released and the cylinder is taken away from the collector and the residual is removed with a press rod when the oil stops coming out. Test result show that an average weight of 0.2049kg oil is obtained from appropriately 1kg weight of roasted groundnut seeds which gives 21.8% of oil yield efficiency and extraction efficiency of 48.3% with an extraction loss of 0.33%. Considering the oil content of groundnut as 45%, it indicates that the simple hydraulic press could be effective in the oil extraction process with minimum extraction loss. It is recommended that it could be produce in relatively large number for usage in rural and semi-urban areas with no electricity to replace the traditional method while an electrically operated hydraulic press could facilitates small to medium scale businesses with improve capacity and efficiency.

Keywords: hydraulic oil press, oil yield, extraction efficiency, improve capacity and efficiency.

I. Introduction

Oil extraction is the process of recovering oil from oil-bearing products through manual process, mechanical or chemical method. The agricultural products are classified into oil seeds (cotton, castor, sunflower etc), nuts (coconut, groundnut, sheanut etc) and mesocarps or fruit (oil palm). Many type of oil are obtained from these products with only a few of them being very significant in terms of world production and traded as major commodities (Robbelen *et a.,*, 1989). These oil as well as their by-products are also very useful as food and non-food material for the production of snacks, cake, margarine, biscuits, cosmetics, detergent, plastic etc (). Oil production is important not only among small to medium scale industries but also to rural populace, employing quite a substantial workforce and also served as a source of income to many communities which engage in their productivity acativities (Abalu, 1978; UNIFEM, 1987).

Extraction of oil from oil-bearing products is mainly carry out in two major ways; the traditional method (primitive) and modern methods. The traditional method has been practiced for ages and is usually a manual process which involves preliminary processing and hand processing. This method is labour intensive, time consuming, unhygienic and has poor oil extraction leading to waste of oil. It is mainly practice in rural areas by farmers which have no access to electricity and income to afford modern machineries and equipment including the technical-know how for the extraction process. Traditionally, oil is extracted from groundnut by roasting and crushing to as fine as possible, afterward, the crushed mass is mixed with water and the oil is obtained by cooking the mixture causing the oil to float. The oil is finally skimmed off and directly heating (Hans, 1989. Ajao *et al*, 2010). The improve method of oil extraction can either be of chemical extraction or mechanical extraction method. The chemical extraction method requires the use of organic solvent to recover the oil from the product. Mechanical method employs the use of device like screw and hydraulic presses as a means of applying the pressure to the seeds for oil extraction (Gunstone and Norris, 1983). Other mechanical device includes oil expeller and improved Ghanis which are used for seed and nut because of the high pressure required to extract the oil (UNIFEM 1993). As reported by Norris (1964), Ward (1976) and Khan and Hanna (1983), the oil yield and quality depend on the content adjustment, heating time, pressure applied, operating temperature among others. The mechanical method involving the screw press is more reliable than the hydraulic press but is slower and produces less pressure, thus relatively low oil yield (Aseidu, 1984). Generally, the mechanical methods have relatively higher operating cost than the traditional method.

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However, they have higher efficiencies and are usually more adaptable for small to medium scale producers (Abubakar and Yiljeb, 1996).

Groundnut oil extraction in most developing nation such as those of the south Asia and Africa is usually done manually by hand and like all other manual operations, it is drudgery and time consuming. The groundnut *Arachis hypogeal* also known as the peanut or earthnut is botanically a member of papillionaceae largest and most important member of leguminous (Hans and Frans 1989; shankarappa *et al.,,* 2003). It is very important oil seed and crop around the globe for its nutritional and trade value (Shankarappa *et. al,* 2003; Olaomi, 2008). Mainly native to warmer climate, groundnut frequently provides food for human or livestock and in the absence of meat, form a valuable dietary protein component (Hammos, 1994).

In Nigeria, groundnut is almost exclusively processed in combination with the utilization of the residue for human consumption and animal feed. In fact, often the by-product a kind of snack called by the Hausas in Nigeria as kulikuli. Groundnuts give edible and pleasant testing oil for human consumption and are used as salad oil for cooking. The oil extracted from groundnut is called groundnut oil. The oil content of groundnut contains up to 50% oil (although the usual range is 25% - 30% protein (Hans and Frans 1989; Hammos, 1994).

Various attempts have been made to develop devices adaptable to the local farmers in Nigeria. The Institute for Agricultural Research, IAR at Ahmadu Bello University, Zaria developed a traditional model for groundnut oil extraction in 1995. The model was operated manually with the mortar installed and centred to ground for sterilely and the pestle was clamped on the mortar such that it could be ported on the casing as it kneaded the ground pestle in the mortar (Eke, 1995) while at the National Agricultural Extension and Research Liaison Services, NAERLS Ahmadu Bello University, Zaria attempt was made to replace the traditional mortar and pestle with manually operated drum chamber and a stirring shaft and finger mechanism as reported by Abubakar (1996).

With the design and construction of a portable hydraulic press at afford cost will eliminate the manual labour involved in groundnut oil extraction, increase oil extraction output per unit time, make high yield groundnut oil affordable to the populace most especially the rural dwellers and also generate income to the local farmers.

II. Materials and Methods

a) Materials and Tools

Materials for the construction of the device were selected to meet the design, safety, cost and service requirements. Stainless steel was used for the pressure cylinder, pressure plates and the collector to avoid contamination of the oil while mild steel was used for constructing the frame.

Steel rule/measuring tape used for measuring length, hacksaw for cutting the frame material to the required dimension while vanier caliper for measuring internal and external diameter of the cylinder, plates and collector. The drilling machine was used for drilling holes on the plates and the cylinder, lathe machine employed for finishing, boring, drilling, and turning operations. The joining of parts was achieved using electric welding.

b) Methods

i. *Design of the Machine Components*

The various components of the machine were designed based on established theories and principle for each member as follows:

ii. *Design of the Pressure Cylinder*

a. *Pressure Required for the Extractor*

The pressure required is given as stated in equation 1 by Khurmi and Gupta (2005).

$$P = \frac{2 \times t \times \delta_a}{d} \quad \text{... (1)}$$

Where; P is the pressure, N/m^2; t is the cylinder thickness, m; δ_a is the allowable stress of the cylinder material; d is the internal diameter of the cylinder, m

Compressive allowable stress for the cylinder material (Stainless steel) grade A403 (WP316) is 15300 Psi ≈ 105.5 N/mm^2 (Robert –James sale, Inc, 2018).

iii. *Area of the Cylinder*

The area of the cylinder is given as stated in equation 2 (Khurmi and Gupta, 2005).

$$\frac{\pi}{4}\left[(D)^2 - d^2\right] \quad \text{... (2)}$$

Where; D is the external diameter of the cylinder, m; D is the interior diameter of the cylinder, m

iv. *Capacity of the Cylinder*

The maximum capacity of the cylinder is given by the total volume (V) of the cylinder as stated in equation 3 (Khurmi and Gupta, 2005).

$$V = \frac{\pi}{4} d^2 h \quad \text{... (3)}$$

Where; h is the height of the cylinder, m

The mass (M) of the groundnut is found by the relation

$$M = \rho \times v \quad \text{... (4)}$$

Where; ρ is the density of groundnut, kg/m^3; V is the volume of the cylinder, m^3

v. *Thickness of the Cylinder Wall*

The cylinder when subjected to an internal pressure experiences tensile stress acting tangential to the circumference. This tends to bursts the cylinder along a longitudinal seam while the tensile stress acting in the direction of the cylinder axis causes failure across a transverse section of the cylinder (Bahl and Goel, 2010).

The total force, F acting on half of the cylinder and tending to rupture it along the cutting plane is given as

$$F = P \times L \times d \qquad ...(6)$$

Where; L is the length of the cylinder, m; P is the pressure, N/m^2

The total resisting force in the cylinder walls is

$$F = 2 \times t \times L \times \delta_h \qquad ...(7)$$

Where; δ_h is the hoop stress,

Equating Equation 6 and 7 gives t

$$t = \frac{P \times d}{2\delta_h} \qquad ...(8)$$

Where; t is the cylinder thickness, m

The total force, F tending to rupture the cylinder along the transverse section is

$$F = \frac{\pi}{4} \times d^2 \times P \qquad ...(9)$$

Force resisting rupture is

$$F = \pi \times t \times d \times \delta_l \qquad ...(10)$$

Equating equation 9 and 10

$$t = \frac{Pd}{4\delta_l} \times d^2 \times P$$

Where; δ_l is the longitudinal stress.

Evidently, hoop stress is double in magnitude as compared to longitudinal stress. Thus the design of the cylinder is based on hoop stress. The hoop stress for a cylinder material in N/mm^2 its value may be taken as 35 Mpa to 100 Mpa depending upon the size and material of the cylinder (Khurmi and Gupta, 2005).

vi. *Design of Circular Flat Pressure Plate*

The thickness, t of a circular flat plate with uniformly distributed pressure over the area is given as stated in equation 12 (Khurmi and Gupta, 2005).

$$t = k_1 d \sqrt{\frac{P}{\delta_a}} \qquad ...(12)$$

Where; k$_1$ is the load factor; σ_a is the allowable design stress

vii. *Design of Frame*

The frame is design in such a way that the pressing operation can be carried out conveniently.

viii. *Design of the Rectangular Frame Base*

For a rectangular flat plate with concentrated load, the thickness is given as stated in equation 13 (Khurmi and Gupta, 2005).

$$t = k_3 \sqrt{\frac{a \times b \times F}{\delta_a \left(a^2 + b^2\right)}} \qquad ...(13)$$

Where; k_3 is the load factor; a is the length of the plate; b is the breadth of the plate.

The coefficient k_1, k_2 and k_3 depend on the plate material and the holding method at the edges.

Table 1: Table of coefficients

Material of the plate	Type of connection	Circular plate (k_1)	Rectangular plate (k_3)
Cast iron	Freely supported Fixed	0.54 0.44	4.3 4.0
Mild steel	Freely supported Fixed	0.42 0.35	3.45 3.0

ix. *Design of axially loaded column*

The jig or frame meant for carrying the pressing is a structure that contains columns and beams. Using the Euler formula as stated in equation 14.

$$F_\alpha = \frac{\pi^2 \times E \times I}{L^2} \qquad ...(14)$$

Where; F_{cr} is the crippling load; is the moment of inertia; E is the Young's modulus; L is the length of member.

x. *Design of beam*

Beams are structural members that carry transverse loads which produce bending moments and shear with bending resistance. They could be horizontal, slopping or vertical and could be simple (having no end moments) or having moment at the each end of the span (continuous or fixed end). For this design, only simple beams existed and were designed appropriately.

Table 2: Summary of Design Calculations

Input	Calculation	Value
D = 122 mm d=104 mm	$\frac{\pi}{4}\left[(D)^2 - d^2\right]$	1357.17 mm^2
d=104 mm h = 183 mm ρ = 580kg/m^3 V =1554560.57mm^3	$V = \frac{\pi}{4} d^2 h$ $M = \rho \times v$	1554560.57mm^3 1kg
σ_a =105.5 N/mm^2 t =8mm d=104mm	$P = \frac{2 \times t \times \delta_a}{d}$	16.2N/mm^2
P= 16.2N/mm^2 d=104 mm σ_h =100N/mm^2	$t = \frac{P \times d}{2\delta_h}$	8.42mm
σ_a =*900Mpa* K_1 = 0.54 d=104mm P = 16.2N/mm^2	$t = k_1 d \sqrt{\frac{P}{\delta_a}}$	7.5*mm*
k_3 = 0.35 $\delta_a = 900Mpa$ F = 21986.15N a = 170mm b =160mm	$t = k_3 \sqrt{\frac{a \times b \times F}{\delta_a (a^2 + b^2)}}$	122 mm

III. Device Mode of Operation and Cost

The machine consists of a pressure cylinder with layers of pressure plate. Roasted groundnut seeds are placed between the layers of the pressure plate. The essence of roasting the groundnut seeds is to increase the yield of oil extraction. The hand driven hydraulic press is used to compress the groundnut in the cylinder thereby extracting the oil. The cylinder consists of holes in which the extracted oil flow out of the cylinder and is collected through the collector. When there is no more oil from the groundnuts, the press is release and the cylinder taken away from the collector and then the chaff is removed with a press rod. The unit cost of production of the groundnut oil extractor is put at #26,900 as at December, 2018 as shown in table 3.

Table 3: Specification and Cost Analysis

S/N	Item Description	Specification	Quantity	Rate (₦)	Cost (₦)
1	Stainless Steel Pressure Cylinder	Internal diameter 104mm, External diameter 122mm, Thickness 9mm	1	1000	1000
2	Stainless Steel Pressure Plate	Diameter 102mm, Thickness 7.5mm	3	450	1350
3	Stainless Steel Top Plate	Diameter 102mm, Thickness 15mm	1	800	800
4	Stainless Steel Collector	Internal diameter 130mm, External diameter 136mm, Depth 30mm	1	350	350
5	Rubber Cup		1	100	100
6	Drill Bit	Diameter 7mm and 6mm	2	200	400
7	Mild Steel Rectangular Base	Length 350mm, Breadth 165mm, Width 85mm	1	1500	1500
8	Mild Steel L-shape Bar	Height 305mm, Breadth 45mm, Width 55mm	4	250	1000

9	Mild Steel Rectangular Bar	Length 350mm, Breadth 55mm, Width 50mm	2	300	300
10	Hydraulic Press System	Potable size	1	15000	15000
11	Hacksaw Blade	Small size	1	200	200
12	Cutting Disc	250mm X 20mm	1	650	650
13	Welding Electrode	Gauge 12 mild steel	20 pieces	350	350
14	Paint	Green oil paint	Half Tin	600	600
15	Miscellaneous			3000	3000
TOTAL					26,900

Plate 1: Hydraulic Oil Press for Groundnut Oil Extraction

IV. Result and Discussion

a) Results

The test was carried out using three (3) varieties of groundnut seeds purchased at Yelwa Tundu market of Bauchi state. Each variety has a mass of 0.9432kg and press operated 220 revolutions. At the end of each extraction process, mass of the extracted oil and residual were recorded as shown in the table below.

Table 4: Values of Test Result

Groundnut variety	1	2	3	Average
Weight of sample (kg)	0.9432	0.9432	0.9432	0.9432
Weight of residual (kg)	0.7386	0.7371	0.7298	0.7352
Weight of oil yield (kg)	0.2013	0.2029	0.2104	0.2049

Calculations

Average Weight of sample, W_S=0.9432kg

i. Average weight of residual, $W_R = \dfrac{0.7386 + 0.7371 + 0.7298}{3} = 0.7352kg$

ii. Average weight of oil yield, $W_{OE} = \dfrac{0.2013 + 0.2029 + 0.2104}{3} = 0.2049kg$

iii. Percentage of oil yield, $o_Y = \dfrac{100 \times W_{OE}}{W_{OE} + W_R} = \dfrac{100 \times 0.2049}{0.2049 + 0.7352} = 21.80\%$

iv. Extraction efficiency, O_{Ee}

We know that the oil content of the seed is 45%

$$o_{Ee} = \frac{100 \times W_{OE}}{0.45 + W_S} = \frac{100 \times 0.2049}{0.45 \times 0.9432} = 48.30\%$$

v. Extraction loss (E_L)

$$E_L = \frac{100[W_S - (W_{OE} + W_R)]}{W_S}\% = \frac{100[0.9432 - (0.2049 + 0.7352)]}{0.9432} = 0.33\%$$

b) *Discussion of Results*

Table 4.2: Summary of Result

Average weight of sample (W_S)	**0.9432** kg
Average weight of residual (W_R)	0.7352 kg
Average weight of oil yield (W_{OE})	0.2049 kg
Percentage of oil yield (O_Y)	21.8%
Extraction efficiency (O_{Ee})	48.3%
Extraction loss (E_L)	0.33%

The test result show that an average weight of 0.2049kg oil is obtained from appropriately 1kg weight of roasted groundnut seeds which gives 21.8% of oil yield and extraction efficiency of 48.3% with an extraction loss of 0.33%. Considering the oil content of groundnut as 45%, it clears shows that the simple hydraulic press could be effective in the oil extraction process with minimum extraction loss. Thus, it is recommended that it should be produce in relatively large number for usage in rural and semi-urban areas with no electricity to replace the traditional method currently in use for groundnut oil production while for medium scale businesses, the manual operated hydraulic press could be replace with electrically operated as this will increase the capacity and efficiency of the device.

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