DESIGN AND DEVELOPMENT OFA MOTORIZED MELON SEED OIL EXTRACTING MACHINE.

J. WADAI, N. D. JONES, AND AARON J. ZIRA
Department of Mechanical Engineering, School of Engineering Technology, Federal Polytechnic Mubi, Adamawa State, Nigeria.

Abstract
The Motorized Melon Seed Oil Extracting Machine was designed and developed using locally available engineering materials for quality melon seed oil extraction. The machine was designed and developed with less technical requirement for maintenance and can perform considerably large quantity of oil from melon seed found in Nigeria within a short operational period. The optimal performance test of the machine presents a result of a through-put of 20kg/hour, at extraction rate of 17.8 liters per hour with 89% yield and an efficiency of 83.97% when tested using 5 kg of melon seed. The machine cost is also estimated at ₦92,750:50 with two (2) month return on investment at full capacity utilization. Hence the melon seed oil extracting machine *is affordable, easily operated and maintained by both Urban and rural dwellers with little training.*

Keywords: Development, Design, Melon seed, Oil extraction, Hygiene, Motorized machine.

INTRODUCTION
Melon seed popularly known as Egusi is fortified food with essential proteins, minerals and vitamins which promotes eye vision, improves the skin, hair, and offer other numerous benefits. Egusi (with variations such as: **Egusi**, **Ohue** and **Agushi**) is the name for the protein-rich seeds of certain cucurbitaceous plants (squash, melon, gourd), which after being dried and ground are used as a major ingredient in West African cuisine. (Rachel 2011). Major egusi-growing nations include Mali, Burkina Faso, Togo, Ghana, Côte d'Ivoire, Benin, Nigeria, and Cameroon (NRC 2006). Species from which egusi is derived include *Cucumeropsis mannii* and *Citrullus lanatus*.(Blench 2006)
Melon is a tendril climbing herbaceous crop. (Oloko and Agbetoye, 2006) report that 100,000 and 488,000 metric tons are produced in Nigeria for the year 1992 and 1997 respectively. Melon has about 60% protein content that enriches the diet of the consumer (Makanyuola et-al, 1978). Unshelled melon seed have major diameter about

12mm, minor diameter 2.3mm, intermediate diameter 8mm and 1000-unit mass of 150kg. Odigboh (1977); and Oloko and Agbetoye (2006).
Oil of citrullus (melon) was extracted and its fatty acid composition determined, the extracted oil was used in diet formation and fed as supplement to rats (Oluba, 2008).
The fatty acid profile of edible oils plays an important role in their stability and nutritional values. Mono-saturated and polyunsaturated fatty cholesterol lowering diets (Mattson et-al 1985). Some engineering properties of the three varieties of melon investigated at specific moisture for the three varieties of melon: C.edulus, C. Vulklgaris and C.lanatus at 6.33, 6.33 and 5.21% dry basis respectively, (Makanjoula 1978).
Melons are mainly found in the eastern Nigeria where about 100 seeds weight is about 12g (Andiron et-al, 1988). The melon seed is said to consist of about 50% oil by weight, 37.37% of protein, 2.6% fiber, 3.6% ash and 6.4% moisture or water. The major fatty acid is linoleic acid for about 62.2% and Melon seed oil appears to be an excellent source of the linoleic acid (Ajilola, et'al, 1990).
Despite the large production and nutritional potentials of the melon seed, there has been a hindrance to its oil extraction in large scale. This is because the traditional method of melon seeds oil extraction appears to be slow, time consuming, inefficient and drudgery; limiting the availability of the product in the market (Olayinola, 1987).
Melon seed oil has a lot of domestic, industrial and cosmetic advantages. The oil extracted from melon can be used in manufacturing margarine, shortening and cooking oil, while the residual cake is a source of protein for livestock feed. Snacks can be produced using the residue. The consumption of melon seeds and its products reduces the chances of developing Terre-arterial of heart disease. Melon seed oil is good in maintaining moisture of dry brittle hair which revitalizes, repair and prevent hair breakage. Some of the numerous benefits of melon seed oil also includes: improving Appetite, Prevention Anaemia, improves bones strength, Prevents Malnutrition, Promotes Heart Health, Improves Vision, Reduces Inflammation, Aids digestion, and possess Antioxidant properties (*Waseem* et'al, 2021 and Finelib.com, 2020). Thus, the demand for a large scale and more efficient means of production of melon seed oil; prompts the design and development of an improved melon seed oil extracting machine to augment and boast the demand of melon seed oil production.

OBJECTIVES

- To design and develop an electric powered portable melon seed oil extracting machine for extraction of oil from melon seed found in Nigeria.

- To boast a mass production of melon seed oil to meet the domestic and industrial needs.
- To make available and affordable melon seed oil extracting machine to the small and medium scale entrepreneurs, boasting the economy of the urban and rural areas.

MATERIAL AND METHOD

Materials Selection and Design Specification

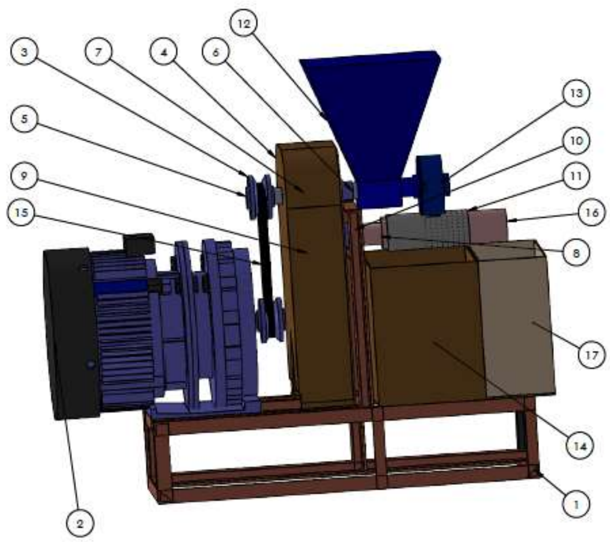
The materials utilized for the design and development of the motorized melon seed oil extraction machine were chosen locally based on their availability, durability in service and hygiene among other important factors. Table 1 provides some major materials selected for the design and development of the machine and their specifications.

Table 1: Material selection and design specification

S/N	Component	Materials	Selection Criterion
1	Metallic stand	Mild steel	Rigidity and availability
2	Electric motor/ Prime mover	- -	Available and convenience
3	Pulley		Availability
4	Gear cover	Mild steel	Rigidity and availability
5	Shaft 1 and 2	Mild steel	Rigidity and availability
6	Bearing 1 and 2	- -	Available and resistance in service
7	Gear 1 and 2		Standard
8	Screw Conveyor	Mild steel	Rigidity and availability
9	Hopper	Mild steel	Rigidity and availability
10	Grinding disc	Mild steel	Rigidity and availability
11	Pinion	Mild steel	Rigidity and availability
12	Cone	Mild steel	Rigidity and availability
13	Extracting chamber	Galvanized steel	Hygiene
14	Oil collector	Galvanized steel	Hygiene
15	Belt		Standard
16	Residue exit	Galvanized steel	Hygiene
17	Residue collector	Galvanized steel	Hygiene

DESCRIPTION OF THE MACHINE

The melon seed oil extracting machine presented in Fig. (1) consist of the following major parts: The hopper, grinding disc, grinding chamber, gears (spur), galvanized pipe (extracting chamber), shafts, bearings, bolts and nuts, electric power source, oil collector chamber, residue extraction port, residue collection chamber, gear cover and metallic stand. The bigger gear is attached to the first conveyor screw of the machine that feeds the grinding chamber; while the second gear is attached to the second conveyor' shaft. The first conveyor of the machine is connected to the electric motor/ prime mover attached to the big gear in meshed with the smaller gear attached to the second conveyor.



17	RESIDUE COLLECTOR	MILD STEEL	1	CONSTRUCTED
16	RESIDUE EXIT	MILD STEEL	1	CONSTRUCTED
15	BELT	----------	1	STANDARD
14	OIL COLLECTOR	MILD STEEL	1	CONSTRUCTED
13	GRINDING CHAMBER	MILD STEEL	1	CONSTRUCTED
12	HOPPER	MILD STEEL	1	CONSTRUCTED
11	EXTRACTION CHAMBER	MILD STEEL	1	CONSTRUCTED
10	BEARING 1	----------	1	STANDARD
9	GEAR 1	----------	1	STANDARD
8	SHAFT 2	MILD STEEL	1	CONSTRUCTED
7	GEAR 2	----------	1	STANDARD
6	BEARING 2	----------	1	STANDARD
5	SHAFT 1	MILD STEEL	1	CONSTRUCTED
4	GEAR COVER	MILD STEEL	1	CONSTRUCTED
3	PULLEY	----------	2	CONSTRUCTED
2	ELECTRIC MOTOR	----------	1	STANDARD
1	METALLIC STAND	MILD STEEL	1	CONSTRUCTED
ITEM NO.	PART DESCRIPTION	MATERIAL	QTY.	REMARKS
DESCRIPTION: ASSEMBLY DRAWING OF THE MELON OIL EXTRACTING MACHINE. (ALL DIMENSIONS ARE IN MM)			SCALE: 1: 5	

Fig. 1: Assembly drawing of a melon seed oil extracting Machine

MACHINE COMPONENTS DESIGN

Hopper

The pyramid shaped hopper fabricated from the metal sheet was welded in slanting form towards the smaller openings. It has the inlet in which the melon seeds are being introduced into the hopper and an inlet throats which connect the hopper to the conveying unit and grinding chamber. These two opening can hold reasonable amount of melon seeds.

The height of the hopper (h) = 220mm= 0.22m**,** Base (b) = 250mm = 0.25m

$$Total\ Surface\ Area = \frac{1}{2} b^2 h \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$Volume\ of\ Hopper == \frac{1}{3} b^2 h \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Conveyor Screw

The screw conveyor whose pitch (21x20) mm is a cylindrical shaft with a sole purpose of conveying the melon seed to the grinding chamber.

Grinding Chamber

This was made to contain the two grinding disc, with one fixed, and the other adjustable and rotates to effect the grinding action.

Where r = 110mm = 0.11m, and π=3.142

$$Area\ of\ back\ plate = \pi r^2 \ldots\ldots\ldots\ldots\ldots 3$$

$$Circumference\ of\ cover = 2\pi r \ldots\ldots\ldots\ldots\ldots 4$$

Extraction Chamber

This is a cylindrical component, 63 mm diameter galvanize pipe which containing the cone, the spring and is perforated to allow the extracted oil flow down to the oil collector chamber. The extraction chamber is perforated to a 0.2mm diameter.

Where the length of the cylinder (l) =150mm, radius of the cylinder (r) = 63mm

$$Area\ of\ extracting\ cylinder = 2\pi r^2 + 2\pi rl. \ldots\ldots\ldots 5$$

Cone

This is attached with a compressional spring inside an extracting chamber and has the following dimension. Length (l) = 40mm, inner diameter (d_{inn}) = 45mm and outer diameter (d_{out}) = 50mm.

The electric motor/ Prime mover

A prime mover or electric motor of 1.5kw is selected as the power source for the melon oil extracting machine. The power rating is capable of providing all motions involved in the process of extracting the oil.

Gears

This is a component that transmit power of from the handle winder to the screw conveyor. As the hand conveyor rotates inside the extracting chamber, the melon seed grinded into paste is compresses to extract the oil.

Given that, D_1 and D_2 are the diameters of the driving and the driven gears with their respective teeth T_1 and T_2; if the driving gear diameter Ø =108mm with a number of teeth = 44, the driven gear diameter Ø = 54mm with number of teeth = 22 which represent a gears ratio of 2:1.

For correct meshing of the gears, the pitch cycle equation must then hold (Khurmi et-al, 2005).

That is, $P_c = \frac{\pi D_1}{T_1} = \frac{\pi D_2}{T_2} \; OR \; \frac{D_1}{D_2} = \frac{T_1}{T_2}$ 6

The Shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. In other to transmit power from one shaft to another, the various members such hand winder, gear, ball bearing and grinding disc are mounted on it. These members along with the forces exerted upon them causes the shaft to bending.

The load carried by the shaft (both the hand winder, gear, ball bearing and the grinding disc) is considered and the equation of maximum shaft diameter is applied as the diameter of shaft has little or no axial load effect (Khurmi et- al, 2005).

$$D^3 = \frac{16}{\pi\tau} \times \sqrt{\left[(K_m M)^2 + (K_t T)^2\right]} \text{.......................................7}$$

Where D = diameter of the shaft, τ = allowable shear stress for shaft, k_m = combine shock and fatigue factor applied to bending moment, k_t = combine shock and fatigue factor applied to torsional moment, M = bending moment and T = torsional moment

According to American Society of Mechanical Engineers (ASME) code for the design of transmission shafts, the maximum permissible working stresses in tension or compression may be taken as 42 MPa for shafts with allowance for keyways (khurmi et-al 2005).

Torque acting on the shaft

Where T = the twisting moment on the shaft per torque N/m, and N = the speed of the shaft in rpm

$$Average\ power = \frac{2\pi NT}{60 \times 1000} \text{.......................................8}$$

$$Torque, T = \frac{Power\ tranmitted}{2\pi N} \text{.......................................9}$$

Thus, the torque transmitted by shaft (T)

$$T = \frac{P \times 60.}{2\pi N} \text{..10}$$

Total weight on the shaft

When F = total load on the shaft and r_1 = radius of driven pulley, then the torque T on the shaft will be:

$$T = Fr_1 \left(Nm\right) \ldots\ldots 11$$

Spring

The spring attached to the cone helps in generating pressure between the cone rotating alongside with the conveyor, pushing the cone inward as it tries to slip out, there by compressing the grinded paste in the oil extraction chamber.

Oil Collector Chamber

The oil collector chamber is just below the extracting chamber to collect the extracted oil. The extracted oil which escape through the perforated section of the extracting cylinder drops gradually into the collector chamber.

PRINCIPLES OF OPERATION OF THE MACHINE

The Melon seeds which is the raw materials as shown in figure ((2) a & b) is first separated from its horned flesh by washing; then lightly fried and shelled as shown on Fig. ((2) c). The frying process is aimed at increasing its dryness and final yield of the melon oil. The shelled melon seed is then fed into the machine through the hopper and the first screw conveyor below the hopper convey the raw materials to the grinding chamber. The first conveyor of the machine is connected to the electric motor/ prime mover attached to the big gear which is in meshed with the smaller gear attached to the second conveyor of the oil extraction chamber. The melon seeds grinded paste then falls under gravity into the extracting chamber (galvanize pipe). The extraction is then done with the help of the conveyor cone inside the galvanize pipe; such that the extracted oil drops into the oil collection container while the residue is further conveyed to the residue exit and drops into the residue collecting container.

THE MELON SEEDS

(a)

(b)

(c) (d)

Fig. 2. Melon seed: (a) Broken ball showing the seeds, (b) Unshelled seeds, (c) Shelled seeds and (d) Grounded seeds.

FABRICATION

The various component of the machine such as conveyor screw, Hopper, Disc housing, extraction cylinder, cone, oil and residue collectors, and the stand were fabricated in conformity to the conventional welding method. The machines and equipment used include: Scriber, Hammer, Chisel, Tape rule, Try- square, shearing machine, angle grinder, Lathe machine, Rolling and Drilling machines. The finishing operation and painting were carried out taking into consideration the required surface finishing and aesthetics.

PERFORMANCE TEST ANALYSIS

The performance test of the machine was carried out using the available melon seed weighing 5kg and was fed into the machine on operation. The oil extraction process is the carried out following its operational principles. The process is then repeated three times and their respective average obtained as illustrated in table (2) below. The extracted oil was collected from the collection chambers and weighed accordingly. The following parameters below were determined and used for the calculation of the machine performance.

Where the Weight of the melon seeds (W_1), Weight of the oil extracted (W_2), Time taken for the extraction (t), Throughput (T_p) in kg/h, Rate of extraction (E_r), Yield (Y_e), and the Extraction efficiency (ε).

$$ThroughPut\left(T_p\right) = \frac{weight\ of\ melon\ seeds\ fed\ to\ the\ machine}{Total\ time\ taken\ to\ extract\ oil\ from\ the\ melon\ seeds}$$

$$Rate\ of\ extraction(E_r) = \frac{weight\ of\ oil\ extracted}{time\ taken\ for\ extraction}$$

$$Yield\ (Y_e) = \frac{amount\ of\ oil\ obtained}{original\ weight\ of\ melon\ seeds\ used} \times 100$$

$$Efficiency\ (\varepsilon)\% = \frac{amount\ of\ oil\ obtained}{oil\ content\ of\ melon\ seeds} \times 100$$

RESULT AND DISCUSSION

A melon seeds of oil 5.3 oil content, an un-altered mass of 5kg fed into the machine; executing the extraction process at an average time of 0.25/hr.

The results obtained during the extraction processes using the oil extraction machine is as summarized on tables (2 and 3) below.

Table (2): Three Performance Test Results of the Melon Oil Extraction Machine.

S/No.	Throughput (T_p)	Rate of extraction (E_r)	Yield (Y_e)%	Efficiency (ε)%
1	19.75kg/hr.	17.45 liters/hr.	89.04%	83.48%
2	20.25Kg/hr.	16.87 liters/hr.	88.79%	84.1%
3	20Kg/hr.	18.99 liters/hr.	89. 17%	84.3%
AVG.	**20Kg/hr.**	**17.8 liters/hr.**	**89 %**	**83.97 %**

BILL OF ENGINEERING MEASUREMENT AND CONTROL

The melon seed oil extracting machine was carefully designed and developed such that it can be afforded by individuals venturing into melon seed oil extraction, and enhancing the economy of the people. Table 3 below present the cost analysis of the machine.

Table (3): Bill of Engineering Measurement and Control of the Melon Seed Oil Extracting machine.

S/N	COMPONENT	MATERIALS	COST(₦)
1	Metallic stand	Mild steel	11,000:00
2	Electric motor/ Prime mover	- -	25,000:00
3	Pulleys 1 and 2		3,000:00
4	Gear cover	Mild steel	1,800:00
5	Shaft 1 and 2	Mild steel	3,200:00
6	Bearing 1 and 2	- -	850:00

7	Gear 1 and 2		3,600:00
8	Screw Conveyor	Mild steel	2,400:00
9	Hopper	Mild steel	4,700:00
10	Grinding disc	Mild steel	3,800:00
11	Pinion	Mild steel	500:00
12	Cone	Mild steel	1,000:00
13	Extracting chamber	Galvanized steel	3,700:00
14	Oil collector	Galvanized steel	5,500:00
15	Belt		2,000:00
16	Residue exit	Galvanized steel	3,000:00
17	Residue collector	Galvanized steel	2,000:00
18	Fabrication		7,200:00
19	Painting	Assorted	8,500:00
TOTAL COST			**92,750:00**

Since the estimated average percentage yield of the melon seed oil extractor machine designed and developed as presented on table (2) is 89%; an approximate monthly profit for using the machine can then be calculated.

$$Monthly\ profit = \frac{89}{100} \times 92{,}750 = 82{,}547:50$$

Thus, eighty-two thousand, five hundred and forty-seven naira, fifty kobo (₦82,547:50K) could be realized as profit on monthly basis. Assuming 45% (**₦37,146.37)** of the profit is spent on staff salaries, maintenance and other contingences, the net monthly savings which becomes 55% (≈ ₦45,401.13K) as return on investment (P) of the machine is then calculated.

$$P = \frac{Total\ \text{cost of}\ equipment}{The\ monthly\ profit} = \frac{92{,}750:50}{45{,}401:13} \approx 2.04 Months$$

This means when a person or group persons invest on this particular machine for only two (2) month will start yielding a profits in the remaining service years of the machine as.

CONCLUSION

The developed automated melon seed oil extraction machine designed and developed has proven its credibility based on the performance evaluation test result obtained with less operational and maintenance effort as compare to other machines used in melon seed oil extraction.

The result showed that the machine attained oil extraction of 17.8 liters per hour, oil yield of 89% and efficiency of 83.97% when 5 kg of melon seed was used as bases and presents return on investment of one month.

RECOMMENDATIONS

i. The machine is recommended for use in both urban and rural areas.
ii. For commercial operation of the melon seed oil extraction, it's advisable to provide foundational floor for the machine to improve rigidity and reduce vibration.
iii. Further modification of the melon machine could be carried out if found necessary.

REFERENCES

Ajilola, O.O., Eniyemo S. E, Fasina O.O and Adeeko K.A. (1990): mechanical extraction of oil from melon seeds. Journal of Agricultural Engineering Research 45.1.

Badiru, I. & Badiru, D. (2013). Isi Cookbook: Collection of Easy Nigerian Recipes. Bloomington: iUniverse. p. 36. ISBN 9781475976717.

Blench, Roger (2006). Archaeology, language, and the African past. Altamira Press.

Denton, I., and Adeniran M.O. (1988): Geographical performance and distribution of the major seed type of Egusi. 10th Annual conference of Horticultural society of Nigeria. P.5-8.

Fadanoro I.I. (1999): Design and construction of a manually operated melon Sheller, university of Ilorin, Project work, department of mechanical engineering.

Finelib.comReadings(2020):https://www.google.com/search?client=firefox-b-d&q=Finelib.comReadings%28 2020%29.

https://www.finelib.com/about/nigeria-food-produce/about-melon-seed-egusi-and-its-numerous-health-benefits/237
ISBN 9780759104655.

Khrurmi, R.S and Gupta J.K (2004): Theory of machines. Euransia publishing House, New Delhi.

Khurmi, R. S. and J.K. Gupta, (2005) *"A Textbook of Machine Design" (4th edition)* Eurasia Publishing House (PVT.) LTD Ram Nagar, New Delhi.

Lanre, D and Adeniran, M.O. (1989): Geographical distribution and performance of the major seed types of Egusi melon (Citrullus Lamatus) in Nigeria. National Horticultural Research Institute, Idi-Ishin, Ibadan occasional paper No 15, pp 1-12.

Makanjuola, G. A. (1978): A study of some of the physical properties of melon seed J. Agr.Eng. Rea. 17:128-137.

Mattson, F.H. and Grundy S.M (1978): Comparism of effects of Dictary saturated, monoun saturated and poly unsaturated fatty Acid on plasma lipids and Lipo Protein Man J. Lipid Res, 26, pp. 194-202.

Morrison S. J (1989), Dennis Lock Handbook of Engineering management Heinemann Newnes, oxford London page 575.

National Research Council (2006). "Egusi". Lost Crops of Africa: Volume II: Vegetables. National Academies Press. pp. 158 (155–171).

Odigbo, E.U. (1979): impact melon shelling machine transaction of the ASAE, p. 1264-1269.

Odigboh, E.U., 1977, A spinning disc "melon" seeds shelling machine: development, design and prototype construction. NIJOTECH Vol.3, No.1.

Olayinola, C.B. (1987): Women in Agriculture paper presented at the workshop on women development, sponsored by DFRR, Abuja. 14^{th}-16^{th} September.

Oloko, S.A. and Agbetoye, L.A.S (2006): Development and performance Evaluation of a melon deppodding machine. Agriculture Engineering Int. The CICGR EJ., 7: PM 06018.

Oluba, O.M., Adeyemi, O., Ojieh G.C and Isiosio. I.O. (2008): Fatty acid composition of citrullus Lanatus (Egusi Melon) oil and its effect on serum lipids and some serum Enzymes. The internet Journal of cardiovascular Research volume 5 No. 2 DDI: 10.5580/14

Rachel C. J. Massaquoi, "Groundnut, Egusi, Palm Oil, and Other Soups", in *Foods of Sierra Leone and Other West African Countries: A Cookbook*, AuthorHouse, 2011, p. 36.

Rotimi, O.O. (2006): Design and construction of melon shelling machine. University of Illorin, B. Engr project work, department of Mechanical Engineering.

Shittu, S. K. & Ndrika, V. I. O. (2012). "Development and performance tests of a melon (egusi) seed shelling machine". Agricultural Engineering International: CIGR Journal.

Waseem Khalid, Ali Ikram1, Muhammad Rehan, Farukh Adeem Afzal, Saadia Ambreen1, Marryam Ahmad, Afifa Aziz and Anam Sadiq (2021). Chemical Composition and Health Benefits of Melon Seed: A Review. Pakistan Journal of Agricultural Volume 34 | Issue 2 | Page 309.