DEVELOPMENT OF A MOTORIZED '*EGUSI*' MELON SEEDS OIL EXPELLER

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ABSTRACT

A motorized melon oil expeller was designed, fabricated and tested. The materials for fabrication were sourced locally. It was developed and fabricated to remove drudgery and reduce losses associated with processing of melon seeds into oil. The machine is simple and can easily be operated and maintained by rural women who are major processors of melon oil. It was tested for throughput capacity (Tp), percent oil yield (Yi) and expression efficiency (Ee). Throughput capacity of 10.12 kg/hr, oil yield of 30.23L/kg and extraction efficiency of 60.83% were obtained when 5 kg of melon seeds were fed into the machine.

KEYWORDS: Oil extraction, melon *(Egusi)* seeds, motorized expeller, machine design.

1. INTRODUCTION

Melon Citrullus Lanatus SSP Coloeynthoides is an annual herbaceous climber of the family cucurbitaceous. There are different types which vary in size and shape, they are round or oblong. The seeds colour varies, white through brown to black and not all melon flesh and seeds are edible.

In Nigeria, the existence of melon dates back to the 17th century (Douglas, 1982). Melon *Egusi* is a popular fruit in Nigeria because of the edible seeds which are commonly used in the preparation of local soup or stew and snacks such as fried melon seed ball known as "*Robo*" in South - Western Nigeria. In the East, the seeds are sometimes roosted and eaten as snacks. The seeds are rich in oil (30 – 50 percent) which is comparable to other oil plants (Omidiji, 1997), the oil contains is a high level saturated fatty acids (Adeniran et al, 1981). It is also an important component of the traditional cropping system usually interplant with such staple crops as cassava, maize, sorghum, etc. (Omidiji et al., 1985). There are two basic seed types of *egusi* melon distinguishable by the presence or absence of seed edges; they are usually stored at a moisture content of 6-7.7%. The first type known locally as "Bara" has thick uniform edge which is either black or white. The second type known as *'Serewe'* has no distinct edge. The two seeds are differently distributed in the country. The *'bara'* is most commonly found in the South-Western and Northern part while *'serewe'* is found in some part of Northwest, East and middle belt of Nigeria. The difference in distribution appears to be based on consumer preference rather than physiological adaptation of the crop (NIHORT, 1976 – 1986).

Odigboh (1979) described the unshelled melon seed as very small having a mean major diameter of about 12mm, intermediate diameter of 8mm, a minor diameter of 2.3mm and weighing about 150mg on the average.

The advent of new processing technologies has led to different types of oil expelling machines ranging from small hydraulic hand pressing to complex shaft screw press for expelling oil from various oil seeds. However, some of the available extractor/expeller cannot be used for expelling oil from shelled melon seeds because of the peculiar nature of the seed; especially the shape and size. With increasing cultivation of melon it becomes necessary to improve on the existing technology in order to increase the quality and the quantity of oil yield. Therefore, there is the need to improve on the existing expeller by developing shelled melon seeds oil expeller that can be affordable by the rural farmers, and to remove the wastefulness, unhygienic and drudgery involved in manual kneading of the seeds for oil by farmers, thereby boosting their income. The objective of the research was to develop a melon seeds oil expeller.

2. MATERIALS AND METHODS

2.1 Description and Working Principles of the Melon Oil Expeller

The expeller consists of a prime mover, pulleys and belt drive, happer, extracting chamber, frame and discharge chamber (Fig. 1). The different parts are described below.

Prime Mover: This generates power to be transmitted through belt to the expelling unit and produces sufficient torque at the unit. A 1hp, 1420 rpm electric motor was used.

Pulleys and Belt Drive: The component transmits power from the prime mover to the expeller shaft. V-groove pulleys and belts were selected due to their advantage over flat belts.

Hopper: This is cylindrical in shape; it serves as the inlet through which the melon seeds are fed into the extracting chamber. The hopper is fabricated from 2 mm thick galvanized iron metal sheet.

The Extracting Chamber: This is where the compression of melon seeds is carried out for release of the oil. The extracting unit consists of a cylindrical barrel of 2 mm thick mild steel and helical screw that serves as a conveyor driven by a belt drive of 1hp, 1420 rpm and 3-phase electric motor. .

The Heater Band: It is located on the choke cone to heat the melon seeds as it is being compressed. The heater band allows the oil within the cells to come to the surface for easy expression of oil from the seeds.

The Discharge Outlet: This is the point where the oil is collected. It is located at the bottom of the barrel.

The Frame: This is the mounting support for all the components of the machine.

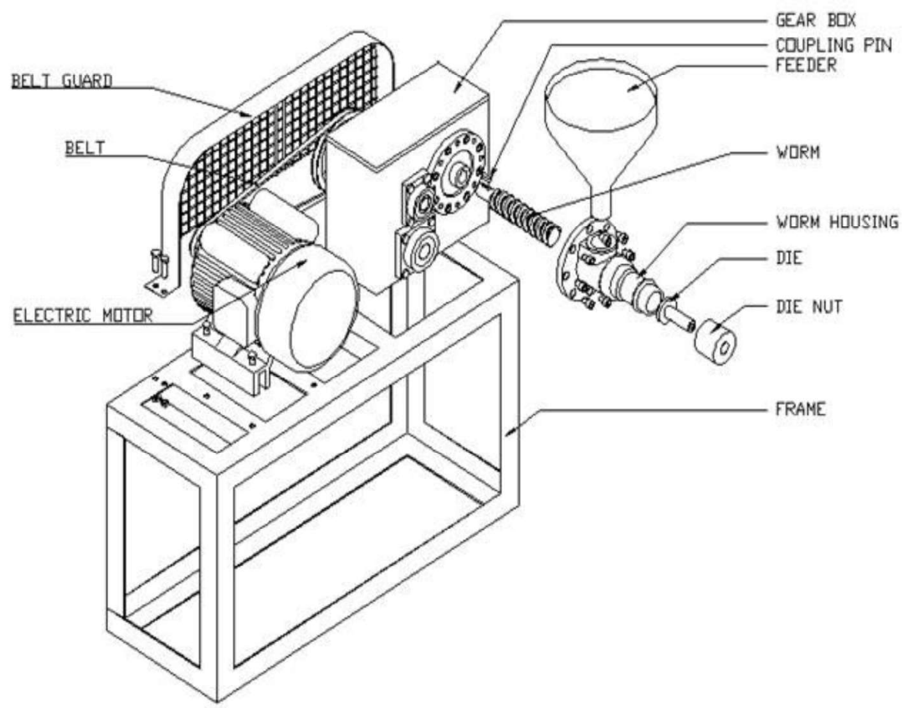

Fig. 1. Exploded View of the Melon Oil Seeds Expeller

2.2 Design Calculations

The following were considered in the design and development of the oil expeller: Efficiency, cost of construction, operating condition, availability of materials and maintenance

2.2.1 Hopper Design

The design considerations for the construction of the hopper of the expeller include:

(i) The volumetric capacity

(ii) The intake mass

It is desired that the hopper whose cross-section is shown in Figure 2.0 will handle a maximum of 5 kg of melon seeds. The following equations were used to estimate the required dimensions.

Top Cylindrical Part:

$$\boldsymbol{Volume, V_1 = \pi R_1{}^2 h_1} \qquad (1)$$

Where: V_1 = volume of the top cylindrical part, π = pie, R_1 = radius of the top cylindrical part, h_1 = height of the top cylindrical part

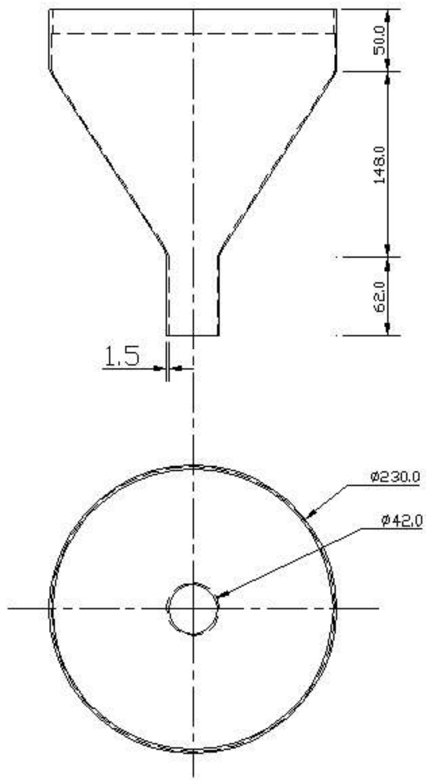

Fig. 2. Cross-section of the Hopper

Conical Part:

$$\mathbf{V = \frac{1}{3}\pi h_2\left(R_2{}^2 \ + R_2 r_2 + \ r_2{}^2\right)} \qquad (2)$$

Where: V =Volume bottom cylinder; R_2 = radius of conical part = 0.1135 m; r_2 = radius of bottom cylinder = 0.0195 m; h_2 = height of conical part = 0.148 m; V_2 = 0.002398823787

$$\boldsymbol{Volume, V_3 = \pi r_2{}^2 h_3} \qquad (3)$$

Where: r_2 = radius of bottom cylindrical part = 0.0195 m; h_3 = height of bottom cylindrical part = 0.062 m;

$$\mathbf{V \ = 0 \cdot 000074074221 m^3}$$

Total Volume = $V_1+V_2+V_3$ = 0.004497m^3

Assuming maximum volume of seeds to be processed at a time is $\mathbf{0.004497}\boldsymbol{m}^{\mathbf{3}}$

Mass Capacity $= \boldsymbol{\rho v}$ (4)
Where: $\boldsymbol{\rho}$ $=$ **density** and $\mathbf{v}$ $=$ **volume**
Bulk densityfof melon $= \mathbf{680\,kg/m^3}$ (Isiaka et al., 2006)

Mass capacity $= 680 \times 0.004497 = 3.05796$ **kg**
Mass capacity $= 3.058$ **kg**

2.2.2 Determination of Speed Required to Expel Oil from Melon Seeds

The ratio of velocities of the driver and the driven is determined by the ratio of the gears that would give the required speed and would expel oil from the melon seeds. The arrangement of the gears is shown in Figure 3.

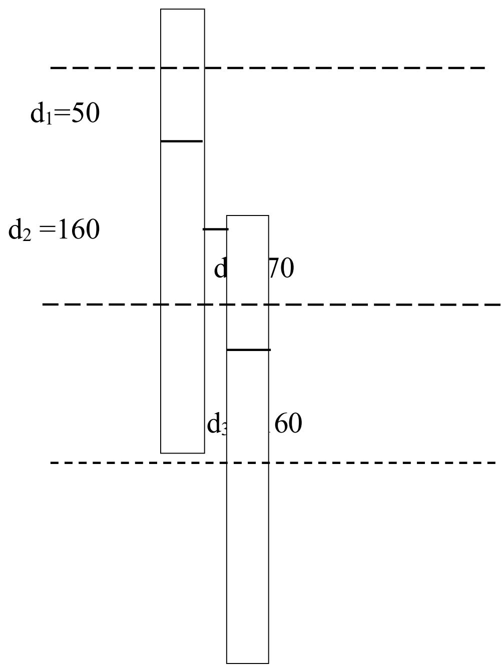

Fig. 3. Arrangement of the Gears in the Oil Expeller

The ratio of velocities of the driver and the driven is expressed mathematically as

$$d_1 N_1 = d_2 N_2 \qquad (5)$$

$\mathrm{d_1} = 50$ **mm diameter of the 1st gear**, $\mathrm{d_2} = 160$ **mm diameter of 2nd gear**
$\mathrm{d_{2'}} = 70$ **mm diameter of 3rd gear**, $\mathrm{d_3} = 160$ **mm diameter of 4th gear**.
$\mathrm{N_1} =$ **speed of 1st gear**, $\mathrm{N_2} =$ **speed of 2nd gear**, $\mathrm{N_{2'}} =$ **speed of 3rd gear**
$\mathrm{N_3} =$ **speed of 4th gear**

$$VR = \frac{N_1}{N_2} = \frac{d_2}{d_1} \qquad (6)$$

$$\mathrm{N_1} = 1420\frac{\mathrm{rev}}{\mathrm{min}} \ \text{speed of the motor} \times \text{pulley ratio}$$

$$\mathrm{N_1} = 1420\mathrm{rev/min} \times {}^{1}/_{3} \quad , \quad \mathrm{N_1} = 473.33$$

$$N_2 = \frac{473.33 \times 50}{160} \quad , \quad \mathrm{N_2} = 147.915 \ \mathrm{rpm}$$

$$\mathbf{VR} = \frac{N_2}{N_{2'}} \times \frac{d_{2'}}{d_2} \tag{7}$$

$$\mathbf{N_{2'}} = \frac{\mathbf{147.915}}{\mathbf{160}} \times \mathbf{70} \quad , \mathbf{N_{2'}} = \mathbf{64.71\,rpm}$$

$$\mathbf{VR} = \frac{N_{2'}}{N_3} \times \frac{d_3}{d_{2'}} \tag{8}$$

$$N_3 = \frac{\mathbf{64.71}}{\mathbf{160}} \times \mathbf{70} \ , \mathbf{N_3} = \mathbf{28.31\,rpm}\,.$$

N_3 is the speed required for expressing oil from melon seed.

2.2.3 Selection of Belt Drive

The selection of the belt drive was based on the following factors: Speed of the driving and driven shafts, speed reduction ratio, power to be transmitted, centre distance between the shafts, positive drive requirements, shafts layout, space available and service conditions. The length of the belt was calculated using equation (9) (Khurmi and Gupta, 2005).

$$L = \pi(r_1 + r_2) + 2c + \frac{(r_1+r_2)^2}{c} \tag{9}$$

Shaft pulley diameter d_2 = 143 mm and so r_1=71.5 mm
Motor pulley diameter, $\mathbf{D_2 = 48\,mm}$ and so r_2 = 24 mm
Centre Distance, $\mathbf{c = 400\,mm}$

L = 1123 mm

Therefore 1123 mm is selected as the length of the belt.

2.2.4 Shaft Design

To design for the shaft one must know the weight of the pulley and gears that will be acting on the shaft as shown in Figure 4.

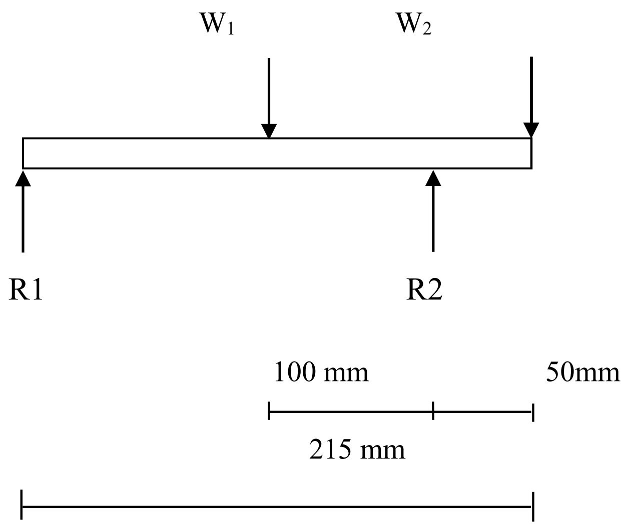

Fig. 4. Loading of the Shaft

Where: W_1 = weight of gear on the shaft; W_2 = weight of pulley on the shaft; R_1 and R_2 = reactions

The weight of the pulley is given as

$$\mathbf{W1 = mg} \tag{10}$$

Where $\mathbf{m = mass = volume \times density}$
g = acceleration due to gravity

Density of mild steel is given as 7850 kg/m^3 (Khurmi and Gupta, 2005)
Volume = surface area × thickness of the pulley (t)

$$\boldsymbol{V = \frac{\pi D^2}{4} \times t} \tag{11}$$

Where: Diameter of the pulley on the shaft $\boldsymbol{D_1 = 143\ mm = 0.143\ m}$
Thickness (t) $\boldsymbol{= 30\ mm = 0.03\ m}$

$$\boldsymbol{W_2 = DVg} \tag{12}$$

W_2 = 7850 kg/m^3 x 0.000482 m^3 x 9.81 m/s^2 = 37.1181 N
But weight of gear is measured to be 30 N
W_1 = 30 N

Therefore Fig. 4 is now loaded as shown in Figure 5

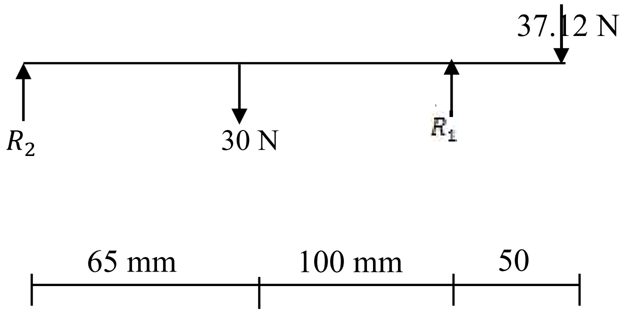

Fig.5. Loading of the Shaft with the Forces known

Now find R_1 and R_2.

$$\sum \boldsymbol{Fy} = \mathbf{0}$$

$$\boldsymbol{R_1} + \boldsymbol{R_2} \ = \mathbf{30} \ + \mathbf{37.118}\ \boldsymbol{N}$$

Taking moment about point R_2

$$\sum \mathbf{M} = \mathbf{0}$$

$\boldsymbol{R_1} \ = \mathbf{60.184}\ \boldsymbol{N}$ and $R_2 = 6.934$ N

To get maximum bending moment and maximum shear force, we draw the bending moment and the shear force diagrams using the force analysis shown in Figure 6.

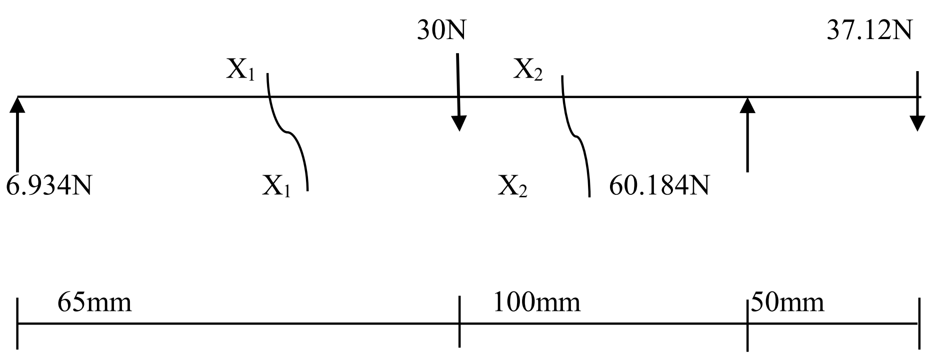

Fig. 6: Force Analysis for the Bending Moment and Shear Force Diagrams

When $\mathbf{x = 0}$

$\mathbf{Moment\ M \ = 0}$

$\mathbf{When\ x = 50\ (from\ right)}$

$\mathbf{\sum M \ = 0}$

$\mathbf{\sum M \ = 37.12 \ \times 50 \ = 1856}$

$\mathbf{when\ x \ \rightarrow 150}$

$\mathbf{\downarrow \sum M = 0}$

$$\mathbf{\sum M \ = 37.12 \times 150 \ - 60.184 \ \times 100}$$
$$\mathbf{= -450.4\ Nm}$$

$\mathbf{when\ x \ \rightarrow 215}$

$$\uparrow \sum \mathbf{M} = 0$$

$$\mathbf{37.118 \times 215 - (60.184 \times 165) + (30 \times 65) = 9930.37 - 9930.37 = 0}$$

The Bending Moment and Shear Force Diagrams are shown in Figure 7.

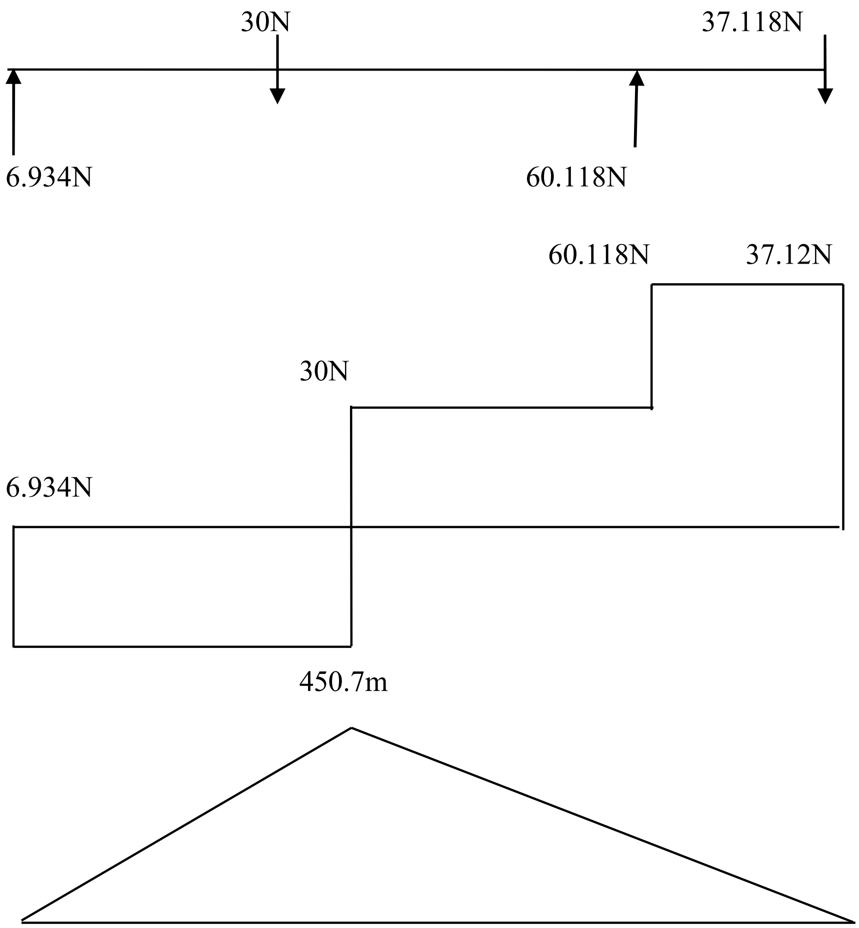

Fig 7. Bending moment and shear force diagrams

2.3 Performance Tests

The *bara* type of shelled egusi melon was used for the performance tests of the machine. The moisture content of the melon pods was determined by gravimetric method and was found to be 6.5 % (wet basis). Tests conducted by feeding 5 kg of melon seeds into the machine, and operating the machine. After each run, materials were collected from the discharge outlet and weighed accordingly.

The processing parameters below were determined and used for the calculation of the expeller performance parameter:
W_1 = Weight of the melon seeds; W_2 = Weight of expelled oil; W_3 = Weight of cake; T = Time of expelling; T_p = Throughput; E_r = Extraction rate; Y = Yield; Ee = Extraction efficiency.

$$\text{Throughput } T_p\ (kg/h) = \frac{\text{Weight of melon seeds fed into expeller}}{\text{Total time taken to extract oil from the melon seeds}} \quad \text{......................(13)}$$

Extraction Rate *Re (Lt/h)* $/(kg/h)$ = $\frac{\text{Weight/ litre oil extracted}}{\text{Time of extraction}}$.....................(14)

Yield *Ye (%)* = $\frac{\text{litre oil obtained}}{\text{Original weight of seeds}}$ x 100.. (15)

Extraction efficiency *Ee (%)* = $\frac{\text{litre of oil obtained}}{\text{Oil content of the melon seeds}}$ x 100........................... (16)

3. RESULTS AND DISCUSSION

From Tables 1 – 3, the oil yield of 30.23%, 1.52 litre expression and efficiency of 60.83% were obtained for the motorized expeller while that of the traditional method gave oil yield of 16.70L /kg and efficiency of 33.43%. On the average a total time of 30.18 minutes was required by the motorized expeller to expel 1.52 litres of oil from 5 kg of melon seeds while the traditional method used 2 h 38min to expel an average of 0.84 litres of oil from 5 kg of melon seeds.

It can be seen that the motorized melon seeds oil expeller performed far better than the traditional method. Further analysis reveals that these differences in the averages of the selected variables of the two groups are statistically significant at 1% level (Table 4.0). This suggests that the litre of oil gotten from motorized method for example is significantly higher than that gotten from traditional method. This is also true for the yield. The same conclusion is drawn for throughput and efficiency. On the other hand, it takes longer time for the expelling process in traditional method than motorized method.

Table 1. Performance Evaluation Indices of Motorized Melon Oil Expeller at Constant Motor Speed (1420rpm), Moisture Content (6.0%) and Constant Weight of Melon Seeds (5kg)

Time of Ext. T (min)	Litre of Oil (Lt)	Wt of Cake W_2 (Kg)	Throughput Tp (Kg/h)	Yield Ye (%)	Efficiency Ef (%)
30.00	1.50	3.20	10.00	30.00	60.00
29.50	1.54	3.18	10.16	30.80	62.00
30.00	1.55	3.20	10.00	30.40	62.00
29.50	1.51	3.20	10.20	30.20	61.00
29.55	1.50	3.30	10.15	30.00	60.00
29.50	1.50	3.25	10.20	30.00	60.00
30.18	1.52	3.22	10.12	30.23	60.83

Table 2. Performance Evaluation Indices of Traditional Method of Melon Oil Expression

Time of Ext. T (h)	Litre of Oil (L)	Wt of Cake W_2 (Kg)	Throughput Tp (Kg/h)	Yield Ye (%)	Efficiency Ef (%)
1.30	1.10	4.20	3.33	22.00	44.00
1.50	0.90	4.15	2.73	18.00	36.20
2.00	0.86	4.30	2.50	17.20	34.40
2.20	0.80	4.35	2.15	16.00	32.00
2.35	0.75	4.45	1.94	15.00	30.00
2.55	0.60	5.25	1.71	12.00	24.00
Mean 1.98	0.84	4.45	2.39	16.70	33.43

Table 3. Summary of Statistical Analysis on Motorized and Traditional Methods of Melon Oil Extraction

Parameter	Type of Method	No of times	Mean	Std. Mean Error
Litres of oil	Motorized method	6	1.5167	0.00919
	Traditional method	6	0.8350	0.06801
Weight	Motorized method	6	3.2217	0.01833
	Traditional method	6	4.4500	0.16583
Throughput	Motorized method	6	10.0833	0.02940
	Traditional method	6	2.3933	0.24040
Time	Motorized method	6	29.74	0.09167
	Traditional method	6	131.67	12.6920
Yield	Motorized method	6	30.2333	0.13081
	Traditional method	6	16.7000	1.36015
Efficiency	Motorized method	6	60.8333	0.40139
	Traditional method	6	33.4333	2.72686

Table 4. Two-tail Comparison Test for the Methods of Melon Oil Extraction

Variable	T	Df	Sig. (2-tailed)*	Mean Difference	Std. Error Difference
Litres of oil	9.933	10	0.001	0.68167	0.06863
Weight	7.362	10	0.001	-1.22833	0.16684
Time	8.030	10	0.001	-101.950	12.693
Throughput	31.752	10	0.001	7.69000	0.24219
Yield	9.904	10	0.001	13.53333	1.36642
Efficiency	9.941	10	0.001	27.40000	2.75625

*significant at 1%

Table 4 shows that there is a significant difference at 1% level between the performance indices of the developed melon oil expeller and those of the traditional method of melon oil expression. The difference between the traditional and motorized method with respect to oil yield, efficiency and time of expression are shown in fig 1 – 3. The figures show that the motorized method is better than the traditional using the parameters (oil yield, efficiency and time required for expression.

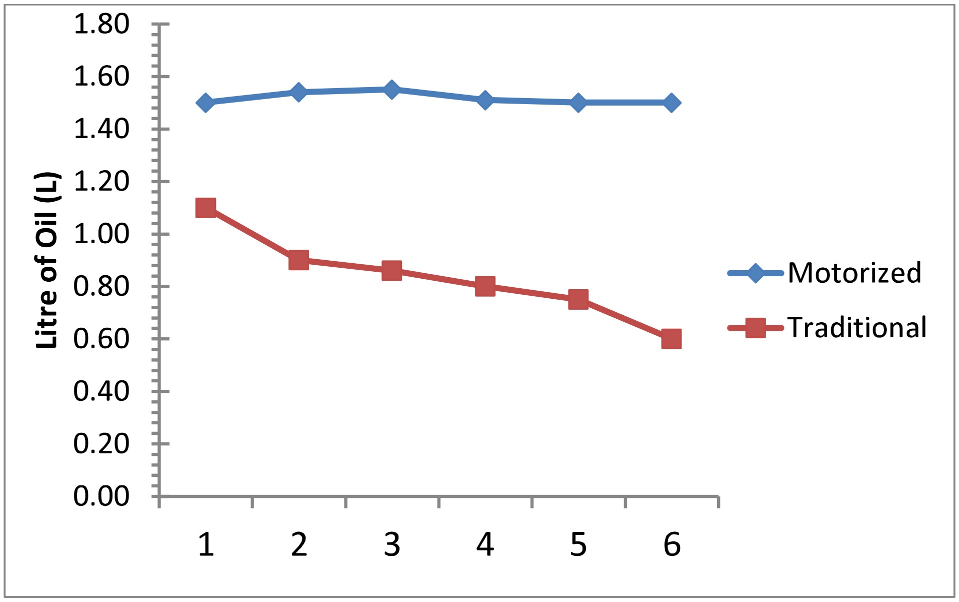

Fig.1. Effect of Liters of Oil Expression on number of Replications from Melon Seeds using Motorized and Traditional Methods

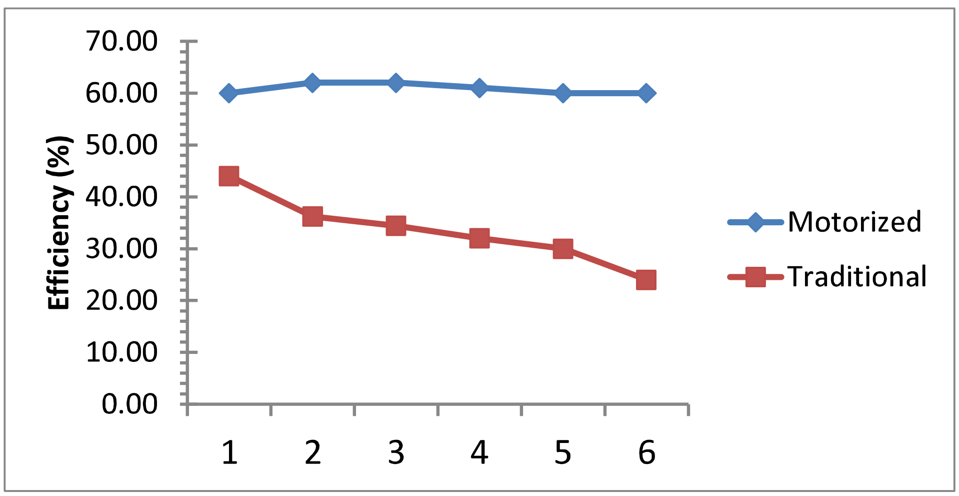

Fig .2. Effect of Efficiencies on number of Replications on Motorized and Traditional Methods of Expression oil from Melon Seeds

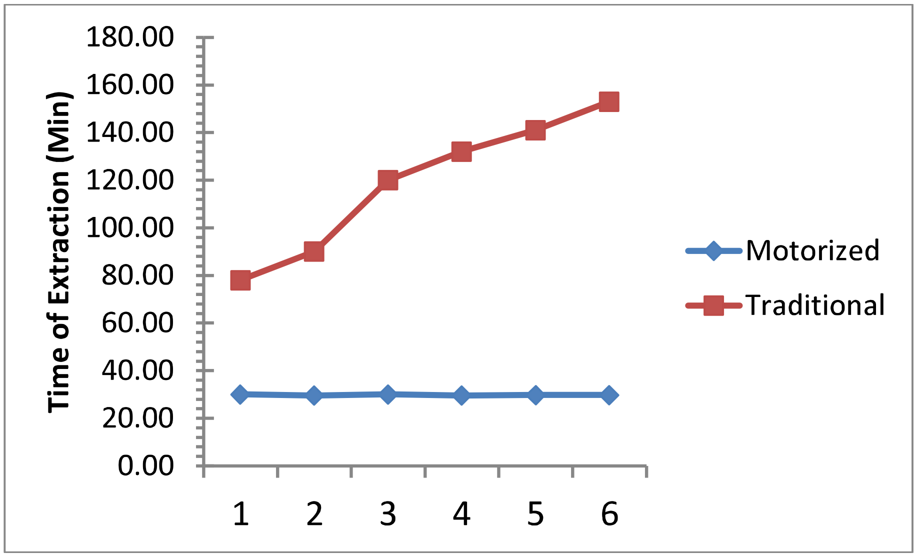

Fig.3. Effect of Time of Oil Expression on number of Replications by using Motorized and Traditional Methods

4. CONCLUSIONS

A motorized melon oil expeller was designed, fabricated and performance evaluation test carried out. The main essence of the machine was to provide a means that would enhance the processing of melon seeds to obtain oil thereby reducing the drudgery and time-consuming operations when the traditional method is used. The result showed that the machine attained oil expelling of 1.52litres, oil yield of 30.23% and efficiency of 60.83% when 5 kg of melon seeds was used as basis.

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