International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 11, November - 2013

Design, Construction and Performance Evaluation of A Bush Mango Juice And Seed Extractor

Gbabo Agidi[1], J. T Liberty[2] and A. S Akingbala[1]

Department of Agricultural and Bioresources Engineering,
[1]Federal University of Technology, Minna, Niger State
Department of Agricultural and Bioresources Engineering,
[2]University of Nigeria, Nsukka, Enugu State, Nigeria

***Abstract*— This work aimed at the design and construction of a bush mango juice and seed extractor. The extractor consists of hopper, beating chamber, extractor chamber which consists of a bottom perforated cylinder and a decreasing pitch screw conveyor (auger), and a lower semi-cylindrical juice collector. The upper shaft to which the beaters are welded has a speed of 250rpm, while the auger has a speed of 98rpm. Bush mango were fed into the beating chamber through the hopper and the beaters beat and conveyed the fruits into the extraction chamber where the juice is then extracted with the help of the decreasing pitch screw conveyor. The extracted juice then flows through the perforations into the lower semi-cylindrical juice collector. The extractor has extraction efficiency of 66%, juice recovery rate of 69%, and capable of extracting bush mango juice without crushing the seeds. The machine has low maintenance cost and replacement of parts can be done with ease because the machine was made from locally available materials. Machine of this nature can be employed to increase the production of bush mango juice locally.**

***Keywords* — Bush mango, extraction chamber, perforated cylinder, seed extractor**

I. INTRODUCTION

Bush mango (*Irvingiagabonensisis*) commonly refer to as Ogbono, African mango, Iba-tree, wild mango, Dikanut or odikabread tree are economically important fruit tree native to moist lowland tropical forest in Central and West Africa, constitute an important part of rural diet in Nigeria (Mollet *et al.,* 1995; Harris, 1996). The tree is a hardwood and the fruit is a fleshy, fibrous drupe, but it is the seeds that are used for weight loss. Traditionally, these are dried in the sun, ground to paste or powder and used to thicken certain Nigerian and Cameroonian soups. The bush-mango-seed extract used for weight loss is rich in proteins, fiber and antioxidants. Research on Bush mango shows beneficial effects for diabetes and obesity, as well as analgesic, antimicrobial, antioxidant, and gastrointestinal activity. (Oben *et al.,* 2008).

Ethnomedicinal treatments utilize the bark, kernels, leaves, or roots for a variety of ailments .The bark is mixed with palm oil for treating diarrhea and for reducing the breast-feeding period. The shavings of the stem bark are consumed by mouth to treat hernias, yellow fever, and dysentery, and to reduce the effects of poison in French Equatorial Africa (George and Zhao, 2007). The antibiotic properties of the bark help heal scabby skin, and the boiled bark relieves tooth pain (Ainge and Brown, 2001). The Mende tribe in Sierra Leone grinds the bark into a paste with water and applies the product to the skin for pain relief. (George and Zhao, 2007; Okolo et al., 1995) In certain parts of Africa, the bark extract is ingested to produce an analgesic effect (Okolo et al., 1995). The powdered kernels act as an astringent and are also applied to burns (George and Zhao, 2007).The stems of the tree have been used as chewing sticks to help clean teeth (Ainge and Brown, 2001).

African bush mango juice produces a quality wine at 8% alcohol content after 28 days of fermentation that in 1 study was comparable in color, flavor, sweetness, and acceptability to a German reference wine (Akubor, 1996; Leekey, 1999).

However, unprocessed bush mango spoils easily, compared to the processed ones (i.e in juice form) and extraction of bush mango juice by squeezing with hand is time consuming, laborious and inefficient. Therefore, this study is aimed to:

i. Design and construct a bush mango juice extractor
ii. Extract bush mango juice without damaging or crushing the bush mango seed and
iii. Also to increase the production of local species mango juice

II. MATERIALS AND METHODS

The following properties were considered in selecting the materials needed for the construction of the extractor:

- Physical properties such as size, shape, density etc.
- Mechanical properties which include; strength, toughness, stiffness, fatigue, hardness and wear resistance
- Chemical properties: this includes resistance to oxidation and all forms of corrosion since the machine is to be used in processing food.
- Material availability: the materials used were selected based on their availability such that they can be obtained from the market with ease.
- Cost of materials: materials used can be made available at a cheaper price to peasant farmers
- Cost of maintenance: replaceable parts were not welded to the machine frame in order to allow for easy replacement of parts.

- ❖ Strength of material: to avoid operational failure, the strength of the materials used was ascertained. These were determined by establishing data and formulae. Based on the data and formulae applied, the strength and size of parts such as central shaft, power of electric motor required, size of bearing and thickness of the sieve materials were determined.
- ❖ Durability and Hygiene: the machine will come in contact with easily oxidized food (liquid substance). It is therefore necessary to ensure all these parts coming in contact with the juice be made of stainless steel of appropriate strength. The use of stainless steel material for constructing the auger, shaft, perforated drum and collector will enhance the durability of the machine because of its corrosive resistance. However, for construction of the proto-type, ordinary, mild steel was used but painted to reduce corrosion.

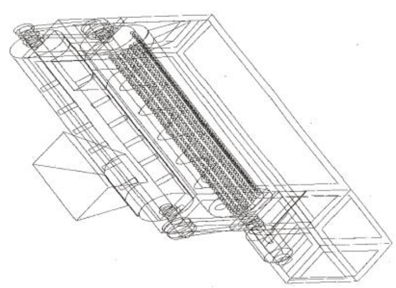

Fig1: Isometric view of the bush mango fruit juice & seed extractor

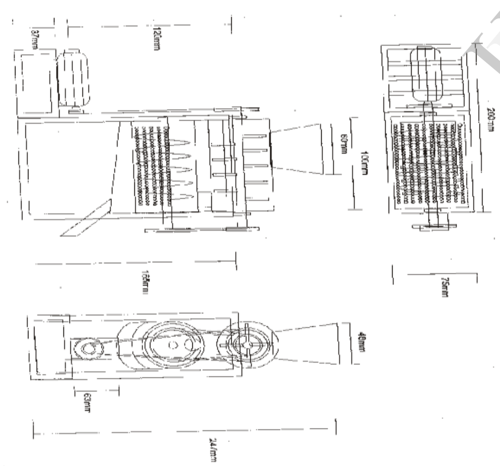

Fig 2: Orthographic view of the bush mango fruit juice & seed extractor

A. Machine Description

The components of the bush mango juice extractor include the following:

i. *Hopper:* the fruits are fed into the beating chamber through the hopper. It is trapezoidal in shape with inlet area of 30cm x 24cm, and outlet area of 20cm x 16cm with a height of 23.25cm.

ii. **Outer Cylinder:** this is a semi-circular drum and has the hopper welded to it. At the lower end, a semi-circular hole is made on it and a flat plate to its base. It is through this that the seed is ejected. Also at the lower part of the cylinder a collecting funnel was attached so that extracted juice can flow out into a container.

iii. *Lower Perforated Drum:* the drum is perforated to have a roughened interior; which breaks the fruit for the juice to flow out through the hole. It also encloses the conveyor.

iv. *Decreasing Pitch Screw Conveyor:* this is a type of screw conveyor with a variable pitch in the decreasing order with the aim of using compressive force to extract the juice from the mango fruit.

v. *Shaft:* it has the screw plate on its circumference. The shaft is of length 700mm and diameter 32mm. on the shaft, a pulley was mounted, which with the help of a v-belt arrangement transmit power to the machine from the power source. The beaters are welded to the section of the shaft near the bottom of the hopper to help beat the fruits for ease of juice extraction.

vi. *Pulley and Belt:* the pulley and belt transmit the rotary motion developed by the electric motor to the shaft.

vii. *Bearing:* bearings were used to support and align the shaft. They carry the shaft to absorb torque and make the operation almost frictionless.

viii. *Machine Frame:* this was made of 40 x 40mm angle iron and has a thickness of 2mm. This is the main part of the machine on which other parts are welded.

ix. *Motor:* this supplies the power needed to drive the extractor. It is mounted on the machine frame below the shaft pulley and has its pulley connected to that of the shaft through a v-belt.

x. *Beating Chamber:* it consists of a cylinder which encloses a shaft to which flat iron bars are welded at an angle of 45^0. This was done so that the beaters can combine both the function of beating and conveying the fruits towards the right side of the beating chamber from where they drop into the extraction chamber.

B. Mode of Machine Operation

When the motor was switched-on to enable the machine rotate speed of 98rpm with the aid of pulley and belt, the hopper was then fed uniformly with the bush mango. The beater beats the bush mango fruit and conveyed into the perforated drum, pressed against the roughened surface. Owing to the nature of the screw conveyor (decreasing pitch type), compression and extraction of the bush mango juice from the fruit was achieved thereby ejecting the bush mango seed out of the drum. The juice which was released through the perforated drum and collected through a funnel attached to the bottom.

C. Design Calculations

The following assumptions were made during the design of the machine components:

a) Expected capacity of the extractor = 2000kg of juice per hour
b) Average size of bush mango = 5.25 x 5.25 x 4.75cm
c) Average size of bush mango seed = 3.25 x 2 x 1cm
d) Average mass of one fruit = 1.132kg
e) Average mass of juice extractable from one bush mango = 0.094kg
f) Mass of bush mango fruit required to be processed per hour in order to achieve the above capacity = 24, 085kg/hour (i.e capacity of conveyor
g) Density of bush mango = 1002kg/m^3
h) Density of mild steel = 7840kg/m^3
i) Power of electric motor = 3.73kW (5hp)
j) Selected length of shaft = 700mm
k) Selected capacity of hopper = 60 bush mango fruits
l) Acceleration due to gravity, g = 9.81m/m^2
m) Motor speed = 1440rpm
n) Maximum weight of shaft pulley = 40N
o) Electric motor efficiency = 85%
p) Allowable shear stress of mild steel = 55 x 10^{6}mN/m^2 for shaft without keyway (Khurmi and Gupta, 2005)
q) Combined shock and fatigue factor applied to bending moment, k_b = 1.5 (Khurmi and Gupta, 2005)
r) Combined shock and fatigue factor applied to torsional moment, k_t = 1.0 (Khurmi and Gupta, 2005)
s) Selected speed of shaft = 98rpm
t) Material factor = 0.5
u) Shear stress for bush mango = 10.2kN/m^2 (Ledger, 2003)
v) Coefficient of friction between belt and pulley = 0.52
w) Selected diameter of motor pulley = 65mm

a) Determination of the first Screw Conveyor (auger) Pitch

The first screw pitch was determined using the equation;

$$C_s = 60 \ x \ \frac{\pi}{4} \ x \ (D^2 - d^2)\rho N\theta$$

Where, C_s = theoretical capacity i.e required auger capacity (m^3/h)

$$C_s = \frac{auger\ capacity\ in\ kg/hour}{density\ of\ bush\ mango\ in\ mango\ in\ kg/m^3}$$

$$= \frac{24085}{1002} = 24m^3/hour$$

Where D = screw diameter (0.245m)
d=shaft diameter (0.032m)
ρ = screw pitch
θ=filling factor (assumed 0.8)
N = shaft speed (98rpm)

$$24 = 60 \ x \ (0.245^2 - 0.032^2) \ x \ \rho \ x \ 98 \ x \ 0.8$$

$$Therefore,\ 24 = \frac{188.5 \ x \ 0.059001 \ x \ \rho \ x \ 0.8}{4}$$

$$24 = \frac{871.94\rho}{4}$$

$$\rho = 0.11m$$

Hence, the first pitch of the screw was taken as 0.11m

b) Determination of the pitches of the decreasing pitch screw conveyor

The screw conveyor was designed using a method by Jones and Kisher (1995). The conveyor must have pitches of decreasing order. In determination of the pitches, iteration method was used. A value was assumed for the first pitch (P(x)) in other to obtain a value for the inlet velocity (v) and then evaluate the remaining four pitches using iteration. The summation of the five pitches must not be greater than the total length of the conveyor (0.5).

Due consideration were given to the size and shape of the bush mango such as length, breadth and width in order to ensure that the first pitch can contain the bush mango fruit and extract juice before reaching the last pitch as well as preventing crushing of the seed. As a result of this expectation, the conveyor was designed such that the last pitch is just a little wider than average length of a bush mango seed (3.25cm).

The formula is given by:

$$P(x) = \frac{4vDL}{\frac{\pi}{4}(D^2 - d^2)N}$$ (Jones and Kisher, 1995)

Where $P(X_n)$ = nth pitch (m)
v = inlet velocity of material (m/s)
D = outside diameter of the screw conveyor (0.245m)
d = inner diameter of the screw conveyor (0.032)
L = Length of the screw conveyor (0.5m)
N = speed in rev/min of the shaft (98rpm)
$P(X_1)$ = 0.11

$$0.11 = \frac{4 \ x \ 0.245 \ x \ 0.5 \ x \ v}{\frac{\pi \ x \ (0.245^2) \ x \ 98}{4}}$$

$$0.11 = \frac{0.49v}{4.54}$$

$$v = 1.274\, m/s$$

$$P(X_2) = \frac{4x0.245x(0.5-0.11)x1.274}{\frac{\pi x(0.245^2 x0.032^2)x98}{4}}$$

$$= \frac{0.4869}{4.54}$$

$$= 0.107m$$

$$P(X_3) = \frac{4x0.245x(0.39-0.107)\,1.274}{\frac{\pi x(0.245^2 x0.032^2)x98}{4}}$$

$$\frac{4x0.245x(0.39-0.107)\,1.274}{4.54}$$

$$= \frac{0.3533}{4.54}$$

$$= 0.078m$$

$$P(X_4) = \frac{4x0.245x(0.283-0.078)x1.274}{\frac{\pi x(0.245^2 - 0.032^2)x98}{4}}$$

$$= \frac{4x0.245x(0.283-0.078)x1.274}{\frac{\pi x(0.245^2 - 0.032^2)x1.274}{4.54}}$$

$$= \frac{0.2559}{4.54} = 0.056m$$

$$P(X_5) = \frac{4x0.245x(0.205-0.056)x1.274}{\frac{\pi x(0.245^2 - 0.032^2)x98}{4}}$$

$$= \frac{4x0.245x(0.205-0.056)x1.274}{4.54}$$

$$= \frac{0.1860}{4.54} = 0.041m$$

Therefore, the required pitches are 0.11, 0.107, 0.078, 0.056 and 0.041m respectively.
Sum of the pitches
= 0.11+0.107+0.078+0.056+0.041 = 0.392m

c) Determination of the Diameters of the Shaft

A shaft was used in transmitting power and it could be solid or hollow. The most important considerations in the design of shafts are the pulley weight and reactions at the bearing that support the shaft. The following free body diagram was used to evaluate the shaft diameter:

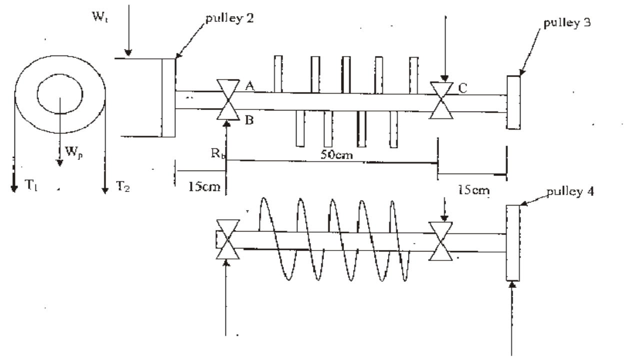

Fig 4: Free body diagram of the shafts

Where W_p= weight of pulley 2
T_1=T_2= tensions in the belt
Assuming maximum weight of pulley (W_p) = 40N = 0.04kN
Taking the distance between the pulley 2 and the left bearing to be 15cm,
$T_1$and T_2 can be calculated from;
P = T x ω
Where P = power of the electric motor (3.73kW)
T = torque, N= motor speed in rpm (1440rpm),
ω = angular velocity (rad/sec)

$$\omega = \frac{2\pi N}{60} \text{ i.e. } P = \frac{2\pi NT}{60},\ T = \frac{60P}{2\pi N}$$

$$T = \frac{60x3.73}{2x3.142x1440} = 0.0247kNm = 24.7Nm$$

Taking the motor efficiency to be equal to 85%,

Effective torque $(T) = 24.7x\frac{85}{100} = 20.995Nm$

But, torque (T) = F x r
Where F = tangential force (N), r = radius of motor pulley (m), Diameter of motor pulley = 65mm,

$$r = \frac{0.065}{2} = 0.0325m,\ 20.995 = Fx0.0325$$

$$F = \frac{20.995}{0.0325} = 646N = 0.0646kN$$

But, F = T_1=T_2 = 0.646kN
Total force (W_t) acting at point A (left end of the upper shaft) is given by:

$$W_t = W_p + T_1 + T_2$$

$$W_t = 0.04 + 0.646 + 0.0646 = 1.332kN$$

From the above body diagram, maximum bending moment occurs at point B and is due to the total force (W_t) acting at point A. therefore, maximum bending moment is given by:

$$M_b = 1.332x\frac{150}{1000}kNm = 0.01998kNm$$

For solid shaft, we have;

$$d^3 = \frac{16}{\pi x S_s} x\sqrt{(k_b x m_b)^2 + (k_t x m_t)^2}$$ (Khurmi and Gupta, 2005)

Where d = shaft diameter (m)
S_s = allowable shear stress (55 x 10^6N/m^2 for shaft without keyway)
K_b = combined shock and fatigue factor applied to bending moment
K_t = combined shock and fatigue factor applied to torsional moment
For load applied gradually, K_b = 1.5 and K_t = 1.0
M_b = maximum bending moment (0.1998kNm)
M_t=maximum torsional moment (0.0247kNm)

Therefore,

$$d^3 = \frac{16}{\pi x(55x10^6)} x\sqrt{(1.5x0.1998)^2 + (1.0x24.7)^2}$$

$$d^3 = \frac{16x300.716}{172.8x10^6}, d = \sqrt[3]{0.000027844}$$

$$= 0.03031m = 30.31mm$$

taking a factor of safety to be 30% of the designed value, actual diameter of the shaft is given by;

$$d = 32 + \left(\frac{30}{100}x32\right) = 41.6mm$$

Therefore, the diameter of the upper shaft was taken as 42mm. The same diameter was assumed for the lower shaft 1.e. 42mm.

d) Design of the Machine's Hopper

To design a hopper for the bush mango juice extractor, the arrangement of the fruits inside the hopper has to be taken into consideration. Considering the dimension of the bush mango fruit (5.25 x 5.25 x 4.75cm), a spherical shape was assumed for the bush mango fruits. Then if this is so, the following arrangement is possible inside the upper:

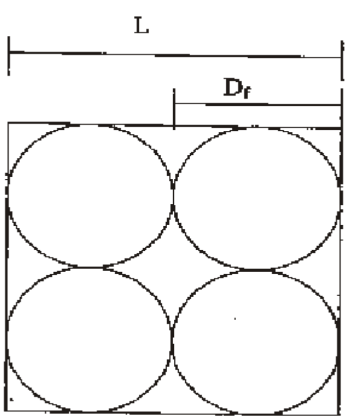

Fig. 5: Arrangement of fruits inside hopper

From the above, average diameter of the bush mango fruit (D_f) is given by:

$$D_f = \frac{L_f + B_f + W_f}{3} = \left(\frac{5.25 + 5.25 + 4.75}{3}\right)cm$$

$$= 5.08cm \text{ Then, } L = (5.08x2)cm = 10.17cm$$

Volume occupied by 8 bush mango fruit (V_{8f}) = L^3 = $(10.17)^3$cm^3 = 1051.87cm^3

The hopper is expected to accommodate 60 pieces of mango fruits. Hence, volume occupied by 60 pieces of bush mango fruit (V) is given by:

$$V_{60f} = \left(\frac{60}{8}\right)xV_{8f} = 7.5x1051.87 = 7889.025cm^3$$

i.e. expected volume of hopper is = 7889.025cm^3

e) Power Requirement

The total power required for complete operation of the machine is given by the summation of the following:
i. Power required for driving the two shafts (P_s)
ii. Power required for driving the three pulleys (P_p)
iii. Power required for extraction of the juice (P_e)
Total power required (P_t) = P_s + P_p+P_e

a) Power required for driving the two shafts (P_s)
According to Jones and Kisher (1995), the power required for driving the upper shaft is given by:

$$P_{us} = \frac{(D^2 xd^2)\rho gNpfl}{8000}$$

Where D = diameter of the beater (0.245m)
d = shaft diameter (0.032m), p = beater pitch (0.11m)
ρ = density of the material (1002kg/m^3)
N = speed of the shaft in rev/min (250rpm)
f = material factor (0.5)
Therefore,

$$P_{us} = \frac{(0.245^2 - 0.032^2)x1002x9.81x250x0.11x0.5x0.5}{8000}$$

$$= \frac{(0.060025 - 0.001024)x1002x9.81x250x0.11x0.5x0.5}{8000}$$

$$= \frac{3987.2}{8000} = 0.498kW$$

Therefore, power required for driving the shaft is 0.498kW.
The lower shaft power (P_{ls}) was calculated as 0.693kW using shaft speed of 98rpm
b)Power required for extraction of the juice (P_e) is given by:
P_e = Tω Where T = torque (Nm)

W = angular speed (rad/sec) But, $T = \frac{\pi d^3 \tau}{16}$

Where d = diameter of the inner cylinder (perforated cylinder), 0.275m and τ = shear stress (10200N/m^2)

$$T = \frac{\pi x0.275^3 x10200}{16} = \frac{\pi x0.0208x10200}{16}$$

$$= \frac{666.42}{16} = 41.65Nm, W = \frac{2x\pi x98}{60}$$

Where N = number of rev/min of the shaft (98rpm)

Therefore,

$$W = \frac{2x\pi x98}{60} = \frac{615.75}{60} = 10.26 rad/\sec$$

$$P_e = 41.65x10.26 = 427.43W = 0.427kW$$

c) Power required for driving the three pulleys (P_p)
Power required for driving pulley 2 was calculated from

$$P_{p2} = T\omega$$

Where T = torque (Nm)
ω = angular speed (rad/sec) But, $T = Fxr = Wxr$
Where W = weight of pulley 2 (40N)
r = radius of pulley 2 (m) = $\frac{D}{2}$
Where D = diameter of pulley 2 (374.4mm)
Therefore, $r = \frac{374.4}{2} = 187.2mm = 0.1872m$
Hence, $T = 40x0.1872 = 7.488Nm$

But, $\omega = \frac{2x\pi xN}{60}$
Where N = speed in rev/min of pulley 2 (250rpm)

$$\omega = \frac{2x\pi x250}{60} = 26.18 rad/\sec$$

$$Therefore, P_{p2} = 7.488x26.18 =$$

$$195.966W = 0.196kW$$

The same procedure as above was used to calculate the power required for driving pulley 3 and 4. It was calculated as 0.077kW each, using weight; 40N each, radius; 3m and 2m and speed; 250 and 98rpm respectively.
Therefore, power required for driving the three pulleys is given by

$$P_p = P_{p2} + P_{p3} + P_{p4}$$

$$= 0.196 + 0.077 + 0.077 = 0.35kW$$

The total power required by the extractor is given by:

$$P_t = P_s + P_e + P_p = 0.693 + 0.472 + 0.35 = 1.515kW$$

Let x be the required horse power,
1 hp electric motor = 0.746kW
Therefore, $x = \frac{1}{0.745} x1.515 = 2.03hp$

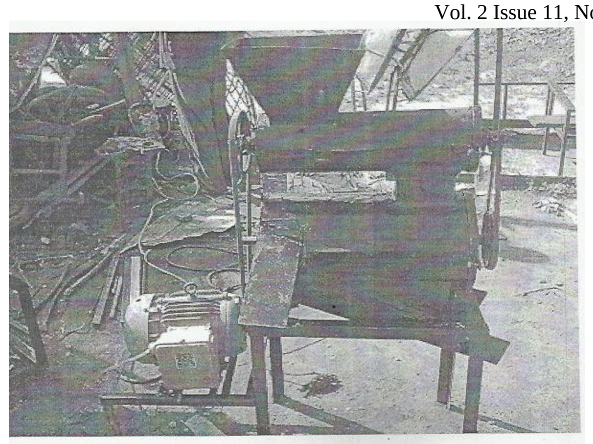

Fig 6: The Constructed Machine

D. Testing Procedures of the Machine

i. The 3hp electric motor was mounted on the frame of the machine
ii. One belt was fitted to both the motor pulley and the pulley attached to the left side of the beater, and another belt was fitted to both the pulley attached to the right hand side of the screw conveyor
iii. The already weight bush mango fruits (25 fruits) were then fed into the beating chamber through the hopper
iv. The electric motor was plugged to the electricity source and switched on
v. The beaters beats and conveyed the fruits towards the right side of the beating chamber which were then dropped into the extraction chamber
vi. With the help of the screw conveyor inside the extraction chamber, the fruits were pressed and the juice extracted which flows into the collection terminal below which existed a juice collection basin which collects the extracted juice.
vii. After collecting the juice, the juice and seeds were weighed together before and after oven drying
viii. The taken for the extraction was taken and recorded
ix. Above procedures were repeated using another set of bush mango fruits
x. Finally, the efficiency of the machine was calculated

III. RESULTS AND DISCUSSION

After carrying out the fabrication of the bush mango juice and seed extractor, its performance was evaluated based on the following parameters:

a) Extraction efficiency (E.E) of the machine
b) Actual machine capacity (C_a) and
c) Juice recovery rate (J_{rr})
d)

a) *Extraction Efficiency (E.E)*

The machine was tested twice using 25 bush mangoes in each batch of the extraction process. The performance test data obtained are analyzed below:

Table 1: Performance Test data

Batch No.	*No. of bush mangoes*	*Initial weight of fruits(kg)*	*Weight of recovered juice/pulp (kg)*	*Weight of recovered juice (kg)*	*Weight of dried seeds (kg)*	*Time of juice extraction (min)*
1	25	2.7410	1.5948	0.8252	0.3245	1.5
2	25	2.4960	1.4278	0.7282	0.2994	1.5
Total	50	5.2370	3.0226	1.5534	0.6239	3

Average number of fruits

$$= \frac{total\ number\ of\ fruits}{2} = \frac{50}{2} = 25$$

Average weight of recovered juice/pulp

$$= \frac{3.0226}{2} = 1.5112kg$$

Average weight of bush mangoes

$$= \frac{5.2370}{2} = 2.6185kg$$

Average weight of dried seeds

$$= \frac{0.6239}{2} = 0.31195kg$$

Hence, extraction efficiency (E.E)

$$\frac{1.5113}{2.6185 - 0.31195} x100 = 66\%$$

b) *Actual Machine Capacity (C_a)*

$$J_{rr} = \frac{Actual\ mass\ of\ juice\ obtained}{Theoretical\ mass\ of\ juice\ in\ the\ fruits} x100$$

Theoretical mass of juice obtained

$$= \frac{75}{100} x1.5113 = 1.1333kg$$

Actual mass of juice obtained

$$= \frac{1.5534}{2} = 0.7767kg$$

Therefore, $J_{rr} = \frac{0.7767}{1.1333} x100 = 69\%$

Lost juice $= 100\% - 69\% = 31\%$

After testing the machine with 50 bush mangoes for 3 minutes at a beater speed of 98rpm, the extraction efficiency of the machine was found to be 66%. The actual machine capacity was found to be 104.7kg/hr and the juice recovery rate was found to be 69% with juice loss of about 31%

IV. CONCLUSION AND RECOMMENDATION

In conclusion, after testing the machine, it was found that the machine has efficiency of 66% and the machine was capable of extracting the juice without crushing the seeds. It was observed also that the efficiency of the machine could be increased by increasing the quality of the bush mango fruits fed into the machine. The machine has low maintenance cost and replacement of parts can be done with ease because the machine was made from locally and readily available materials.

The following are recommended:

i. The length of the beater should be increased in order to increase the beating time and hence allow for easy and efficient juicing
ii. The length of the auger should be increase and should cover about 95% of the shaft for proper juicing and easy ejection of seeds
iii. The perforation of the inner cylinder should be increased in order to allow free flow of the extracted juice
iv. Pulping machine should be incorporated to separate the juice from the fruit pulp hereby avoiding blockage of the perforations
v. Stainless steel could be used in lieu of mild steel for all parts in contact with the fruit

REFERENCES

[1]Ainge L, Brown N. Irvingia gabonensis and Irvingia wombolu. A State of Knowledge Report undertaken for The Central African Regional Program for the Environment. Oxford Forestry Institute. Department of Plant Sciences. University of Oxford. United Kingdom. 2001.

[2]Akubor P.I. The suitability of African bush mango juice for wine production. Plant Foods Hum Nutr . 1996;49(3):213-219.

[3]George IN, Zhao Y. Pharmacological activity of 2,3,8-tri-O-methyl ellagic acid isolated from the stem bark of Irvingia gabonensis . Afr J Biotechnol . 2007;6(16):1910- 1912.

[4]Jones and Kisher, 2005. Mechanical Engineers Handbook (5th Edition). MC Graham Company

[5]Julius E. Oben et al., 2008. Lipids in Health and Disease: The use of Cissus Quadrangularis/Irvingia Gaabonensis Combination of weight loss.

[6]Khurmi, R.S and Gupta, J.K, 2005. A Text Book of Machine design. Eurasia Publishing House (Pvt) Ltd., Ram Nagar, New Delhi, India.

[7]Leakey R. Potential for novel food products from agroforestry trees: a review. Food Chem . 1999;66(1):1- 14.

[8]Ledger, S.N., 2003. Impact and Pressure Resistance of Mango

[9]Okolo CO, Johnson PB, Abdurahman EM, Abdu-Aguye I, Hussaini IM. Analgesic effect of

Irvingia gabonensis stem bark extract. J Ethnopharmacol 1995;45(2):125-129.