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Original Research Article

Development of a Small Scale Pineapple Juice Extraction Machine

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Abstract: A pineapple juice extraction machine was designed and fabricated using local available resources. It was powered by a 2 hp single phase electric motor. Test indicates that juice yield, extraction loss, and extraction efficiency were 75%, 4.8% and 71% respectively. This shows remarkable improvement of that reported by Olaniyan *et al*. The pineapple juice extraction Machine was able to produce 18lts/s.
Keywords: Development, Pineapple, Juice, Small scale, Extraction, machine

INTRODUCTION

World Pineapple production in 2011 constituted more than 19 million metric tons, with Nigeria producing about 1.4 million metric tons (about 7% of the world production), which placed it in the seventh position [1]. It was discovered that several tons of pineapple is lost annually in Nigeria. High cost of processing machine, late harvesting, lack of adequate preservation method, lack of easy means of transportation are some of the constrains. It is pertinent that pineapple be processed to finished product that can be stored, preserved, packaged, and transported or consumed, such as juice for human consumption and cake for use as animal feeds [2]. Reported that fruit juice is the next best thing to fresh fruit. Pineapple juice can be consumed freshly or mixed with other fruit juice to form fruit jams. Fruit juice is ready and rich source of vitamins, fibre and mineral salt for human consumption due to its uses as medicine, food, and appetizer [3]. It is essential for human and animal growth, aid metabolic activities and improve health standard of the people. In Nigeria fruit juice is highly demanded among various age groups growing at over 10% per annum, currently, this has led to influx of varieties of imported and home-made juice into the market [4]. Production of juice locally will help reduce cost of the product in the market, improve the living standard of the peasant farmers, through large scale production and exportation of finished pineapple products, and improve health standard of the people. The majority of fruit juice is produced from imported concentrate. Nigeria has a comparative advantage to produce fruits relative to other African countries. There is a promising investment opportunity in fruit concentrate processing. Fresh pineapple has 60 percent edible part. The fruit contains 80-85 percent of water, 12- 15 percent sugars, 0.65 percent acid, 0.4 percent protein, 0.1 percent fiber and several vitamins mainly A & C. It could be used for cosmetic purposes, pharmaceuticals, fuel and ultimately food. The pineapple fruit is adequately suitable for the preparation of beverages, syrups and cocktails. It is also used for the production of frozen concentrates, which is becoming very popular due to their remarkably preserved fresh fruit flavor and potent enzyme. The most important products are canned slices, chunks, bottled juice as well as crushed fruit. There is no doubt that the quality of life in Nigeria particularly in rural areas is currently poor and loathsome. Fruit production if well commercialized is capable of generating vast sums of money from proceeds of local and export sales of fresh fruits and industrial raw materials for sustainable income and nutrition security.

Juice extraction is the process by which the liquid potion of the fruit is been squeezed or forced out of the solid part of the fruit either by manual or mechanical means. Manual or traditional method involves macerating fruit with hand or peeling, slicing, blending and pressing the fruit after washing. This method is highly labour intensive, unhygienic, tedious and time consuming as compared to mechanical means. These methods are not only energy sapping and time consuming, but also yield low quantity juice and are unhygienic [5].

Extracting pineapple juice using a cage press that is hydraulically or screw operated requires the fruit to be sliced prior to extraction. Also, the worm shaft of a continuous screw press extractor cannot handle the whole fruit without it being cut into smaller pieces before feeding in. The task of manually slicing the fruit before juice extraction is time wasting, energy sucking, and grossly inefficient. Therefore, the objective of this study was to design, develop and fabricate a machine that can perform a combine function of slicing, and squeezing out juice for small scale pineapple farmers. This would make possible the extraction of juice from whole pineapple fruits in a continuous manner more efficiently.

Pineapple (Ananas Cosmosus) is one of the most important tropical fruits; it is grown in areas like Africa, Asia, and Europe etc. [6] Observed that over 50% of different kinds of fruits produced by fruit farmers in Nigeria are usually wasted yearly due to lack of efficient storage facilities; after those fruits have been harvested. It was estimated that about 0%- 80% of pineapple fruit is wasted after harvesting [7], Pineapple as a fruit is an important source of energy. However its availability is seasoned and they are perishable. Hence they need to be processed into juice and preserved which also results in value additions. This juice can be consumed freshly or be processed into healthful beverages.

Several engineers, technologists, designers, etc have gone into the design and production of machines that can process the fruit pineapple into juice to either stop or reduce the rate at which the harvested fruits are being wasted. Juice extractors are of various types and forms based on their functions, working principles mode of operation, utilities, and capacities.

Sylvester *et al*. [8] designed, constructed and evaluated the performance of a manual juice extraction machine. It consists of screw, perforated inner cylinder, outer (receiving) cylinder, manual presser, faucet, and frame. In this design, the juice was obtained through hand pressing. It was observe that the hand pressing was too tedious and time consuming. The result showed that the machine produced efficiency of 83.86 and 85.38% and extraction capacity recorded were 1.29kg/h and 1.23kg/h for orange and pineapple juice,

Sylvester *et al*. [8] designed and constructed a portable and a manually operated orange juice extractor. It combines the action of beating and chopping often by macerating. It consists of two main parts, globate and a manually operated mechanical unit. The mechanical units consist of a pair of bevel gears two bearings and two shafts. The machine can extract juice from about 180 – 220 oranges per hour.

Hebbar H.U *et al*. [5] developed and evaluated the performance of a multi-fruit juice extractor using pineapple, orange and melon fruits. The machine was designed to exert on the pineapple both compressive and shear squeezing force through an Auger conveying system. It consist of a tool frame, juice extraction encasement, screw conveying tapered shaft, perforated screen base, collection chute, gear box and electric motor. Performance tests were carried out using pineapple, orange and water melon that were introduce into the machine as peeled and unpeeled fruits. The performance indicators considered were percentage juice yield, extraction efficiency and extraction loss. Result shows that type of fruit and peel condition significantly influence the performance indices at 1% level of significance. Percentage juice yield for peeled and unpeeled pineapple, orange and melon were 79.1% and 68.7%, 77% and 69.5% and 89.5% and 89.7% respectively. Extraction efficiency was respectively 96.9%, 94.3% and 96.6% for peeled pineapple, orange and water melon, and their respective unpeeled value was 83.6%, 84.2% and 97.1%. The extracting loss of peeled and unpeeled fruits was respectively 2.1 and 2.7 (pineapple), 2.1 and 2.5% (Orange), and 2.9 and 2.6% (water melon).

Asemota Justine [9], stated that the fruit juice extractor composed of two gears engaged together and connected to two rollers by means of shafts. The shaft of the rollers is mounted in intermarrying spur wheels so that the rotation of one results in the rotation of the other. The roller with the bigger gear is the element selected to receive power from the driving unit.

In order to achieve effective juice extraction, a press was incorporated into the machine. This strain out the remaining juice that may be present in the fruit after passing through the rollers, the juice which finally flows through a tap at one end is collected in a steel container. The disadvantage of this design is that, there is the tendency for the grater to get dull after a series of crushing operation, thereby requiring a periodic change of grater.

Olaniyan A. M [10] stated that blades are mounted on the shaft and housed by the hopper. The blades are placed radially to one another. The design was incorporated with an electric power unit consisting of an electric motor, belt which drives the screw shaft and provides the power necessary for the fruit juice extraction. On placing the pineapple into the hopper, they are cut by blades into small masses. The sliced fruits are thereafter selected by the spiral shaped shaft which transports them at low speed along the cylindrical housing. However, the application of shear and compressive forces by the screw shaft on the pineapple as they are conveyed along the length of the screw converts them to juice which is collected into the juice collector. The disadvantages of this design are that a change of blade is required at interval due to their becoming blunt with time. The perforated screen, pulleys, shaft adjuster, collectors opening and hopper, easily get corroded because they are not made with stainless steel materials. The juice being crushed, cannot be properly extracted, thus there is room still for juice wastage.

Asemota Justine [9] stated that the two crusher type of fruit juice extraction machine is manually operated to serve domestic purposes only. The prepared pineapple is placed into the machine from the top after the removal of the pulp with the help of the two springs embedded into the cover. There is initial compression on the cut pineapple before the final crushing in between the crushers. An effort is applied to the handle which moves the crushers to perform its functions. The juice obtained is collected into a container (juice collector) which finally flows out through tap at one end of the machine. The disadvantage of this work is that since it is manually operated, there was wastage of time and the possibility of producing at constant speed for the crushing was not there.

R. S. Khurmi *et al*. [11], designed, fabricated and tested a small scale mango juice extraction machine. The major components of the machine included hopper, perforated drum, screw conveyor, juice outlet, waste outlet, main frame, electric motor and motor stand. Other components included screw shaft, the juice collector, top cover and the transmission system. The screw conveyor conveys and presses the mango fruits against the perforated roughened drum. The machine was tested using freshly harvested mango fruits and results obtained showed an average juice yield, extraction efficiency and extraction loss of 34.56%, 55.14% and 10.15%, respectively.

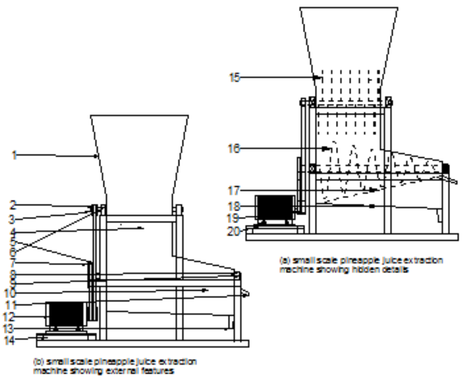
Olaniyan AM [12] designed and fabricated a small scale motorized orange juice extractor, using locally-available construction materials. The essential components of the machine include feeding hopper, top cover, worm shaft, juice sieve, juice collector, waste outlet, transmission belt, main frame, pulleys and bearings. In operation, the worm shaft conveys, crushes, presses and squeezes the fruit to extract the juice. The juice extracted is filtered through the juice sieve into juice collector while the residual waste is discharged through waste outlet. Result showed that the average juice yield and juice extraction efficiency were 41.6 and 57.4%, respectively. It was powered by a 2 hp electric motor; the machine has a capacity of 14 kg/h.

Justification

Large quantity of pineapple fruits are produced and wasted in Nigeria and many other developing tropical countries to deterioration due to metabolic activities which occur immediately after harvesting. It is highly essential to process and preserve the fruits in order to guarantee regular supply of juice at affordable prices. Hence there is need to Design and fabricate a machine for effective extraction of juice from the fruits to reduce post-harvest losses and wastage.

AIM AND OBJECTIVE

The aim of this project is to design and fabricate an easy to operate, affordable, and effective juice extraction machine for use in extracting juice from pineapple and to evaluate the performance of the extractor.



PINAPPLE EXTRACTION PARTS	
S/N	PART NAME
1	Hopper
2	Slicing shaft pulley
3	Slicer shaft
4	Slicing chamber
5	Belt
6	Main frame
7	Extrusion shaft pulley
8	Bearing
9	Main shaft
10	Extraction chamber
11	Waste discharge port
12	Electric motor
13	Juice outlet port
14	Electric motor sitting
15	Slicing blade
16	Extrusion mechanism
17	Filter
18	Steep barrel base
19	Two way driver pulley
20	Bolt and nut

Figure 1 diagram of small scale pineapple juice extraction machine

METHODOLOGY

Pineapple juice extraction machine was designed and fabricated at the workshop of National Engineering Design Development Institute Nnewi anambra state. The power requirement of the pineapple juice extraction machine was selected from table 20.1 [13]; to be 2hp.single phase electric motor. The power requirement was used to determine the torque needed for the operation of the machine. The slicer shaft and conveyor shaft diameter were determined using the ASME Code equation for a solid shaft with little or no axial load.to avoid failure. Appropriate belt type, size, pulley size, speed were determined for maximum performance. A step screw conveyor was selected to enhance easy conveyance, crushing, and pressing to extract juice. The pyramidal frustum shaped hopper was attached to the trough and to the conveyor housing; all mounted on the frame through bolt and nut. Electric motor sitting was welded to the frame. Figure 1 is the diagram of small scale pineapple juice extraction machine.

MATERIAL SELECTION

The materials used include stainless steel for the Hopper, Blades, Shafts, extraction chamber and juice discharge point. Stainless steels resist corrosion in most normal environments. Mild steel was used for main frame and electric motor stand.

Design Considerations and Calculations

Design Considerations

The following factors were considered in the design of the pineapple juice extractor:

- Availability and cost of construction materials.
- Slicing and extraction unit were design with stainless steel to avoid contamination of juice.
- The hopper was designed to accommodate the required quantity of pineapple fruits and the slicing and the extraction units for high efficiency.
- Taper screw conveyor was adapted to ensure maximum crushing, pressing and easy conveyance of the sliced pineapple lumps, to enhance high extraction efficiency.
- Designed for strong main frame to ensure structural stability and strong support.

Design calculation

Design of hopper

Volume of Pyramidal frustum shaped hopper V in (m^3) was obtained from equation 1.

Volume (v)=$\frac{1}{3}H(B_1^2+B_2^2+B_1B_2)$……………………………………………………………………………(1)

Where: B_2 = length of the lower base

B_1 = length of the upper base

H = height

B_2 = 0.4m, B_1= 0.6m, H = 0.5m substituting in the equation we have

v = 0.13 m^3. The hopper was assumed to be loaded with pineapple to fullness, assuming volume of pineapple equal volume of hopper.

Mass of pineapple the hopper can contain m in (kg) was obtained from equation 2.

We have,

$\rho = \frac{m}{v}$…………………………………………………………………………………………… (2)

Where: v = volume (m^3)

ρ = density of an average pineapple (kg/m^3)

ρ = 964.5kg/m^3, (it.famousio.com/www/Pineapple+Design). Substituting in equation 2 we have m = 125.4kg

Design of slicer shaft diameter

The power required to operate the slicer shaft and screw conveyor was selected to be 2hp from table 20.1 page 658 group (A) [13], It was assumed that half weight of mass of pineapple in the hopper acted on the conveyor which is equal to 62.7N

Twisting moment T_w in (*Nm)* was obtained from equation 3

$T_w = \frac{P\,60}{2\pi N}$ …..………………………………………………………………………………… (3) [13]

Where: N = Speed of shaft (rpm)

$\boldsymbol{\pi}$ = constant

P = power required
P = 1.5kw, N = 1420rpm, T_w = 8.41NM.
Slicer Shaft diameter d in (mm) was determined based on strenght from equation 4
$d^3=\frac{16}{\pi S_s}\sqrt{(K_bM_b)^2+(K_tM_t)^2}$…………………………………………………………………..………..(4)
Where: K_b and K_t are constant i.e for gradual loading of a rotating shaft
M_t = torsional moment of shaft (*N)*
M_b = maximum bending moment of slicer shaft (*N)*
S_s = maximum allowable shear stress (N/m^2)
K_b = combined shock and fatigue factor for bending = 1.5
K_t = combined shock and fatigue factor for torsion = 1.0 [13], M_t = 26.30N, M_b = 0.006N, $S_s = 10 x 10^6$, K_b = 1.5, K_t = 1.0. Substituting in the equation we have d = 24mm

Design of belt and pulley
Driven pulley diameter (D_2) in (mm) was determined from equation 5
$N_1D_1=N_2D_2$……………………………………………………………………...……………..(5)
Where: D_1 = diameter of driving pulley
D_2 = diameter of driven pulley
N_1 = No of rev/m of driving pulley
N_2 = No of rev/m of driven pulley (rpm)
D_1 = 100mm, D_2 = 80mm, N_1 = 1420rpm, substituting in the equation we have N_2 = 1775rpm.
Length L of belt in (mm) was obtained from equation 6
$L=2C+\frac{\pi}{2}(D_1+D_2)+\frac{D_{2-}D_1}{4C}$……………………………………………………………………….……….(6)
Where: C = centre to centre distance of pulley
But $C=2(D_1+D_2)$……………………...………………………………………………….………. (7)
D_1 = 100mm, D_2 = 80mm, substituting in the equation we have C = 360mm,
L = 1002.8mm
Speed of driver pulley V_1 in (rpm) was obtained from equation 8
$V_1=\frac{\pi D_1 N_1}{60}$…………………………………………………………………………………….………..(8)
Where: D_1= diameter of driver pulley
N_1= no. of revolution of driver pulley
D_1= 100mm, N_1 = 1420rpm substituting in the equation V_1 = 7.44m/s
Speed of driven pulley V_2 in (rpm) was obtained from equation 9
$V_2 = \frac{\pi D_2 N_2}{60}$…………………………..……………………………………………………………. (9)
Where:
D_2= diameter of driven pulley
N_2= no. of revolution of driven pulley
D_2= 80mm, N_2 = 1775rpm, substituting in the equation, V_2 = 7.44m/s
The contact angle α in (degree) was determined from equation 10
$Sin\alpha=\frac{D_{1-}D_2}{2C}$.. (10)
Substituting in the equation, $\alpha = 1.72^o$
Lap angle l_a in (deg) was obtained from equation 11
$l_a=180^{o-}2\alpha$…….……………………..…………………………………………………..…......(11)
Substituting in the equation, $l_a = 56.2^o$
Maximum Belt tension T in (N) was determined from equation 12
$T = S_s A$………………………..………………………………………………………...…. (12)
Where: S_s = maximum shear stress = 25% of 40Mpa according to the standard code given by (ASME)
Area of belt A in (mm^2) was determined from equation 13
$A=T_bxW$…………………………….……………………………………………………...……. (13)
Where: T_b = thickness of belt
W = width of belt
T_b = 0.008m, W = 0.013m, Substituting in the equation, A = $1.04 x 10^{-4}m^2$
T = 1040N
Centrifugal tension (T_c) of belt was determined from equation 14

$T_c = MV^2$ .... (14)
M = 0.12kg/m, $V = V_1 = V_2$ = 7.44m/s, T_c = 6.64N
Tension (T_1) in (N) on tight side was determined from equation 15
$T_1 = T - T_c$ ………………………………………………………………………………………………..(15)
T_1 = 1033.36N
Recall that 2.3 log $(\frac{T_1}{T_2}) = \varphi\theta \text{Cosec}\beta$ [13]…………………………………………………………………..(16)
Where: = μ = coefficient of friction for rubber = 0.3
θ = angle of = 0.981rad
β = groove angle of the material $2\beta = 34^o \beta = 17^o$ substituting we have
T_2 = 375.8N
Torsional moment (M_t) in (N) of belt was determined from equation 17
$M_t=(T_1-T_2)D/2$…………………………...……………………………………………...……(17)
Substituting we have M_t = 26.30Nm

Considering the horizontal loading from the belt thereby, neglecting the weight of the shaft, total vertical loading acting on the pulley (W) in (N) was determined from equation 18
$W = T_1 + T_2$ ……………………………………………………………………………...….... (18)
Where: T_1 = Tension on tight side
T_2 = Tension on the scale side
T_1 = 1033.6N, T_2 = 378N, substituting, W = 1409.2N

Design of screw conveyor shaft diameter for pineapple juice extraction machine
The shaft was designed based on the following assumptions

1. It was assumed that half weight of mass of pineapple in the hopper acted on the conveyor which is equal to 62.7N

The power required to operate the screw conveyor and the slicer was selected to be 2hp from table 20.1 [13]. The twisting moment of conveyor shaft is equal to twisting moment of slicer shaft. The total vertical loading acting on the pulley (W) was determined from equation 18.

Shaft diameter for the screw conveyor was determined based on strength from equation 4. M_t = 28.39N, M_b = 59.58N, $S_s = 10 \; x \; 10^6$, K_b = 1.5, K_t = 1.0. Substituting in the equation we have d = 33.4mm
The screw pitch was designed using 19, obtained from [11].

$P_s = \frac{4vDL}{\frac{\pi}{4}(D^2+d^2)N}$…………………………..………………………………………………………(19)

Where: P_s = the screw pitch,
V = the inlet velocity of raw material,
D = the outside diameter of screw,
d = the inside diameter of screw,
L = the length of the screw shaft,
N = the shaft speed.
D = 0.348m, *d* = 0.116m, *L* = 0.976m, *V* = 0.0085m/s, substituting, P_s = 0,116m.

Speed of conveyor (V_c) was determined from equation 20

$V_c = \frac{D \; x \; \pi \; xN}{60}$……………………………………………………………………………..………..(20)
Where: D = diameter of conveyor screw
π = constant
N = rpm
Substituting, V_c = 25.87m/s
The extraction capacity C_e of screw conveyor was determined using equation 21
$C_e = (D^2 + d^2)xPaxN$ …….………………………………………………………………….………(21)
Where: Pa = average screw pitch

C_e = processing capacity
N = rpm of screw
Pa = 0.116m substituting, C_e = 22.24lt/s.
Juice yield J_Y in (%) was determined from equation 22

$$J_Y = \frac{100W_{JE}}{W_{JE}+W_{RW}} \qquad (22)$$

Where: W_{JE} = weight of juice extracted,
W_{RW} = weight of residue.
W_{JE} = 89kg, W_{RW} = 30kg, substituting, J_Y = 75%
Extraction efficiency E_E in (%) was determined from equation 23

$$E_E = \frac{100W_{JE}}{W_{FS}} \qquad (23)$$

$W_{FS} = 125$kg, substituting, E_E = 71%.
Extraction loss E_L in (%) was determined from equation 24

$$E_L = \frac{100(W_{FS}-(W_{JE}+W_{RW})}{W_{FS}} \qquad (24)$$

Substituting, $E_L = 4.8$%

RESULT AND DISCUSSION

Test conducted shows that, the juice extractor sliced the pineapple perfectly and conveyed to the extraction unit where it was squeezed, and compressed to extract the juice. The juice yield, extraction loss, and extraction efficiency were 75%, 4.8%, and 71% respectively. These results indicated improvement from those reported by [4], this is attributed to the tapered screw conveyor designed and used as recommended by [14]. The result of the test indicates that the machine perform satisfactorily though it requires some modification to improve the performance of the juice extractor.

CONCLUSION

A pineapple juice extractor was developed and tested. The juice extractor was effective, portable, can easily be reproduce, repair and maintain. The material selection was to meet good hygienic standard. It was powered by a 2hp single electric motor; good for small and medium scale juice production in both rural and urban areas. The extractor can produce about 18lts/s which is reasonable for small or medium scale pineapple farmers and help in providing employment then reducing over dependence on government for employment.

REFERENCES

1. Baruwa OI; Profitability and constraints of pineapple production in osun state, nigeria. Journal of Horticultural Research, 2013; 21(2): 59-64.
2. Kazembe HW; Approaches to successful development of low-cost; fruit juice extraction technologies; Case Study to improved rural livelihood, in Malawi. Stuttgart Hohenhein, Conference on International Agricultural Research for development. Merriam Webster, 1981.
3. Ashurt PR; History of fruit drink and food flavouring. Rumbold and Sons Limited Second Edition. New York, 1991; 9-35.
4. Oyeleke FI, Olaniyan AM; Extraction of juice from some tropical Fruits using a Small Scale Multi-fruit Juice Extractor. African crop science conference procedings, 2007; 8: 1803-1808.
5. Aviara NA, Lawa AA, Nyam DS, Bamisaye J; Development and performance evaluation of a multi-fruit juice extractor. Global Journal of Engineering, Design & Technology, 2013; *2*: 16-21.
6. Aviara NA, Lawa AA, Nyam DS, Bamisaye J; Development and performance evaluation of a multi-fruit juice extractor. Global Journal of Engineering, Design & Technology, 2013; 2: 16-21.
7. Hebbar HU, Sumana B, Raghavarao KSMS; Use of reverse micellar systems for the extraction and purification of bromelain from pineapple wastes. Bioresource Technology, 2008; 99:4896–4902.
8. Aikhonbare DV, Badmus GA; Development of a small Scale Fruit Extraction and Bottling Equipment. Journal of Nigerian Institute of Agriculturtal Engineers (NIAE), 2003; 2: 100-110.
9. Abulude FO, Elemide AO, Ogunkoya MO; Development and Performance Evaluation, of a Juice Extractor Constructed in Nigeria. Research Journal of Applied science, 2004; 2(1): 31-34.
10. Sylvester AA, Abugh A; Design and Construction of an Orange Juice Extractor Proceedings of the World Congress on Engineering, July 4 - 6, London, U.K, 2012.
11. Asemota J; Design and Construction of a Pineapple Juice Extractor, Department of Mechanical Engineering Ambrose Ali University, Ekpoma Edo State, 2007; 6-20.

12. Olaniyan AM; Development of a Small Scale Orange Juice Extractor Journal of Food Science Technology, 2010; 47(1):105-108.
13. Khurmi RS, Gupta JK;, Machine Design. Eurasia Publishing House (P) Ltd. Ram Nagar, New Delhi, 110055, 658, 2008.
14. American Society of Agricultural Engineers, ASAE; Moisture measurement forages in ASAE standard 44Ed, 1997; 62.
15. Olaniyan AM, Obajemihi OI; Design, Development and Testing of a Small Scale Mango Juice Extractor. Journal of Agricultural Science and Technology B 4, 2014; (2014): 1-7.