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Development and Performance Evaluation of a Motorized Gari Sieving Machine

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ABSTRACT

One of the most important steps in the cassava-to-gari processing chain, is the breaking into tiny particles of the de-moisturized grated white paste cassava that can easily be garified into dried gari. Lump breaking and sieving is commonly done by hand to remove ungrated and tread like cassava. A faster method of lump breaking and sieving in gari production necessitated the need for the designing of the motorized gari sieving (sifting) machine, aimed at reducing or completely eliminating all problems associated with sieving of gari. As output of the machine increased per day, promote hygiene improve the quality of gari and save time when compared with the traditional method of sieving. The machine is made of the main frame, hopper, lump breaker, sieving chamber and equipped with a 0.75 kW motor operating at 1400 rpm. The performance was evaluated and this reveals an average sieving rate of 0.033 kg/s and a mean efficiency of 78%.

Key words: Development, Evaluation, Motorized, Gari, Sieving

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a tuberous root crop grown majorly in the tropical regions of the world such as Latin America, Sub-Sahara Africa, and Asia. Its drought tolerance and ability to thrive in marginal soils has been widely acknowledged [1-4] and this endears it to most farmers. Cassava can be used in various ways and each component of cassava plant, from leave to roots can be utilized in one way or another. In some communities, the leaves are consumed as a vegetable, or used in soup as ingredient or dried and fed to livestock as protein feed supplement. It is known globally as a cheap source of calorie in human diet and animal feeds especially in Africa where it accounts for 60% of root crops consumption. Cassava is primarily a source of carbohydrate and contains very little protein or fat. The approximate composition of the cassava tuber is starch, 20-30%; protein, 2-3%; water, 75-80%; fat, 0.1%; fibre, 1.0%; ash, 1-1.5%.

Cassava can be processed into varieties of food for man among which are gari, fufu/akpu, starch, abacha, tapioca, kpokogari and lafun (cassava flour) among the rural dwellers [5]. Currently, it is fast becoming a foreign exchange earner due to its new status as a major industrial raw material for the production of wide varieties of flour-based and starch-based products such as *Lafun* (fermented flour), *gari* (flakes), High Quality Cassava Flour (HQCF), alcohol for fuel, glue, starch and so on [6-8]. Today, about 60% of cassava is used for industrial purposes while 40% is consumed by the households. As reported by [9], in Nigeria, a Federal Government directive on 10% cassava flour utilization in wheat-based baking flour has triggered a serious hike in demand for cassava. Most postharvest processing operations of cassava tubers are still being done manually.

Cassava Processing into Gari

Cassava processing into gari consists of various unit operations. Fresh cassava tubers are peeled, washed and grated. The grated pulp is put in sacks (Jute or polypropylene) and the sacks are placed under heavy stones or pressed with a hydraulic jack between wooden platforms for 3-4 days to express excess liquid from the pulp while it is fermenting. Fermentation imparts an acidic taste to the final product. The dewatered and fermented lumps of pulp are crumbled by hand and most of the fibrous matter is removed. The remaining mass is sieved with traditional sieves (made of woven splinters of cane) or iron or polyethylene mesh. After being sieved, the fine pulp is then roasted in an iron pan or earthen pot over a fire. If the sieved pulp is too wet, it takes longer time to roast resulting in a finished lumpy product with dull colour. Palm oil may be added to prevent the pulp from burning during roasting and to give a light yellow colour to the *gari*. When palm oil is not added, a white *gari* is produced. Palm oil contains substantial quantities of vitamin A; yellow *gari* is 10-30 percent more nutritious therefore more expensive than white *gari* [4-5, 10-12].

Gari is creamy-white granular flour with a slightly fermented and a sour taste made from fermented cassava tuber. It is a dry fermented and gelatinized coarse meal. It is mixed into a paste with hot or cold water and eaten with soups or stews. It is also used as snack when mixed with milk and sugar. This product can be stored for up to 2 years if kept below 12% moisture content. Gari is consumed in Nigeria, Ghana, Togo, Benin and Cameroon [13]. [14] recorded that sifting (sieving) is an essential process in the production of gari which is one of the major products of cassava in Nigeria. It is necessary to sift before and after garification to remove oversized grain fractions. It is particularly important to sift after frying to remove the bigger grains so as to make it more attractive and to increase the market value of the product.

Gari is widely known in Nigeria and other West African countries. Nigeria in African is the largest producer of cassava [15]. Its production is commonly estimated at about 49 million tons a year. Cassava plays a vital role in the world food security because of its capacity to yield under marginal soil conditions and its tolerance to drought. Cassava performs five main roles; farm reserve crop, rural food staple, cash crop for urban consumption, industrial raw materials and foreign exchange earner. Nigeria among African countries has made attempt to diversity the use of cassava as primary industrial raw material in addition to its role as livestock feed. Cassava could be transform into two principal product-flour and gari from new and traditional varieties. The newer varieties give higher yield which could be seen as the improved varieties. Mechanization allows people to process large quantities quickly before they get spoil as people in less underdeveloped and developing countries of the world rely on only traditional methods for the processing of cassava into food products [16]. In the mechanization of the cassava processing methods into gari, different machines have been developed. These machines have their different features that characterize their modes of operations, advantages and efficiencies.

Sifting (Sieving) of Gari during Processing

One of the most important steps in the cassava-to-gari processing chain, is the breaking into tiny particles of the de-moisturized grated white paste gari that can easily be garified into dried gari. Lump breaking and sieving is commonly done by hand to remove ungrated and tread like cassava. The cassava lump formed during processing is broken into smaller particles to enhance sieving. The sieving is achieved locally by placing the broken lumps on a local mesh made of raffia palms or metal and then robbed with the human palm. This is to reduce the cassava lump to the smallest possible grain sizes as well as remove the remains of the cassava roots, as well as some cassava chips which may adversely affect the quality of the gari [15], [17]. The properties of the material to be used on the sieve are very important as they are factors on their own for effective sieving operations. Such properties include the physical, mechanical and thermal properties of the material needed to be determined for a proper sieve analysis.

A faster method of lump breaking and sieving in gari production necessitated the need for the designing of the motorized gari sieving (sifting) machine, aimed at reducing or completely eliminating all problems associated with sieving of gari. With the motorized garisiever, appreciable quantities can be sieved over a short period of time resulting in an increased production [16].

Development and application of Gari Sieving Machine

The quality of gari produce and ultimately the texture of the end product depends on two prime factors namely: (1) the sieve aperture size used and (2) the garifying process, which includes heat input regulation and the manipulative skill of the operator. Considering these factors, if the sieve aperture size is too small, it not only result in the sieved cassava mash being too fine but also have a feedback effect on the operator who will exert more energy to shear and compress the mash over the sieve and at a higher time. On the other hand, if the aperture is larger than optimum, though sieving will be faster and the operator will be more at ease, the sieve may end up not eliminating unwanted particles. Evidently, an optimum sieve aperture size will be needed to marry time, operators comfort and a sieved particle that will produce an acceptable gari grain after garification [17]. [18] classified gari into extra fine grain, fine grain, coarse grain and extra coarse grain gari. And, observed that “generally, for making eba, the fine grain or coarse grain gari are usually okay and the extra coarse grain for soaking” [19].

[20] developed a cassava sieve, he carried out a performance evaluation on the machine with an efficiency of 76% and output capacity of 69.12 kg/h. Mechanized graters are needed to produce a sufficient quantity of cassava mash to meet market demands and standards. Smallholder processors therefore need to learn how to use and maintain these machines [13].

[21] fabricated a cassava lump breaker with locally available materials such as mild steel, stainless steel, and so on, but they failed to carry out a comprehensive performance evaluation in terms of the efficiency and throughput capacity on the machine. They recommended that the machine should be constructed with stainless steel materials because it prevents corrosion and allow hygienic operation.

Also, the test sieves and tests required to arrive at these grain sizes were specified. But the bulk of gari consumed in both rural and urban areas are produced by rural cassava farmers who obtain dewatered cassava mash sieves from the local craftsmen. The rural cassava farmers may have no choice but to use the sieve size seemingly imposed on them by the

local craftsmen until it is proved beyond reasonable doubt that increasing the sieve aperture to an optimum will benefit them in the cassava processing business and that gari produced will still retain its acceptable quality for making eba.
[22] D*eveloped a* motorized cassava sifter was developed and evaluated. The sifter was powered by a 3.41kW petrol engine; the overall dimension of the machine is 1117 x 1045 x 500 mm. The sifting unit is made of a shaft of 980mm x 25 mmØ. On the shaft are 16mm alternatively, arranged on the rods are bristles rubbing brushes that does the pulverization. There are also spikes in between the first two brushes, these assist in breaking the cassava mash lumps. The sieve was gauge 1.5mm thick stainless steel and concave in shape with a dimension of 800 and 400 mm respectively it is perforated in regular size of 2 mm Ø. There is a rubber seal in between the upper concave cover and the concave sieve this prevents cassava mash been sieved escaping from the sifting chamber. Test results showed that the sifter has sifting efficiency of 90% at sifting speed of 450 rpm with an output capacity of 132.78 kg/h at a moisture content of 40%. Particle sizes of the sifted mash ranged from 0.378 to 0.38 mm, while the fineness modules was 1.91.
[14] Recorded that a combine gari post grinder-sifting machine was designed, constructed and tested with the aim of easing the problem of sifting and grinding of oversized grains after the garification process. The machine consists of the hopper, sieving unit, grinding unit, electric motor mounted on a frame. The electric motor pulley drives the double groove pulley while this in turn drives the single groove pulley of the grinding machine. The double groove pulley is keyed to camshaft which runs parallel under the sieve trough. The cam is always in direct contact with the sieve trough base. Hook attachment are incorporated at mid-point of sieve trough and the frame top, this allow the fixing of extension to keep the trough in constant contact with cam during operation. From the cam the sieving unit receives the power which results in the reciprocating motion that makes the gari to fall into the chamber and pass out through the outlet.
According to [14] the test results showed that the machine has a highest sifting capacity of 28.2 kg/hr with sifting and grinding efficiencies of 85.5 and 84.0% respectively. A minimum and maximum loss of 12.8 and 27.3% of gari grains respectively were observed during the performance test. The sifting efficiency decreases with increase in loading of the machine while the grinding efficiency increase with loading. The machine could be adapted to handle other low bulk density materials such as yam flour, ground spices and other powdery products. The machine can easily be dismantled and it's operational and maintenance procedure is simple.
Mechanized sieves have been conceived and developed as a means of reducing human effort and time involved in sieving operation. [23] Developed and evaluated a motorized cassava mash sifter, which was powered by an electric motor. The machine dimension was put at 915 mm × 455 mm × 630 mm. Test result according to the report show that the sifter has efficiency of 93.3% at 26% moisture content at sifting speed of 410rpm and output capacity of 135 kg/h. [24] Developed a motorized dewatered cassava mash sifter at the National Centre for Agricultural Mechanization (NCAM) which was evaluated to determine the effects of operating speed on its sifting efficiency. Four operating speeds were chosen for the study, these are, 450, 500, 600 and 650 rpm. The machine was allowed to run, and the time required completing the sifting of 15 kg dewatered mash sample at all the tested speeds were noted and recorded. Sifting efficiency achieved was 86.5% at an operating speed of 650 rpm while the lowest efficiency achieved was at 75.5% while operating at a speed of 450 rpm and output of 200kg/h.
In the light of this, a development and performance evaluation of a motorised gari sieving machine is conceived (Add more justification to this).

MATERIALS AND METHODS

Design Considerations

In the design of this motorized sieving machine, careful consideration was given to a number of factors such as: Strength of materials for the fabrication, moisture content of the materials that is to be processed on the machine, cost of the required materials, expected life span of the design, cost of maintenance of the design and availability of replaceable parts [25-26].

Design, Materials and Components of the Sieving Machine

The materials used in the fabrication of the gari sieving machine included but not limited to; mild steel, alloy cast iron, cast aluminum and so on. Some of the major components of the designed gari sieving machine are motorized cassava lump breaking and sieving machine which consist mainly of the following components namely main frame, hopper, lump breaking pot, sieving chamber, discharge outlet, pulleys electric motor, bevel gears, shaft etc. Some of these items are described below;

i. **Main frame:** This is the main unit of the machine on which every other components of the machine are supported. It is fabricated with high strength material that will withstand vibration. Mild steel angle rod is selected. It is to be welded together to make for rigidity.
ii. **Hopper:** The hopper is a funnel shaped receptacle through which lumps of gari are fed into the breaking head through gravity. The hopper is casted solidly to the lump breaking pot cover.
iii. **Lump breaker:** This comprises of the driving shaft, spikes and spikes holder. It is designed with the use of a 20mm mild steel shaft. 10mm mild steel rod is welded on the shaft to serve as spikes that will provide the whirling effect. They are all contained in a pot casted with aluminum to prevent corrosion.

iv. **Sieving chamber**: The sieving chamber is designed with casted aluminum to prevent corrosion and subsequent rusting of the sieving chamber. It is a square trough of considerable depth to prevent spilling. It is casted and holes are drilled on it.

v. **Pulleys:** These are mechanical devices that are sued to transmit motion/power from one shaft to another. The pulley is preferred for this purpose as the velocity ratio is the inverse ratio of the diameters of the driving and driven pulleys.
The pitch diameter could be determined by the relationship: velocity ratio

$= N_N/D_R$

Where D_N = Diameter of driven pulley
D_R = Diameter of driven pulley
N_R = Rotational speed of driver shaft
N_N = Rotational speed of driven shaft

The pulley and belts are preferred to this purpose as the distance between the two pulley is short, resulting in negligible slip between pulleys, easy installation, long life, high velocity ratio, high power transmission and its ability to absorb to shock.

vi. **Electric motor:** The machine is to be driven by one horse power (1hp) or 0.75 kW electric motor, running at about 1400 rpm.

vii. **Bevel gears:** Bevel gears are used to transmit motion or power at constant ratio between two shafts whose axis intersect at an angle. The bevel gear is used to transmit power to the lump breaking shaft and the sieving chamber.

viii. **Shafts:** Shafts are rotating machine elements used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque or twisting moment set up in the shaft permits power to be transmitted to various machine parts linked to the shaft. Three shafts are used in the design the first or primary shaft is connected to the electric motor with the aid of a vee belt.
Below is a table showing the parts and materials to be used for their design and the properties of the selected materials.

The power is generated by an electric motor of 1hp (0.75kw) and is transmitted to the primary shaft by means of pulleys. A second shaft is connected on the main shaft (primary shaft) by means of bevel gears to transmit power to the lump breaking chamber. A third shaft is connected, still from the primary shaft and is used to produce an oscillatory motion in the sieve.

Power transmission

The pulley and V-belt were chosen for the transmission of power from the motor to the other moving parts. This is because this transmission system gives compactness, is easy to install with negligible slip. Most importantly, the belt and pulley produces a high velocity ratio. The diameter of the driver pulley, D_A, thickness of belt, T, input speed, N_A, output speed, N_B, diameter driver pulley, D_A, and service factor are essential parameters in power transmission calculation.

Torque

The torque for driving pulley is gotten by the relation

$$T = \frac{PX60}{2\pi N_B}$$

Where P = Designed power
N_B= Speed of driven pulley

Tension of the belt

Let x = external angle of contact of the belt
x can be estimated using the relation

$$Sinx = \frac{D_B - D_A}{2x}$$

Also, let Q = angle of lap on the smaller pulley on the motor Shaft (D_A).
This can be determined with the use of the relation

$$Q = (180° - 2x)X\frac{x}{180}$$

Bevel gears

Three shafts were used to transmit power with the aid of bevel gears.
Given that T_G = Actual of teeth on gear
T_P = Actual of teeth on pinion

$$Velocity\ ratio, V.R = \frac{T_G}{T_P}$$

Volume of Lump Breaking Pot

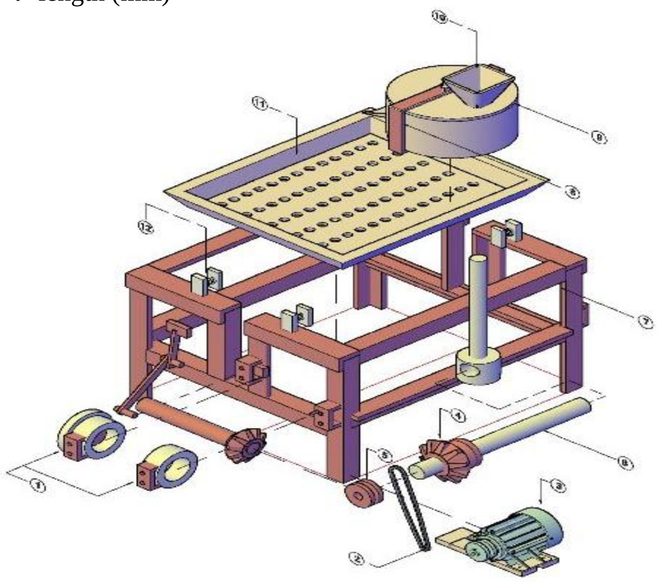
The volume of the lump breaker is given by the relation

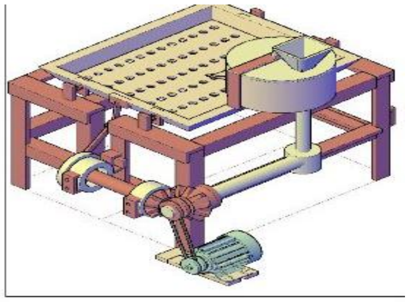
Volume of a cylinder = $\pi r^2 l$

Where

r =radius (mm)

l=length (mm)





S/N	ITEM DESCRIPTION	MATERIAL
1.	LINK	MILD STEEL
2.	V-BELT DRIVE	RUBBER
3.	ELECTRIC MOTOR	CAST IRON
4.	BEVEL GEAR	CAST IRON
5.	OPEN BELT PULLEY	CAST IRON
6.	MAIN SHAFT	STEEL
7.	FRAME	STEEL
8.	SIEVING POT HOLDER	IRON
9.	LUMP BREAKING POT	ALUMINIUM
10.	FEED HOPPER	ALUMINIUM
11.	SIEVE	ALUMINIUM
12.	RETURN SPRING	IRON

Fig. 1 The Completed Gari Sieving Machine and an Exploded Drawing

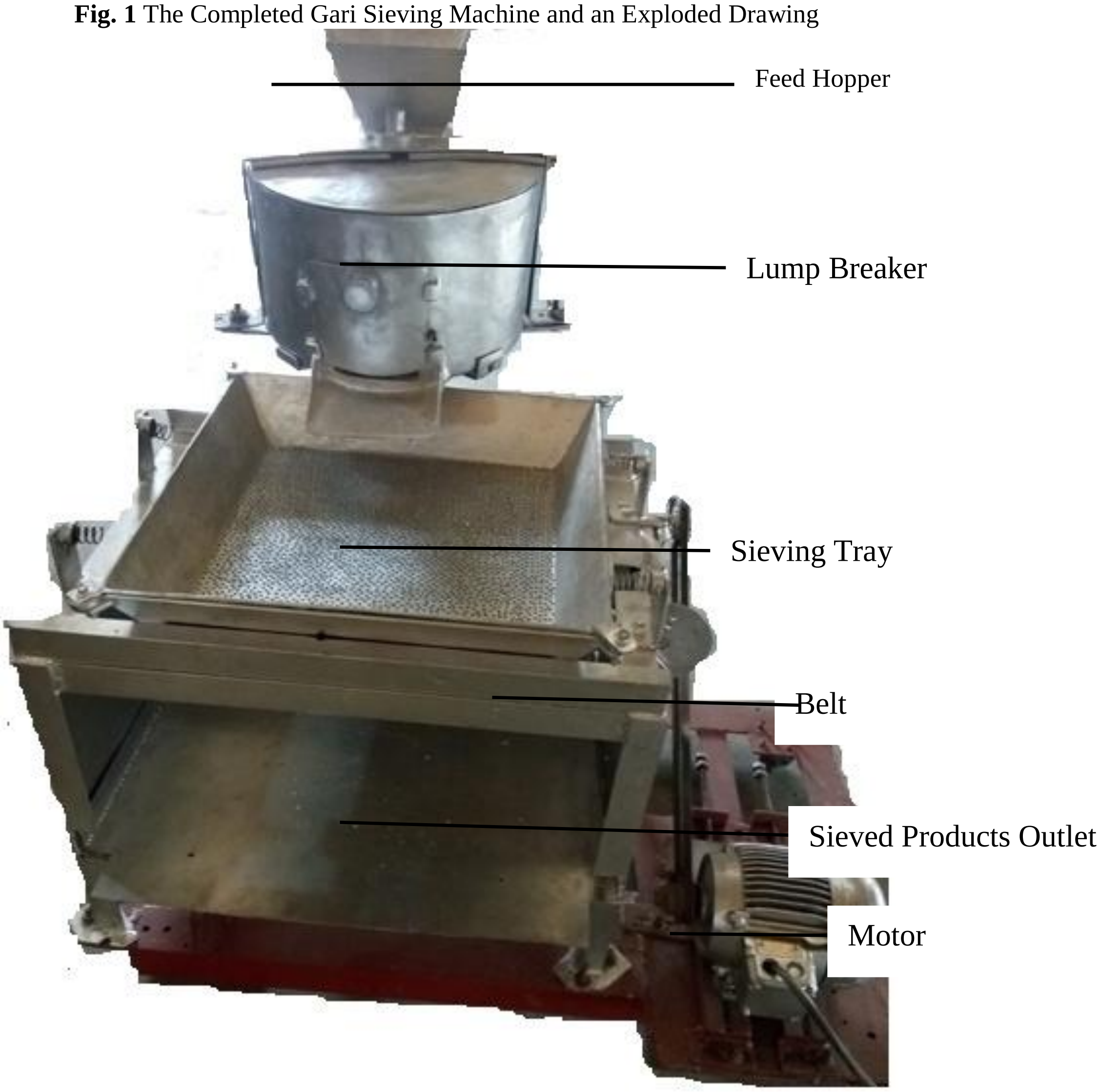


Fig. 2 The Completed Gari Sieving Machine

Fabrication of Sieving Machine

Fabrication of the designed parts of the gari sieving machine was carried out in the Mechanical Engineering Workshop of the Cross River University of Technology, Calabar.

All required parts were fabricated to sizes, welding was done accordingly using appropriate electrodes and assembly of parts was carried.

Testing of Sieving Machine

The parameters tested for included the mass of gari which could be sieved, the time for which this sieving could be done, the rate of sieving and the overall efficiency of the machine was also calculated. Although different gari sieving machines have been designed, fabricated and tested with varying efficiencies. The gari sieving machine under consideration has a unique feature of the lump breaker which was incorporated to reduce operation time and to increase its efficiency. The samples used in the testing of the machine were processed through the raw cassava to the demoisturizedgari or dried gari. Different masses of the gari were obtained as samples, 1-5 corresponding to masses;1.0kg, 1.5kg, 2.0kg, 2.5kg and 3.0kg respectively. The machine was set up appropriately with adequate power supply. Loading of the machine with the samples was executed at different intervals with their respective masses. A stop watch was used to obtain the different times taken for each sample to be completely sieved.

RESULTS AND DISCUSSION

At the end of the fabrication and assembly of the gari sieving machine, it was subjected to various tests and the results obtained are tabulated below.

Performance Test Result

Table -1 Performance Test Results of the Motorized Gari Sieving Machine.

S/N	Initial mass (kg)	Mass and residue (kg)	Mass sieved (kg)	Time (Sec)	Efficiency (%)	Sieving Rate (kg/Sec)
1	1.0	0.30	0.70	30	70	0.023
2	1.5	0.40	1.10	45	73	0.033
3	2.0	0.45	1.55	60	76	0.033
4	2.5	0.50	1.50	75	60	0.033
5	3.0	0.60	2.40	90	80	0.033

Table 1 shows the result of the different test samples according to the time taken for the sieving to be completed, the initial mass of the sample, the mass of the residue or the unsieved materials and the sieving rate of the machine at each given sample. The average values of the above parameters were calculated as also shown. Summary of the tested samples on average basis shows that2.0kg of gari sieved left a residue of 0.4kg. This indicated that 1.45kg of the sample was completely sieved out of the 2.0kg average mass. The average time taken for the sieving of the 2.0kg of the gari was 60 seconds which means that, the sieving rate of the machine is 0.033kg/s. This also implies that, the efficiency of the machine is about 78%. This efficiency compares favourably with other gari sieving machines designed and fabricated by different authors such as [3, 22-23, 27-28].

CONCLUSION

The design, fabrication and performance evaluation of a motorized gari sieving machine was carried out. This work was successfully executed with new features added, such as lumps breaker, aluminum sieving chamber to prevent corrosion and rusting, guardson running parts incorporated to ensure the safety of the operator and improve machine life and the use of link in place of Cams and Followers. The test result shows an overall efficiency of 78%.

REFERENCES

[1]. El-Sharkawy, A. M. International Research on Cassava Photosynthesis, Productivity, Eco-physiology and Responses to Environmental Stresses in the Tropics. Photosynthetica, **2006**, 44 (4): 481-512.

[2]. Kolawole, O. P. and Agbetoye, L. A. S. Engineering Research to Improve Cassava Processing Technology. International Journal of Food Engineering, **2007**, Vol. 3 issue 6 Article 9: 1- 15.

[3]. Uthman, F. Design and fabrication of cassava lump breaking and sieving machine, **2011**, Pg: 42-50.

[4]. Julianti, E., Lubis, Z., Ridwansyah, Yusraini, E. and Suhaidi, I. Physicochemical and Functional Properties of Fermented Starch from Four Cassava Varieties. Asian Journal of Agricultural Research, **2011**, 5: 292-299.

[5]. IITA, The uses of Cassava. Published by the Integrated Cassava Project of the International Institute of Tropical Agriculture, Ibadan, Nigeria, **2005**, pp 87, 98, 95.

[6]. Agbetoye, L. A. S. Engineering Challenges in Developing Indigenous Machinery for Cassava Production and Processing. Proceedings of Nigeria Society of Engineers Conference and Annual General Meeting, **2003**, pp 80-86.

[7]. Agbetoye, L. A. S. Improving the Technology of Cassava Harvesting and Processing Mechanisation for Food Security in Nigeria. Proceedings of the International Conference on Science and Technology. Federal University of Technology, Akure, Nigeria, **2005**, pp. 196 – 205.

[8]. Kolawole, O. P., Agbetoye, L. A. S. and Ogunlowo, A. S. Sustaining World Food Security with Improved Cassava Processing Technologies: The Nigerian Experience. Sustainability, **2010**, 2: 3681- 3694.

[9]. Oriola, K. O. and RAJI, A. O. Frictional Properties of the Roots of Three Cassava Cultivars. Journal of Agricultural Engineering and Technology (JAET), **2017**, Vol. 23 (No. 2), pp. 37-47.

[10]. Olawoye, J. E. Rural Women Role in Oyo State Nigeria. Journal of Rural Sociology, **1992**, Vol. 2 No. 1 (in press).

[11]. Onabolu, A. Cassava Processing, Consumption and Dietary Cyanide Exposure. IHCAR, Karohnska Institute, Sweden, **2001**.

[12]. Oluwole, O. B., Olatunji, O. O. and Odunfa, S. A. A process technology for conversion of dried cassava chips into gari. Nig Food J, **2004**, pg: 65-73.

[13]. FAO, Food and Agriculture Organization of the United Nation, **2000**.

[14]. Adejumo, B. A. and Ola, F. A. Development of a Combined Gari Post Grinder Sifting Machine. Journal of Agricultural Engineering and Technology (JAET), **2010**, Vol. 18 (No. 2), pp. 77-86.

[15]. Olufemi, L. O. Revitalizing Ogun State Agriculture Publication no.3 ISBN 978-2941-77-3 printed by Afrographic Nigeria Ltd Ibadan GAri production, **2003**, pg. 103-105.

[16]. Simolowo, O. E. Developing Archetypal Machines for a Sequence of Food- Slurry Processing Operations: An Overview, African Journal Online (AJOL), **2011**, vol 5, No 5. Available from https://www.ajol.info/index.php/afrrev/article/view/72299. [Assessed: 17th June, 2018].

[17]. Adzimah, S. K and Gbadam, E. K. Modification of the designs of cassava grating and cassava dough pressing machines into a single automated unit. European J Sci. Res, **2009**, 38(2):306-314.

[18]. ARSO, African Organisation for Standardization, ARS 854, Gari- Specification, **2012**.

[19]. Bounds, R. B. Extension of Shelf Life of Gari by Hygiene handling, **1993**, www.academicjournals/org/ajb, [Assessed: 5th January, 2018].

[20]. Orojinmi, M. A. Development of cassava siever. Unpublished HND project Agricultural Engineering Department, Kwara State Polytechnic, Ilorin, **1997**.

[21]. Sulaiman, M. A. and Adigun, R. A. Fabrication of cassava lump breaker. Unpublished project report submitted to the Department of Mechanical Engineering, Kwara State Polytechnic, Ilorin, **2008**.

[22]. Samaila, S. R., Ogunjirin, O. A. andOlowonibi, M. M. Development and Performance Evaluation of Motorized Cassava Mash Sifter. Journal of Agricultural Engineering and Technology (JAET), **2010**, Vol. 18 (No. 2), pp. 46-54.

[23]. Kudabo, E. A, Onipede, E. A, Adegbenro, O. A. Design, fabrication and performance evaluation of an improved cassava mash sifter. J Agric. Vet Sci, **2012**, pg: 53-64.

[24]. Jackson, B. and Oladipo, A. Evaluating sifting efficiency of a dewatered cassava mash sifter at different operating speed. Afr. J. Agric Res, **2013**, 8(23):2819-2824.

[25]. Gupta, J. K. and Khurmi, R. S. Machine Design 13th Edition, Metric Edition, **2000**.

[26]. Jame, P. M. Theory of sieving analysis, principles, methods and application of particle size analysis. Cambridge University Press, New York, **2007**.

[27]. Ndaliman, M. B. Design and construction of a pedal operated cassava grander unpublished manuscript, **2006**.

[28]. Alabi, I. O. Design, Fabrication and Performance Evaluation of Motorized Cassava Lumps Breaker. Unpublished HND Project, Agricultural Engineering Department, Kwara State Polytechnic, Ilorin, **2009**.