Journal of Agriculture and Veterinary Sciences **Volume 4, March 2012**

www.cenresinpub.org
ISSN 2277-0062

DESIGN, FABRICATION AND PERFOMANCE EVALUATION OF AN IMPROVED CASSAVA MASH SIFTER

Kudabo, E.A; Onipede, E.A and Adegbenro, O. A
Department of Agricultural Engineering and Water Resources
Kwara State Polytechnic, Ilorin

ABSTRACT

A Motorized Cassava Mash Sifter was developed and evaluated. The Sifter is powered by an electric motor; the dimension of the machine is 915mm × 455mm × 630mm.Test results show that the sifter has the highest efficiency of 93.3% at 26% moisture content at the sifting speed of 410rpm. Output Capacity of 136.2kg/hr was obtained and this increase as the Feed rate increases at 26% moisture content .Analysis of Variance for the Sifting Efficiency was computed and the result reveals that the speed and interaction of speed x federate and speed x federate x moisture content are significant at 5% probability. The machine is affordable and adequately manageable therefore recommended for the small scale Cassava Processor.
Key words: Mash, Sifter, Sifting Efficiency, Cassava and Fabrication

INTRODUCTION

In the past, maize was Africa's most important food crop, however, maize production in Africa is risky due to unpredictable rainfall, and it is not financially feasible to depend on irrigation. For this reason and perceived others, cassava (*Manihot Esculeta, Crantz*) became the most important food crop in Africa. (IITA, 1989). Cassava as a food crop could play a vital role in the food security of the world because of its capacity to yield under marginal soil conditions and its tolerance to drought.

Origin of Cassava

The crop originated in South America, where its tubers have been used throughout the ages as a basic food; from there it spread to other regions of the world. It is now the most widely cultivated crop in Africa and is grown by small holder farmers, who depend on seasonal rainfall. Cassava is typically grown by small scale farmers using traditional methods, and often on land that is not suitable for other crops. It is a major food crop in Nigeria (Kim, 2009). It supplies about 70% of the daily calorie of over 50million people (Agbetoye, 1999) and about 500million people in the world. Some cassava varieties show high resistance to drought and mosaic disease, high yield, even in agro ecological conditions where other starch bearing crops do not thrive. The prevailing climate change, the threatening global warming and the expected negative impact on the yield of less hardy crops highlight further advantages of cassava as the crop of the century. Traditionally, cassava was cultivated by farmer at subsistence levels as the "**poor man's food**". Currently, semi-commercial and commercial farmers are available due to increasing awareness and proof of functional versatility of cassava flour especially in the food manufacturing sector (Ernersto et. al., 1999; Cardoso et al., 2000; FAO, 2002). It is produced into gari, lafun, tapioca kokote, fufu and ackhe.

World production of cassava root was estimated to be 184 million metric tons in 2002. The majority production was in Africa, where 99.1 million metric tons were grown, while 51.5 million metric tons were grown in Asia and 33.2 million metric tons in Latin America and the Caribbean. Nigeria has doubled the production of other major producers of cassava such as Thailand and Indonesia since 1990, and the country has surpassed the Brazil as the world's leading producer of cassava. The total area of cassava crop harvested in 2001 was 3.1 million hectare with an average yield of about 11t/hectare. The rapid adoption of tropical manioc selection (TMS) improved cassava varieties and the presence of the International Institute of Tropical Agriculture (IITA) in Ibadan has assisted Nigerians position as a leader in cassava production. (Peter et al., 2010) Dewatering of cassava mash is a difficult operation and occurs after the peeling operation, fermentation and pressing (dewatering) are done in one operation. The duration of this fermentation affect the colour, taste and texture of the gari. After fermentation is complete, the mash is pressed to reduce the water content and the cyanide acids. The traditional method of dewatering grated cassava mash involves tying and twisting the neck of a Hessian sack over which heavy stone are placed for one or two days.

At village level, gari is fried in shallow cast iron pans after sieving with raffia mat. The sieved cassava mash is spread thinly in the pan in 2 to 3kg batches. A piece of calabash is often used in stirring the gari on the hot surface of the pan to prevent it burning until the frying is completed. Gari frying is complex procedure which depends on the skill of the operator. The in ability to control the temperature of frying, exposure of the operator to heat and smoke from the fire, and steam from the wet cassava mash have been major setback in the traditional frying of gari. The fried gari is finally spread on a mat or polythene to cool before packaging (Peter et al., 2010)

Constraints to Cassava processing

Constraints to cassava processing include the absence of efficient equipment; appropriate processing technologies, machines, and tools. These are not easily affordable and sometimes unavailable at the farm level. The currently available ones were merely fabricated without adequate engineering research. Presently, the equipment available is the grater, dryer and dewatering machines. Some success was recorded with graters and some dewatering tools. The dewatering tools work in batches while factories need a continuously working machine for better production. Sifting/ sieving is one of the greatest constraint and a key process for making cassava processing to gari, because large percentage of grated cassava are still been sifted manually using local sieve made from plant materials, which is often called "raffia sieve". Making cassava production competitive both at the domestic level and for export to world market requires wide research and investment into processing machine design and development, among others. Improved processing, storage and packaging technologies to extend shelf life will go a long way towards helping the world to maintain food securities; this would contributes to increasing cassava root availability and reliability, which can provide self, sufficiency and also allow export to areas of the world where food is not available (Peter et al., 2010).

The Need for the Modification of Cassava Mash Sifter

The method of operation of existing motorized cassava mash sifter is realized to be inefficient enough because it is also time consuming and laborious due to its recommendation just as the traditional method of sifting the cassava mash which is usually done manually. In other to solve this problem, the need thus, arises to modify the motorized cassava mash sifter that would not only remove the drudgery associated but also increases the output per hour to meet up with the high demand of cassava and its product by making provision for the outlet of the unsifted materials providing cover for the hopper to reduce the amount of spilled cassava lump while the machine is working so as to increase the throughput capacity and efficiency.

Objectives of the research work

The objectives of the research work are as follows:

i. To design and fabricate a modified cassava mash sifter
ii. To carry out the performance evaluation of the modified cassava mash sifter in terms of the efficiency, throughput capacity by varying moisture content, speed and feed rate.

LITERATURE REVIEW

According to Peter, et.al. (2010) sifting of gari is one of the major problems of gari processing over the years, demanding urgent solution. In 1980, cassava production was relatively steady with highest production of 33million tons till early 90's when the production rose to about 87million tons. Sifting involves the separation of the coarse particles i.e. ungrated portion of cassava lumps from the fine and smoother ones (NCRI, 2006).After the moisture content of the mash or pulp has been reduced to about 35 to 40% in the process of dewatering, it is then sieved. To determine the moisture content, a small lump of the pulp is taken and squeezed between the palm, if it is sufficiently dewatered, it will disintegrate i.e. break into smaller particles easily. Put the dry pulp into a sieve and sift it to remove the unwanted thrash. Sieving operation in Nigeria is done mainly with the traditional method by peasant farmers. (IITA, 1989). An improve process of making gari is describe by Nessrs Levis and in Research Report No. 2, Federal Institute of Industrial Research, 1985. However it was felt that a number of technical and mechanical improvements could be adopted which would make gari processing more efficient and save considerably factory space requirement. The processes include peeling, grating, pressing/fermenting, granulating/separating and frying.

Pulverization of pressed mash and sieving of dewatered mash or lumps is necessary to achieve efficient heat transfer during frying process (OAU, 1998). Ife Research Group (1998) reported that in Osun and Ondo state, manual sieving method is still dominated (84.5%) and (15.4%) processors used the machine and of these, 66.7% utilize the grater, while the remaining 33.3% used the mechanical shaker. They also reported that the mechanical shaker is unreliable while some processors sieve after using the grater, this is because the grater does not remove the fiber but only achieves further size reduction (Research Institute OAU, 1998).

The raffia sieve on the other hand has a major drawback in the sieving position because it require bending and stretching which result in aches and pains in the back and sometimes may injure the person carrying out the sieving operation (Olufemi, 2003). Granulating and separating are the process involve in the sieving action of gari. In local practice, this is done by rubbing the pressed fermented pulp through homemade sieve which separates most of the fiber and ungrated lumps to give a coarse grain moist mass. The use of aluminum sieving plate with circular perforation and brushes instead of raffia sieves and hand respectively. [FAO, 1992]. He also suggested investigations of gang or method for additional granulation.

Pulp Sieving / Sifting

After pressing, the dewatered cassava mash is a solid cake, which has to be broken up and sieved to remove the large lumps and fiber and to obtain homogenous product. To know this moisture content, squeeze it in the folds of palm if it is sufficiently dewatered, it will disintegrate (IITA, 1990). Uniform particle size is important because it makes for a more uniform roasting of individual particles during the frying operation. Indeed, smaller particles takes less time and energy to roast, sieving the final product of gari ensures uniformity of the product. Gari is first sifted after dewatering in other to remove the fiber (ungrated cassava pieces).

A flow chart depicting the improved gari processing method as provided by IITA, 1990 is shown in figure 1.

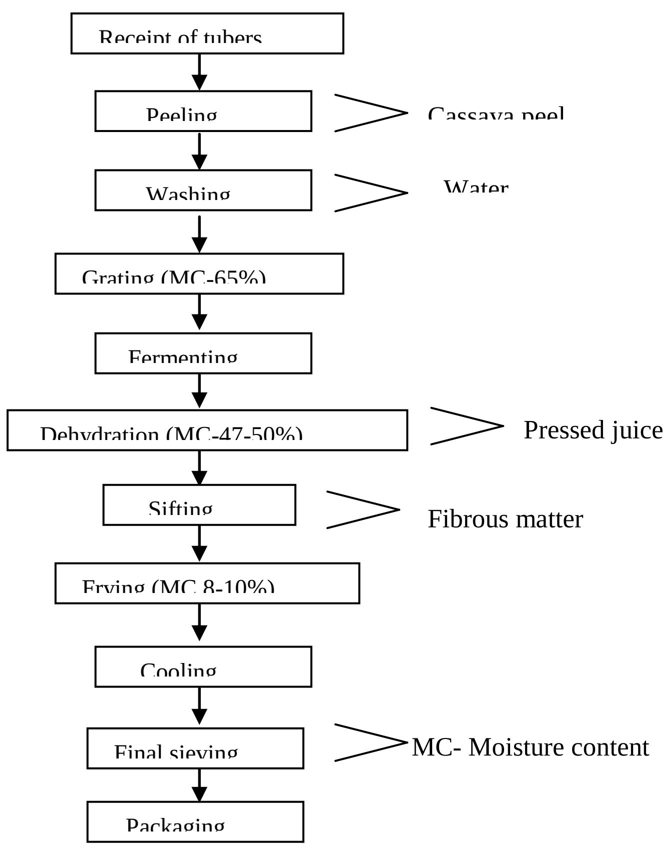


Fig 1.0: ***Flow Chart of gari Processing.***
Source: **IITA *(1990).***

Design Concept of the Existing Cassava Sifting Machine

The machine was design based on the concept that sifting is by rubbing the cassava mash on the two surfaces (the pulverizing unit and the sifting unit). According to shama (1991), sieving was defined as a process which depends primarily on physical forces to accomplish the desired separation of components and they are quite commonly used in most phases of food industries. He stated further that the process of sieving is usually referred to as mechanical separation. Ishola (1992) mentioned that to achieve a perfect sieving process, the properties of the material have to be borne in mind as they are factors on their own for effective sieving operation. These are the physical, mechanical and thermal properties of the materials to be sieved and they are particle size, weight, length, surface texture, affinity for liquid e.t.c and these must be determined for proper sieve analysis. These properties also help in choosing of appropriate sieving processes for different materials to be used in the construction of sieving machine and the determination of sieve size.

Therefore the design of the covering drum is such that there is decreasing gap between the brushes and the covering drum with maximum clearance at the top. This allows the mash fed into the hopper flow down through the spikes inside the hopper, then it will; be pulverized after leaving the hopper, it will enter into the circular net system covered by the covering drum, through the space in between the alternatively arranged brushes, the solid cake are broken down by the rods, and this is further rubbed on the sieve by brushes and the grated one will be passing through the outlet collecting trough. Cassava fibers and part of cassava root that were not properly grated will be collected through the residue collection trough.

Review of Existing Cassava Mash Sifter

Sulaimon and Adigun (2008) fabricated a cassava lump breaker with locally available materials such as mild steel, stainless steel, e.t.c 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. Orojinmi (1997), developed a cassava siever, he carried out a performance evaluation on the machine with an efficiency of 76% and output capacity of 69.12kg/hr. he suggested that the machine can be improved upon so as to increase the efficiency and capacity, to lessen the hectic aspect of the sieving operation. Alabi , (2009) also developed a motorized cassava lump breaker and sifting machine but recommended that an outlet provision should be made for unsifted materials, cover for the hopper, and also a cover should be made for the pulley and electric motor for the protection of the operator.

METHODOLOGY

Design Concept of the Cassava Mash Sifter

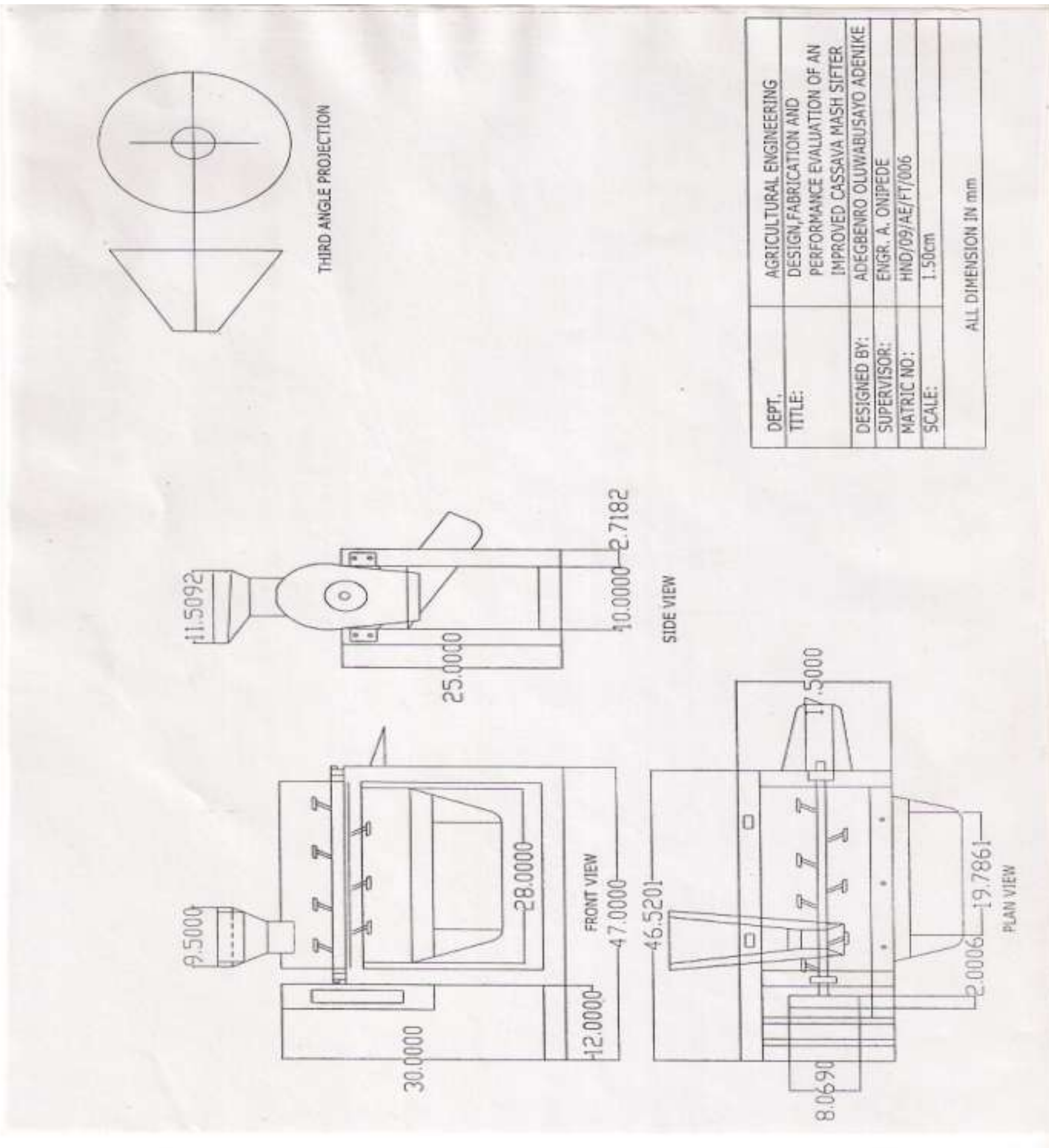
The machine was designed based on the concept that sifting is by rubbing the cassava mash on two surfaces (The sifting unit and the sieve).The design of the concave canopy is such that there is decreasing gap exist between the brushes and the concave canopy with a maximum clearance of 75mm at the top. This allows the mash fed into the hopper flows down the sifting chamber. The clearance decrease as the sifting unit moves to the concave canopy (angle Ø=0). It then increases gradually to a clearance of 1.5mm at the bottom where the sifting unit (brushes) rub the mash against the sieves thus, effecting sifting. The particles of sifted mash that are of the same sizes as the sieve passes through while the bigger ones which are the ungrated cassava root parts and fibers are retained and conveyed to the residue collecting trough by the sifting unit which also serves as auger. The orthographic projection is presented in Figure 1.

Mash Sifter Under Construction

Figure 2 and 3 shows

Fig.2: Front View/Elevation

Fig.3: Side View/Elevation


THIRD ANGLE PROJECTION
DEPT.
AGRICULTURAL ENGINEERING
TITLE:
DESIGN,FABRICATION AND PERFORMANCE EVALUATION OF AN IMPROVED CASSAVA MASH SIFTER
DESIGNED BY:
ADEGBENRO OLUWABUSAYO ADENIKE
SUPERVISOR:
ENGR. A. ONIPEDE
MATRIC NO:
HND/09/AE/FT/006
SCALE:
1.50cm
ALL DIMENSION IN mm
11.5092
2.7182
10.0000
25.0000
SIDE VIEW
9.5000
28.0000
FRONT VIEW
47.0000
12.0000
30.0000
17.5000
46.5201
19.7861
2.0006
8.0690
PLAN VIEW

Assembling Procedure of the Machine

The material are welded together to form a frame. The welding of the frame's joint is done intermittently to ensure firmness of the welded materials. The sieve housing {concave canopy} was formed by the frame and the sieve was placed inside it. The shaft is made to pass through the spikes; the shaft is then made to pass through the bearing placed in the bearing housing. The scrubbing brushes are then bolted to the shaft. The assembly of the frame, housing, breaking chambers and residue outlet is the last step; the housing, breaking compartment and the residue outlet are placed in the frame. At this point too, the collection base is placed at front of the machine below the frame. All these are bolted to the frame firmly. The concave canopy is placed and bolted, the second bearing and the bearing housing are placed on the concave, the upper parts of the frame are bolted together and the pulley is put and tightened to the upper part of the shaft end.

The machine is then ready to be used. Fig. 4 is the complete assemble of the Machine.

Fig. 4: Complete assemble of the Mash Sifter.

Test Procedure

Preparation of Test Materials

Cassava tubers were bought from a local market in Ilorin, Kwara State. The tubers were peeled, washed, grated, fermented and dehydrated. The Motorized Cassava Mash Sifter was tested at speeds between 410,540 and 595rpm. 1, 2 and 3kg of cassava mash was weighed in three replications and the moisture content was determined before the test. After sifting, sample of sifted mash that is fried was used to determine its fines modulus using Tyler sieves analysis method. The throughput capacity, output capacity and the sifting efficiency were also calculated. The sifting efficiency was then tabulated in a Factorial Experimental Plot Design and its ANOVA table was computed.

Determination of the Optimum Speed required for sieving at high efficiency

The Machine was tested at operating of 410, 540 and 595rpm respectively using cassava mash samples of 26, 30 and 35% moisture content. At speed 410rpm and 26% M.C, the machine has the highest output capacity of 136.2kg/hr with sifting efficiency of 93.3%. As the speed of the sifter increases the output capacity decreases. It implies that some of the mash that were supposed to be sifted has been conveyed along with the residue because the operating speed was too high for the sifting unit to adequately sift the cassava mash, thus, leading to decrease in quantity of the cassava mash sifted.

Determination of Output Capacity(kg/hr)

$$Q_C = \frac{W_C}{T} \ldots\ldots\ldots\ldots\ldots\ldots eqn.1$$

Where:

Q_c = Output capacity (kg/hr)
Wc = Weight of the sifted mass (hr)
T = Time of sifting (T)

Determination of Sifting Efficiency

$$EF(\%) = \frac{W_2}{W_1} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots eqn..2$$

Where:

Ef = Sifting efficiency (%)
W_2 = Weight of the sifted mash (Kg)
W_1 = Initial weight of the cassava mash (Kg)

Determination of the Moisture Content

The grated pressed cassava was divided into three at the same M.C. A portion was oven dried, another was sun dried, while the last portion was used as another moisture content level. A probe was used to test their M.C, the results are as follows; 26%, 30%, and 35% respectively.

RESULT

Result of the Sifting Efficiency

Result of the sifting efficiency is presented in the Table 1 below with three speeds under three moisture contents and Three Feed rate levels in a factorial experimental plot design with the feed rate as the main plot, moisture content as sub plot and speed as sub plot factors with the replications.

DISCUSSION

Cassava Mash Sifter Efficiency Parameters were the Speed, Feed rate, and Moisture Content, the result of Variance Analyses on the parameters are presented in the table 4. It can be seen that, the highest output that was determined at the 1st Feed rate at 1st Moisture Content and 1st Speed was 136kg/hr. Table 2 present the analysis of variance table for the sifting efficiency and it revealed that there was no significance difference in replication and feed rate but was notice in the treatment and speed. The interaction between feed rate and speed was used; it was significant at both 5% and 1% probability level. Furthermore, the interaction between feed rate and moisture content was not significant. There exist significant different between speed and moisture content at both 5% and 1% probability level, the result also shows that the interactions between feed rate, moisture content, and speed was only significant at 1% probability level.

Table 1: Data of Sifting Efficiency of the Cassava Mash Sifter (x100)

		Speed {410}			Speed {540}			Speed {595}		
		Rep1	Rep2	Rep3	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3
1kg	26	0.83	0.72	0.71	0.70	0.70	0.70	0.69	0.68	0.69
	30	0.60	0.60	0.58	0.67	0.66	0.62	0.52	0.50	0.52
	35	0.54	0.53	0.54	0.52	0.50	0.51	0.50	0.49	0.50
2kg	26	1.80	1.80	1.79	1.74	1.72	1.71	1.70	1.68	1.68
	30	1.67	1.67	1.65	1.60	1.58	1.58	1.40	1.38	1.36
	35	1.21	1.20	1.20	1.20	1.18	1.16	1.18	1.15	1.15
3kg	26	2.80	2.79	2.78	2.60	2.56	2.57	2.55	2.50	2.51
	30	2.70	2.69	2.70	2.40	2.35	2 38	2.30	2.28	2.25
	35	2.20	2.20	2.18	2.18	2.15	2.14	2.00	2.00	1.98

Table 2: Analysis of Variance for Sifting Efficiency of the Cassava Sifter.

Source of Variation	Degree of Freedom	Sum of square	Mean Square	Computed F	Tabular F	
					5%	1%
Replication	2	0.0228	0.0114	0.0073^{ns}	3.40	5.61
Treatment	2	13.4456	6.7228	4.3222^{*}	3.40	5.61
Error {a}	24	37.3298	1.5554			
Feed rate {A}	2	176.56	88.28	0.0085^{ns}	3.37	5.53
Speed {B}	2	271060.43	135530.22	13.045^{**}	3.37	5.53
Moisture.{C}	2	752.44	376.22	0.0362^{ns}	3.37	5.53
A × B	4	271224	67806	6.53^{**}	2.74	4.14
A × C	4	915.55	228.9	0.02^{ns}	2.74	4.14
B × C	4	271799	67949.75	6.54^{**}	2.74	4.14
A × B × C	8	271976	33997	3.27^{*}	2.32	3.29
Error {b}	26	27013.43	10389.67			
Total	80	50.7982	0.63497			

Acv = 8.31% ***ns = not significant*** ***** = significant at 5% level***
Bcv = 8.66% **** = significant at 1% level***

CONCLUSION

A machine suitable for the breaking and sieving of cassava lumps for the purpose of processing the cassava into gari was designed and fabricated. This machine was aimed at improving on the traditional methods of sieving grated dehydrated cassava. The motorized cassava sifted was observed to perform efficiently at all the sifting speed when compared with local sifter. However, the highest sifting efficiency of 93% was obtained at sifting speed of 410rpm and at moisture content of 26%.The values of the output capacity obtained were very high which means more of the cassava mash being sifted is recovered. The motorized sifter is therefore considered appropriate for small and medium scale farmers that may want to go into gari processing.

RECOMMENDATION

The fabrication of the cassava mash sifter can be further improved and modify to increase its efficiency and output capacity by;

- Making a rubber seal in-between the edge of the concave cover and the sifting chamber,
- The receiving outlets should be folded to help gather the sifted materials effectively.

REFERENCES

Agbetoye,L. A. S. (1999): Development in Cassava Harvesting Mechanization. West Indian J. Eng. 1999, 22, 11-19

Alabi, I.O, (2009): Design, Fabrication and Performance Evaluation of Motorized Cassava Lumps Breaker. Unpublished HND Project, Agricultural Engineering Department, Kwara State Polytechnic. Ilorin

Ernesto, M., Cardoso, A.P, Cliff, J, Bradbury,J.H,(2009): Cyanogenic Potential of Cassava Flour; field trial. Food Sci. Nutr., 49: 93-99

Food and Agricultural Organization (FAO)(1992): Development of the Cassava Processing Industry, report by N0 1529 by Mole Th.Zwankhuizee,

International Institute of Tropical Agriculture, (1990): Cassava in Tropical Africa. A Reference Manual pp.90-93, 95-97 and p. 100 International Institute of Tropical Agriculture, 1991: The Fourteenth Package of Recommendation for Food Crops and Livestock Production in south-western Nigeria pp.37-42

Ishola, T.O,(1992): The Basis of Separation of Particles(Research work) Unpublished HND Thesis,Civil Engineering Department, Kwara State, Polytechnic, Ilorin

Kim,H.S, (2009): Cassava;Gabon seeks Nigerias help;http://cassava mews/blogspot.com/2009/cassava.Gabon.seek.Nigerias.help.html

NCRI, (2006). Cassava processing publication National cereal research institute. Research briefs June 2006. Pg.10

OAU, (1998). Post harvest technology research group, (1998). Capacity and Agroprocessing technology needs of women in Osun and Ondo State, survey report conducted for the UNDP under the WID/NIA program by the PHTRG, Obafemi Awolowo University Ile-Ife.

Olufemi L. O., (2004). Revitalizing Ogun State Agriculture Publication no.3 ISBN 978-2941-77-3 printed by Afrographic Nigeria Ltd Ibadan GAri production pg 103-105.

Orojinmi M.A. (1997). Development of cassava siever. Unpublished HND project Agricultural Engineering Department Kwara State Polytechnic Ilorin.

Peter O. K., Leo A., Simeon O.A., (2010). Sustaining world food security with improved cassava processing technology: the Nigeria experience sustainability 2010, 2. 3683-3694; doi:10.3390/su2123681.

Shama A.P. (1991). Machines for cleaning and grading Agricultural produce,vol. 28, no. 2, journals of Agricultural Engineering research pg 39.

Sulaiman M.A. and Adigun R.A, (2008). Fabrication of cassava lump breaker. Unpublished project report submitted to the department of Mechanical Engineering Kwara State Polytechnic Ilorin.