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Evaluating sifting efficiency of a dewatered cassava mash sifter at different operating speed

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Amotorized dewatered cassava mash sifter developed at the National Centre for Agricultural Mechanization (NCAM) 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. Statistical analysis of variances showed that the speed had significant effect on the sifting efficiency of the sifter at 5% significant level. The highest 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. Increasing operating speed increases the sifting efficiency of the machine.

Key words: Sifting, efficiency, dewatered cassava mash, sifter, speed.

INTRODUCTION

Cassava (*Manihot esculenta*) is a woody shrub of the *Euphorbiaceae* spurge family. It is a native of South America and extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous root as a major source of carbohydrates. Claude and Denis (1990) reported that, cassava is the third largest source of carbohydrates for humans.

Hahn and Keyser (1985) reported that, Cassava is one major root crop grown in many countries of the humid regions and that it is a good source of calorie in the tropical regions of the world. World consumption of cassava for food (fresh or processed) is concentrated in the developing countries where more than 70% of the root produced is used as food. The most popular from to which cassava root is processed and consumed is known as Gari. FAO (1992) describes Garias as a dry finely granulated product prepared from partially fermented cassava root, and reported its popularity in West Africa, Asia, Latin America, and Brazil as the second most important staple after rice.

Cassava processing into the various products is strenuous and time consuming which gives credence to the call by Odigboh (1985) that, attention should be given to the development of appropriate processing equipment for the various unit operations in cassava processing, so as to minimize the level of drudgery, improve processing hygiene and ensure the wholesomeness of the processed cassava products. Dewatered cassava mash sifting has been one of the main problems associated with the processing of cassava into a storable form in order to safeguard economic waste and to ensure its availability as a food product.

Various designs of dewatered cassava mash sifter have been made e.g. Sulaiman and Adigun (2008) fabricated a cassava lump breaker with locally available materials but failed to carry out its evaluation, Alabi (2009) also developed a motorized cassava lump breaker and sifting machine while Kudabo et al. (2012) designed, fabricated and evaluated a cassava mash sifter.

According to Jackson (2011), it takes about 3 men an

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Figure 1. Pictorial view of the motorized sifter.

Figure 2. Arrangement of sifting brushes inside the sifter.

hour to sift 1 kg of dewatered cassava mash using the traditional methods as an operation that will be efficiently carried out in 1 min using the mechanical sifter. Sifting is a very important process in the production of garri as it ensures the wholesomeness and homogeneity of the finished product, it reduces the energy required during the frying process. Peter et al. (2010) reported that, dewatering of cassava mash as a difficult operation which occurs after the peeling operation, however during gari processing operations carried out by National Centre for Agricultural Mechanization (NCAM) (2013), it recorded sifting to have the highest operating time after peeling in granulated cassava processing operation.

Sifting is the next and most time consuming stage in gari production, attempts to mechanize this production stage deserves careful study. Hence the need to investigate the effects of the operating speeds on the sifting efficiency of the sifter'.

Description of the sifter

The motorized cassava mash sifter, is made up of a hopper, sifting chamber cover, sift and residue outlet chutes and is powered by a prime mover. Figure 1 presents the pictorial view of the sifter, while Figure 2 shows the arrangement of the sifting brushes in the sifting chamber. In Figure 3 the brushes, the shaft carrying the brushes in the sifting chamber, the sift outlet the chaff outlets and the material flow from the hopper to the delivery chute in the sift outlets and the chaff outlets are clearly shown.

The hopper is, positioned at the top of a circular drum housing the sifting chamber. Passing through the drum is a shaft caring the sifting brushes which is arranged spirally on the shaft. Below the sifting chamber are a sieve and the grain outlet. At one end of the sifter is the pulley assembly; while at the other end is the fiber outlet. The sifter rest on a rectangular frame made of angle iron, 16 mm and is driven by an internal combustion engine.

METHODOLOGY

Experiments to study the effects of operating speeds, on the sifting efficiency of a dewatered cassava mash sifter, was carried out at the Engineering Scientific Service (ESS) Department, of the NCAM, Idofian, Kwara State, Nigeria using an existing mechanical sifter.

Freshly harvested cassava roots were obtained from the research farm of the NCAM, Idofian, Kwara State and were processed according to methods reported by IITA (1990). The root was dewatered to moisture content of between 46 and 50%$_{wb}$ as reported by Akande et al. (2004). Moisture content determination was carried out using the oven drying method. The moisture content is calculated using the equation below;

$$M_{wb} = \frac{W_m}{W_m + W_d} \times 100$$

Where, M_{wb} = Moisture content wet basis. W_d = Weight of bone dry material. W_m = Weight of moisture. Source: AOAC (2000).

The optimum sifting time was obtained by running the machine at the different speeds and allowing the sifting operation to be carried out on the 15 kg of dewatered cassava mash sample.

The machine was allowed to run, and the time required to completely sift the fed mass of sample at all the tested speeds was chosen as the approximate sifting time to be used in the experiment. Operating speed was selected based on findings from preliminary investigations and test was carried out on the sifter. For this experiment, speeds selected were, 450, 500, 600 and 650 rpm

Approximate sifting time arrived at after the preliminary testing of the sifter was 5 min which was adopted for the experiment. After sifting, sample of sifted mash were analyzed for determination of the particle size using the Tyler sieves analysis method, at the end of the test analysis the following were calculated:

Throughput Ic (kg/h)

This determines the input capacity of the sifter and it is expressed as:

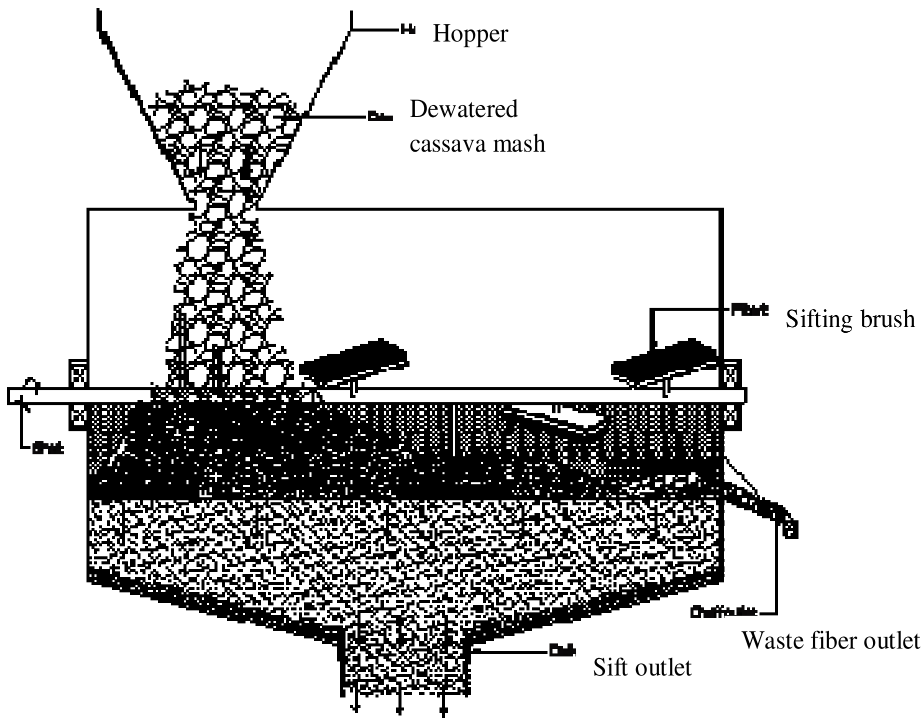

Figure 3. Sectional view of the sifter and material flow in the sifter.

$$I_c(Kg/hr) = \frac{W_1}{T_2} Kg/hr$$

Where W_1 = Initial weight of the cassava mash (kg), T_2 = Time of sifting (min), Ic = Input capacity (kg/hr). Source: Keith (2001).

Output capacity O_c (kg/h)

This determines the quality of cassava mash sifted per hour and is expressed as:

$$O_c(Kg/hr) = \frac{W_2}{T_2} Kg/hr$$

Where: O_c = Output Capacity (kg/h), W_2 = Weight of sifter mass (kg), T_2 = Time of sifting (min). Source: Keith (2001).

Sifting efficiency (%)

This determines how efficiently the Cassava Sifter is sifting and is expressed as:

$$E_s(\%) = \frac{W_1}{T_1} \times 100\%$$

Where: Es (%) = Sifting efficiency, W_2 = Weight of Sifter mash (kg), W_1 = Initial weight of Cassava mash (kg). Source: Keith (2001).

Particle size analysis (mm)

This is done to determine the sizes of the particles produced from the sifter, is indicated by a modules number F.M, and is calculated by the equation.

D_m = 0.0041 × $2.54(2)^{FM}$ (mm), Source: Akintunde and Tunde (2001).

Statistical analysis

For the cause of this experiment a 4^3 factorial experiment in a randomized complete block design (RCBD) was used to evaluate the effect of operating speed on the sifting of efficiency of the dewatered cassava mash sifter. Factors included in the design were brush clearance, brush density and machine operating speed all considered in 3 replicates. Data obtained from the measured parameters, in the study of the effects of operating speed on the sifting efficiency of the mechanical sifter were analyzed statistically using the analysis of variance (ANOVA).

Four levels of operating speed, brush density and brush clearance were used to carry out the investigation in 3 replications each making a total of 192 values that were individually tested and measured. The results obtained were recorded and evaluated using the Statistical Package for Science and Social Sciences, (SPSS) version (11.0) at the university of Ilorin Statistics department.

RESULTS AND DISCUSSION

The operating speed of the sifter is seen to have a significant effect on the sifting efficiency of the sifting machine as shown in Table 1 at 5% significance level. The Duncan Multiple Range Test was used to determine the actual level of significance and results shown in

Table 1. ANOVA table for subject factors (speed, brush density and sieve clearance).

Source	Type iii sum of squares	df	Mean square	F value	Sig
Corrected model	7266.69[a]	63	115.344	17.224	0.000
Intercept	1214076.371	1	1214076.371	181292.80	0.000*
S	1154.079	3	1718.026	256.546	0.000*
D	873.608	3	291.203	43.484	0.000*
C	781.163	3	260.388	38.883	0.000*
S*D	331.579	9	36.842	5.501	0.000*
S*C	43.673	9	4.853	0.725	0.686
D*C	21.911	8	2.435	0.364	0.950
S*D*C	60.678	27	2.247	0.336	0.999
Error	857.187	128	6.697		
Total	1222200.250	192			
Corrected total	123.879				

*significant at 5% alpha level. S = operating speed, D = brush density, C = brush clearance.

Table 2. Effect of speed on sifting efficiency.

Operating speed (rpm)	Sifting efficiency (%)
450	73.29[a]
500	76.03[b]
600	82.26[c]
650	86.51[d]

Mean difference is significant at the 5% level. Values are means of 3 replications.

Table 2. From the table the highest level of significance was at an operating speed of 650 rpm with a mean efficiency value of 86.51%, while the lowest was at an operating speed of 450 rpm with a mean efficiency value of 73.29% at the speed range used. All the means values were significantly different from each other an indication that, the operating speed has a significant effect on the sifting efficiency.

The significant effect is due to the fact that, as the operating speed is increased there is increased agitation of these sift in the sifting chamber resulting in increased bombardment of the sift on the walls of the chamber. This causes the breakdown of the cohesive forces holding the particles together resulting in the loosening of the particles and conversion of the lumps into grains which will easily pass through the screen of the sieve. The rate at which the cohesive force is broken down reduces as the operating speed is reduced, due to the fact that force is a product of the mass and the acceleration. This implies that, at high operating speed promotes the crumbling of the sift lumps and the conversion of the lumps into grains which in the end facilitates the passage of these sift through the sieve.

Figure 4 shows the rate of increase in the sifting efficiency as operating speed increases. It is seen from the figure that, there is a continuous increase in the sifting efficiency with increased operating speed. As the operating speed increases the sifting efficiency of the sifter increases, which is in agreement with the findings of Rajvir et al. (1978) and Jackson (2011), where it was concluded that, increased speed increased decorticating efficiency of a groundnut-decorticating machine and a dewatered cassava mash sifter, respectively.

However, it was observed that, the sifting efficiency will continue to increase as the operating speed increases in a linear direction until a point is reached when the rate of rotation of the sifting brushes and the bombardment of the dewatered mash causes so much agitation that the dewatered mash is carried along with the rotating brushes making it difficult for it to fall and pass through the sieve. This was observed to be the case when the machine was operated above 650 rpm as shown in Table 3.

From Table 1, other factors that had significant effect on the sifting efficiency of the sifter were the brush density, the brush clearance, and the interaction of the speed with the brush clearance.

Conclusion

Based on the analysis of the results obtained from the evaluation of the sifter it can be concluded that:

a) The operating speed of the machine is a determinant in the efficient performance of the sifter since it has a significant effect of the efficiency of the machine,
b) It can equally be concluded that, the increasing speed causes the rapid breakdown of the forces of cohesion holding the dewatered cassava mash particles together, thereby transforming the lumps to grains that will easily

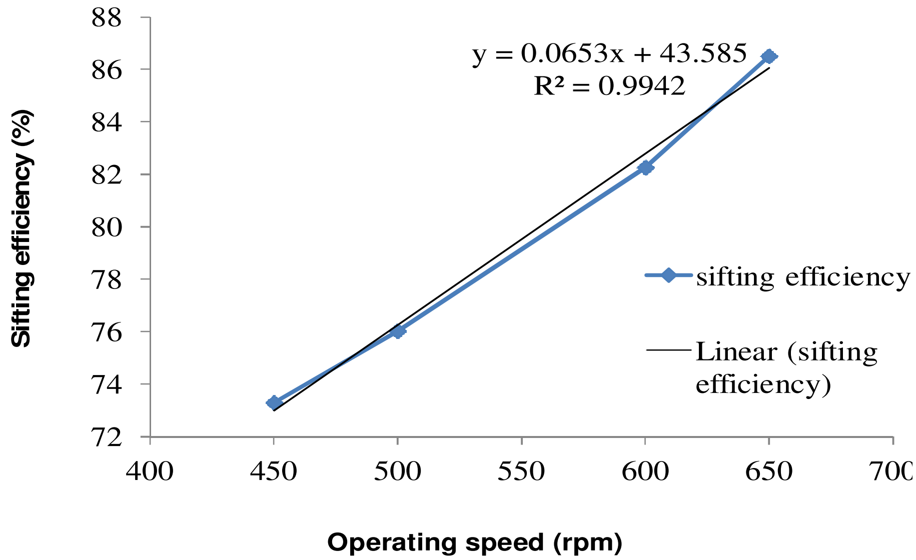

Figure 4. Effects of speed on sifting efficiency.

Table 3. Multiple range test on speed for mean values of efficiencies.

Operating speed	N	1	2	3	4	5
450	48	73.2854*				
500	48		76.0271*			
600	48			82.2583*		
650	48				86.5063*	
700	48					40.2*

*Values are mean of 3 replications, N = number of test.

pass through the sieves,

c) In addition from the results it is seen that, the mean efficiency of the sifter increases with the increase in operating speed. However continuous increase in speed up to a certain point causes the machine to vibrate excessively triggering a disproportionate agitation to the dewatered mash which leads to the accelerated rotational movement of the sifts along the rotation of the sifting brushes. This causes the sifting efficiency of the machine to reduce due to the fact that, less sift is able to pass the sieve per unit time. This happened at speeds above 650 rpm for the sifter,

d) It is also concluded that, if operated within the operating speeds stated, the dewatered cassava mash sifter can be used profitably for the industrial sifting of dewatered cassava mash during gari processing. This will increase the production capacity of the processor as against what was obtained when sifting was carried out manually,

e) With a sifting capacity of 200 kg/h the mechanical sifter will increase income and ensure timeliness of the gari processing operation.

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