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Performance Evaluation of a Dewatered Cassava Mash Sifter

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Abstract
Sifting of cassava mash is an essential unit operation for the production of gari and still a manual operation in tropical crop processing. In this study, the existing machine was modified, tested and performance evaluation was also carried out at three moisture content levels (24.6%, 22.3%, and 20.2%) wet basis at varying speeds of (1200rpm, 970rpm, and 730 rpm) and feed rate of (5kg, 10kg, 15kg, and 20kg). The results show that the sifter has the highest efficiency of 99.4% at 20.2% moisture content at the sifting speed of 1200rpm. Output Capacity of 569.03kg/hr was obtained and this increased as the feed rate increases at 20.2% moisture content. Analysis of Variance for the Sifting Efficiency was computed and the result reveals that the speed, feed rate, and moisture content are significant. The machine is affordable and adequately manageable therefore recommended for the small scale and medium scale cassava processor.

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I. Introduction

Cassava (Manihot Esculenta, Crantz) is an important root grown in many parts of the world and Nigeria is the largest producer. The demand for cassava food products among other root and tuber crops in Nigeria comparatively ranks high. 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. Traditionally, cassava was cultivated by the 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.,* 2009). It is produced into gari, lafun, tapioca kokote, fufu and ackhe.

At the village level, gari is fried in shallow cast iron pans after sieving with raffia mat. The sievedcassava mash is spread thinly in the pan in 2 to 3kg batches. A piece of the calabash is oftenused in stirring the gari on the hot surface of the pan to prevent it from burning until the frying iscompleted. Gari frying is a complex procedure which depends on the skill of the operator. The inability to control the temperature of frying, exposure of the operator to heat and smokefrom the fire, and steam from the wet cassava mash have been a major setback in theTraditional frying of gari. The fried gari is finally spread on a mat or polythene to cool beforepackaging (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 affects the color, 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 is placed for one or two days.

Sifting/ sieving is one of the greatest constraint and a key process for making cassava processing to gari because a large percentage of grated cassava is 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 the world market requires wide research and investment into processing machine design and development, among others.

Thus, an existing dewatered cassava mash sifter was tested, modified and evaluated for its performance to determine its optimum capacity and efficiency of operation.

II. Materials and Methods

2.1 Description of the Dewatered Cassava mash sifter

The cassava sifting machine was designed and fabricated in the Department of Agricultural and Bio-Environmental Engineering. The machine consists of the following components; hopper, frame, pulverizing chamber (spike), scrubbing chamber (paddle), screening (sieve), and drive mechanism. The machine is being powered by a pulley connected to the electric motor. The rotary motion of the motor is transmitted to the shaft

of the scrubbing chamber. At the same time, power is being transmitted to the pulverizing chamber (spike) by the pulley. The rotary motion from the motor at pulverizing chamber pulverized the dewatered cassava mash lump and then to the scrubbing chamber which performed the sifting and passed out the outlet.

Figure 1: Cassava mash sifter

2.2 Performance Test

450kg of cassava mash at 24.6% moisture content dewatered cassava mash was divided into three portions (150kg) each, one portion (150kg) was subjected to sun dry for 24hrs and another portion (150kg) was subjected to 48hrs sun drying, while the last portion (150kg) was sieved immediately. The machine was set into motion, at 24.6% moisture content dewatered cassava mash, 5kg, 10kg, 15kg, and 20kg consecutively of cassava mash was poured through the hopper into the machine at speed of 1200rpm $S_{1,}$ 970 rpmS_2, and S_3 at 730rpm in which 50kg each was used for speed one S_1, Speed two S_2 and Speed three S_3 to determine the machine capacity and efficiency. The time spent on the sifting was recorded. The fine mash sifted and the undersized mash on the sieve was collected, weighed and recorded.

The same procedure was repeated for (150kg), 24hrs sun-drying of 22.3% moisture content dewatered cassava mash and for (150kg) 48hrs sun-drying of 20.2% moisture content dewatered cassava mash respectively.

The following parameters were then used to carry out the evaluation of themachine;

(i) Sifting Efficiency(SE):

SE (%) = $\frac{Ms}{Ml} \times 100$

Where *Ms =mass of sifted mash, (kg)*

Ml = mass of mash loaded, (kg)

(ii) Machine Capacity (MC) which is obtained by using the relation

MC =$\frac{Ms}{t}$

Where *Ms = mass of sifted mash, (kg)*

t = time spent, (hour)

III. Results and Discussion

3.1 Results

The tables below show the results of the tests carried out at different speed and time of operation.

Table 1: Machine Capacity and Efficiency at brush speed of 730rpm

TEST 1 at 24.6% MC				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.10	8.70	13.93	18.15
Mass of Under sized on the sieve (kg)	0.80	1.00	0.94	1.50
Time taken to sieve (Sec)	90	173	294	315
Machine capacity (kg/h)	164	181.04	170.57	207.43
Machine Efficiency (%)	82	87	92	90.75

Table 2: Machine Capacity and Efficiency at brush speed of 970rpm

TEST 2 at 24.6% M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.30	8.95	14.0	18.20
Mass of Under sized on the sieve (kg)	0.45	0.67	0.70	1.05
Time taken to sieve (sec)	70	155	250	292
Machine capacity (kg/h)	221.14	207.87	202.32	224.38
Machine Efficiency (%)	86	89.5	93.67	91

Table 3: Machine Capacity and Efficiency at brush speed of 1200 rpm

TEST 3 at 24.6% M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.50	8.83	14.53	18.45
Mass of Under sized on the sieve (kg)	0.35	0.90	0.30	1.30
Time taken to sieve (min)	57	111	190	260
Machine capacity (kg/h)	284.21	286.38	275.31	255.46
Machine Efficiency (%)	90	88.3	96.87	92.25

Table 4: Machine Capacity and Efficiency at brush speed of 730rpm

TEST 4 at 22.3% M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.40	9.05	14.30	19.10
Mass of Under sized on the sieve (kg)	0.46	0.45	0.45	0.50
Time taken to sieve (min)	70	138	231	265
Machine capacity (kg/h)	226.29	236.09	222.86	259.47
Machine Efficiency (%)	88	90.5	95.3	95.5

Table 5: Machine Capacity and Efficiency at brush speed of 970rpm

TEST 5 at 22.3% M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.73	9.43	14.48	19.05
Mass of Under sized on the sieve (kg)	0.15	0.41	0.38	0.60
Time taken to sieve (min)	57	108	190	210
Machine capacity (kg/h)	298.74	314.33	274.36	326.57
Machine Efficiency (%)	94.06	94.03	96.05	95.25

Table 6: Machine Capacity and Efficiency at brush speed of 1200rpm

TEST 6 at 22.3% M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.76	9.10	14.75	18.95
Mass of Under sized on the sieve (kg)	0.16	0.60	0.12	0.72
Time taken to sieve (min)	43	83	150	195
Machine capacity (kg/h)	398.51	394.70	354.00	349.85
Machine Efficiency (%)	95.02	91.00	98.30	94.75

Table 7: Machine Capacity and Efficiency at brush speed of 730rpm

TEST 7 at 20.2 % M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.68	9.48	14.52	19.39
Mass of Under sized on the sieve (kg)	0.31	0.30	0.30	0.40
Time taken to sieve (min)	58	107	182	220
Machine capacity (kg/h)	290.48	318.95	287.21	317.29
Machine Efficiency (%)	93.60	94.08	96.08	96.95

Table 8: Machine Capacity and Efficiency at brush speed of 970rpm

TEST 8 at 20.2 % M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.90	9.53	14.63	19.53
Mass of Under sized on the sieve (kg)	0.09	0.30	0.20	0.35
Time taken to sieve (min)	45	75	160	190
Machine capacity (kg/h)	392	457.44	329.18	370.04
Machine Efficiency (%)	98	95.30	97.53	97.65

Table 9: Machine Capacity and Efficiency at brush speed of 1200rpm

TEST 9 at 20.2 % M.C				
Mass of mash loaded (kg)	5.00	10.00	15.00	20.00
Mass of fine mash (kg)	4.92	9.80	14.91	19.75
Mass of Under sized on the sieve (kg)	0.05	0.15	0.07	0.17
Time taken to sieve (min)	36	62	118	150
Machine capacity (kg/h)	492	569.03	454.88	474.00
Machine Efficiency (%)	98.40	98.00	99.04	98.07

3.2 Discussions

The result in the tables shows that as the moisture content of the cassava mash decreases, the sifting of the cassava mash increases. This is a result of the fact that, at higher moisture content, the cassava mash tends to stick to the sieve causing clogging hence, the reduction of the mash obtained at the outlet. Although, a spike was incorporate in the machine to pulverize the cassava mash to enhance sifting operation and hence, a highest free flow trend of sifted mash by comparisons was obtained at the graph in fig 1 at brush speed of 1200 rpm, under 20.2% moisture content.

Also, the feed rate has slight significance on the sifting efficiency, because as the feed rate increases at high moisture content level, the time required for sifting of the loaded mash increased. However, at higher speed, the quantity of the fine cassava mash obtained was highest in comparison with the ones obtained at lower speeds of different levels of moisture content.

By critically examining the results for undersized in the tables at different brush speeds, it was observed that the mass of fine mash retained on the screen increases as the moisture content increases. This indicates that they are directly proportional to another.

The relationship between machine efficiency and the speed with respect to moisture content was significance. As the speed increases, the machine efficiency increases. However, at lower moisture content level, the machine efficiency was higher. This was as a result of free-flowing of pulverizing cassava mash through the screening sieve (4mm aperture).

Considering the relationship between machine capacity and the speed of operation of the screen, the result shows that the higher the speed, the higher machine capacity. However, an optimum machine capacity of **569.03kg/hr** was obtained at a moisture content of **20.02%** (wet basis) and at the highest brush speed of **1200rpm**.

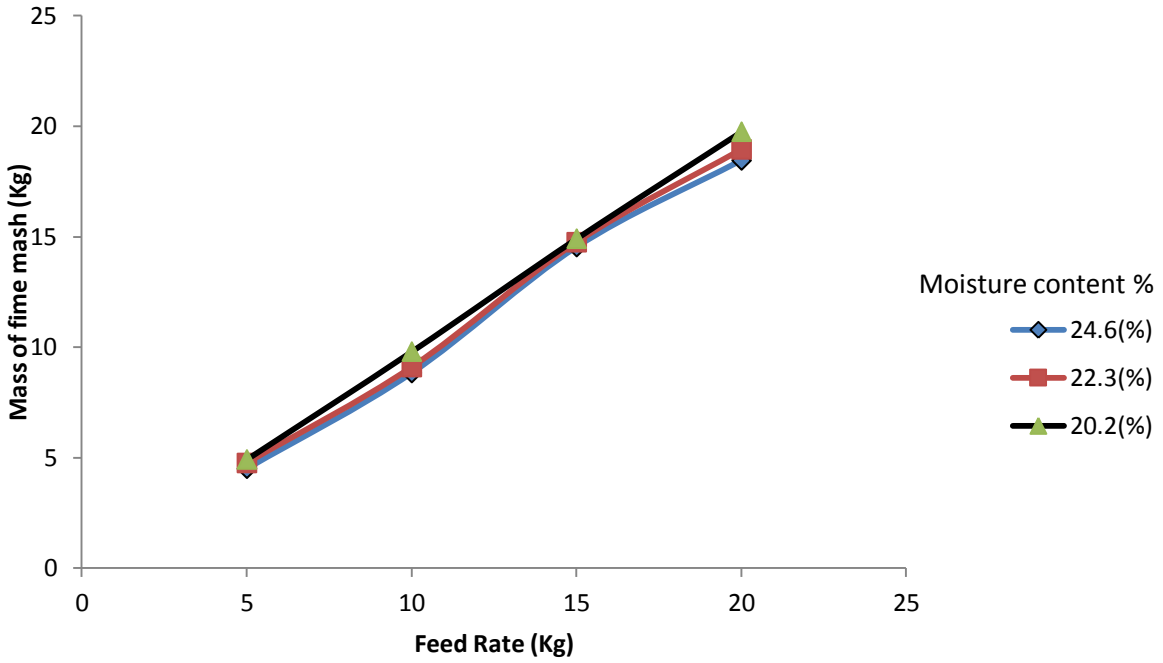

Figure 1: Effect of moisture content and feed rate at 1200 rpm

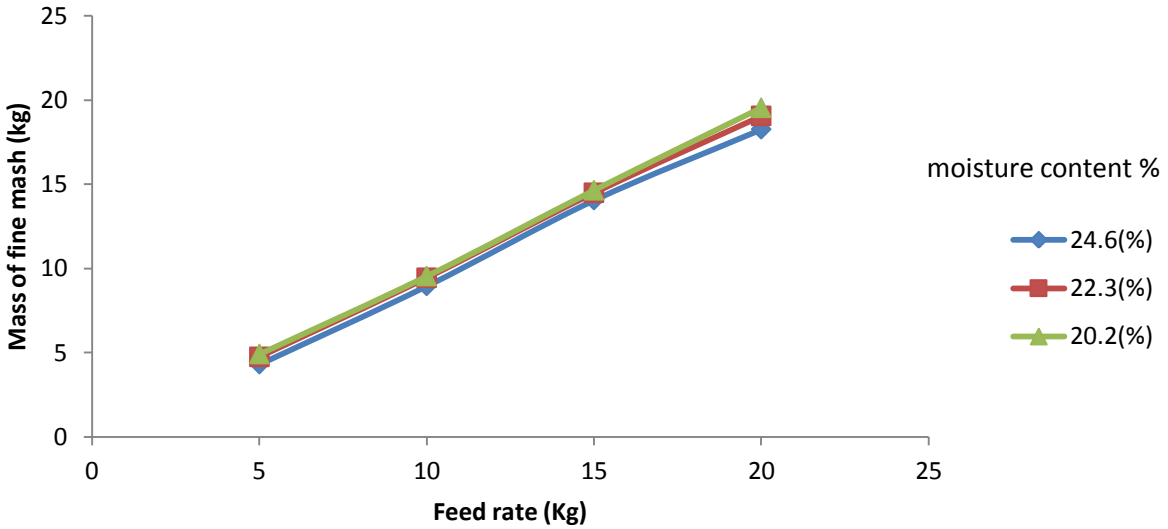

Figure 2: Effect of moisture content and feed rate at 970 rpm

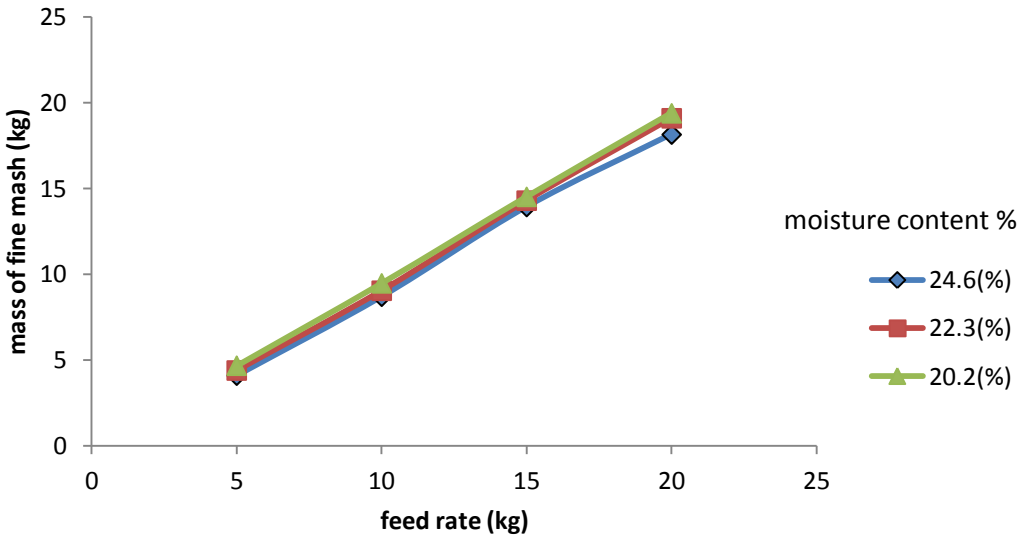

Figure 3: Effect of moisture content and feed rate at 730 rpm

IV. Conclusion

The motorized cassava mash sifter was modified, tested and the performance evaluation was carried out. It was observed that the machine perform efficiently at all sifting speed when compared with locally, manual and traditional method of sifting cassava mash which is more tedious, time-consuming and laborious, this machine makes the sifting easier and much faster than the existing methods.

However, the highest sifting efficiency of 99.04% was observed at sifting speed of 1200rpm and moisture content of 20.2%. 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.

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