PERFORMANCE EVALUATION OF NCAM MANUALLY OPERATED DEWATERING PRESS

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ABSTRACT

The NCAM Manually operated dewatering press was evaluated. It has a rectangular shaped cage of an overall dimension of 138cm x 71cm x 84cm. A performance test was carried out on the manually operated dewatering press using grated fermented and unfermented cassava mash. Test results showed that the highest mean dewatering efficiency of 38.15% was obtained on the fermented cassava mash, when the mean Moisture content of the mash was at 66.47% wet basis while the lowest mean dewatering efficiency of 37.68% was obtained on the unfermented cassava mash when the mean Moisture content of the mash was at 70.11% wet basis with the mean dewatering time of 7hrs:45mins and 8hrs:30mins for fermented and unfermented cassava mash respectively. The average particle size of the mash was 0.76mm. The dewatering rate of the press for both fermented and unfermented cassava mash was found to be $3.6\times10^{-3kg}{}_{hr}$. The mean output capacity of the press for the fermented and unfermented cassava mash were found to be $37^{kg}{}_{hr}$ and $42.09^{kg}{}_{hr}$ respectively while the mean input(throughput) capacity of the press on the fermented and unfermented were found to be 50.23 $^{kg}/_{hr}$ and $56.36^{kg}/_{hr}$ respectively. Particle size analysis of the cassava mash used for the dewatering operation was found to be 3.06 for fineness modulus and 1:4:0 for uniformity index. The particle size analysis of the dewatered cassava mash was 2.55 for fineness modulus and 1:7:0 for uniformity index, while the average particle size was 0.61mm.It is recommended that an improvement should be made on the dewatering press to enhance its dewatering rate and increase its efficiency. Consideration may also be given to automating the dewatering press to completely eliminate human fatigue and drudgery during operation.

KEYWORDS: Dewatering press, cassava mash, performance evaluation.

1. INTRODUCTION

The production and processing of cassava roots (*manihot species*) have now become a major economic activity in Nigeria due to the encouragement given by the government through her initiative on Root and Tuber Expansion Programme (RTEP). Cassava roots can be processed into different products such as gari, "lafun", high quality cassava flour (HQCF), starch, etc. These products are obtained from the different unit operations after harvesting the roots as reported by Odigboh (1985). Such unit operations include: peeling, washing, grating, chipping, dewatering, drying, milling and so on.

Efforts made in the mechanization of cassava processing in Nigeria dated back to the 1970s and mid 1980s. Mechanized gari and HQCF processing machines especially cassava grater, chipper, dewatering press, etc have become widespread in southern Nigeria. The recent call for diversification of cassava processing options in the IFAD assisted, Root and Tuber Expansion Programme (RTEP) is timely and required strong promotional efforts to popularize cassava chipping, drying, grating, dewatering and pelletting machines in the food and non-food cassava processing industries. Thus, as observed by Akintola (1996) the development of cassava processing machines offers a cost effective and speedy approach to achieving this objective. In addition, evaluation tests on these cassava processing machines should not be overlooked for further improvement on the machines.

Dewatering as one of the unit operations play a major role in processing of cassava roots into HQCF, and gari, for it hastens the drying process of cassava mash in the production of HQCF, where the rate of drying determines the quality of the cassava flour obtained. Also, the moisture content of fermented or unfermented cassava mash before garifying needs to be reduced to an optimum moisture content of 45%wb for good quality gari to be obtained. Akande, et al (2004), and Ihekeronye and Ngoddy (1985) had reported that the optimum moisture content of dewatered cassava mash required for garification is between 45% to 50% wb, while Raji (2006), reported that the initial moisture content of cassava mash to pass through a flash drier for the production of high quality cassava flour (HQCF), starch, and odourless fufu should not exceed 45% wb. Hence, dewatering of cassava mash should be aimed at removal of moisture from cassava mash to an optimum level for further processing into gari or HQCF.

Traditionally, cassava mash dewatering is carried out using logs of wood and ropes arranged with heavy stones that serve as load for pressing out water from the bagged mash; this is commonly done in the southern part of Nigeria. In some other parts of the world, the cassava pulp is packed in leaves and pressed under a heavy stones, sometimes, with the aid of pole leverage, or in a wooden screw press. The traditional equipment for this purpose in Latin America known as a tipiti is a cylindrical shaped basket, which has been specially woven so that its shape can be varied. In its normal shape, the basket is packed with fresh cassava pulp and hung from a tree branch, the basket is then pulled downward until it is long and thin. During this pulling operation, the pulp is subjected to considerable pressure, which drains off a substantial proportion of the cyanide containing juice Asiedu (1989).

Due to the drudgery involved in this unit operation (dewatering) different technologies have been introduced for dewatering of cassava mash. He most commonly known equipment are hydraulic press and screw press. The hydraulic press is commonly found among the small-scale gari processing centres, while the screw press has just begun to gain ground in cassava processing industries.

The objectives of the study were to evaluate the performance of the NCAM manually operated dewatering machine and determine what modifications that can be made to improve the machine's performance.

2. MATERIALS AND METHODS

2.1 Description of the Dewatering Press

NCAM manually operated dewatering press is a rectangular shaped cage of overall dimensions of 138cm x 71cm x 84cm. It consists of a body frame made of 7cm x 7cm and 4cm x 4cm, angle iron, a screw shaft of length 102cm and diameter 4.5cm, and a rectangular plate of dimension 45cm x 57cm with a thickness of 10mm. A circular plate (pressure transfer plate) of diameter 51cm and thickness 2.0cm is attached to the lower end of the screw shaft, with the aid of a bushing of 7cm diameter and a height of 10cm. A rod of length 130cm and diameter 21mm is attached to the upper end of the screw with the aid of another bushing of the same dimension that serves as the handle of the screw press. At the mid top of the frame are two u-shaped channels which serve as supports to a nut of diameter 7cm and height 10cm, and through which the screw shaft passes for ease of operation of the screw press. Figures 1&2 show the isometric and orthographic views of the NCAM manually operated dewatering press.

The dewatering press is operated when a considerable number of bagged cassava mashes have been loaded into the press. Then the screw shaft is screwed down until the rectangular plate exerts pressure on the bagged cassava mash to dewater it. The screwing down continues till no more water drips from the mash. Therefore the screw shaft is screwed up to release the dewatered cassava mash.

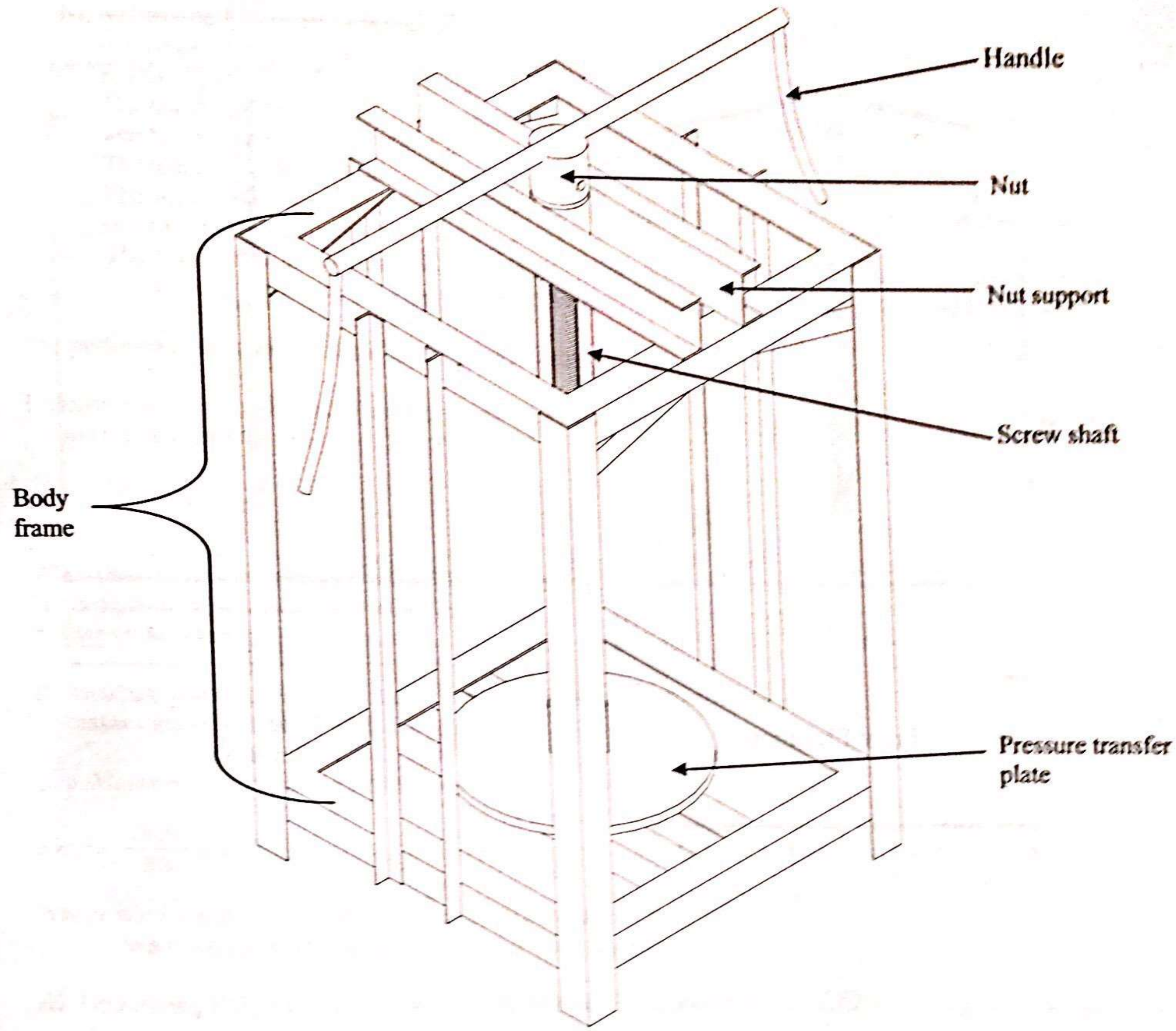

Figure 1. Isometric projection of NCAM cassava mash dewatering press

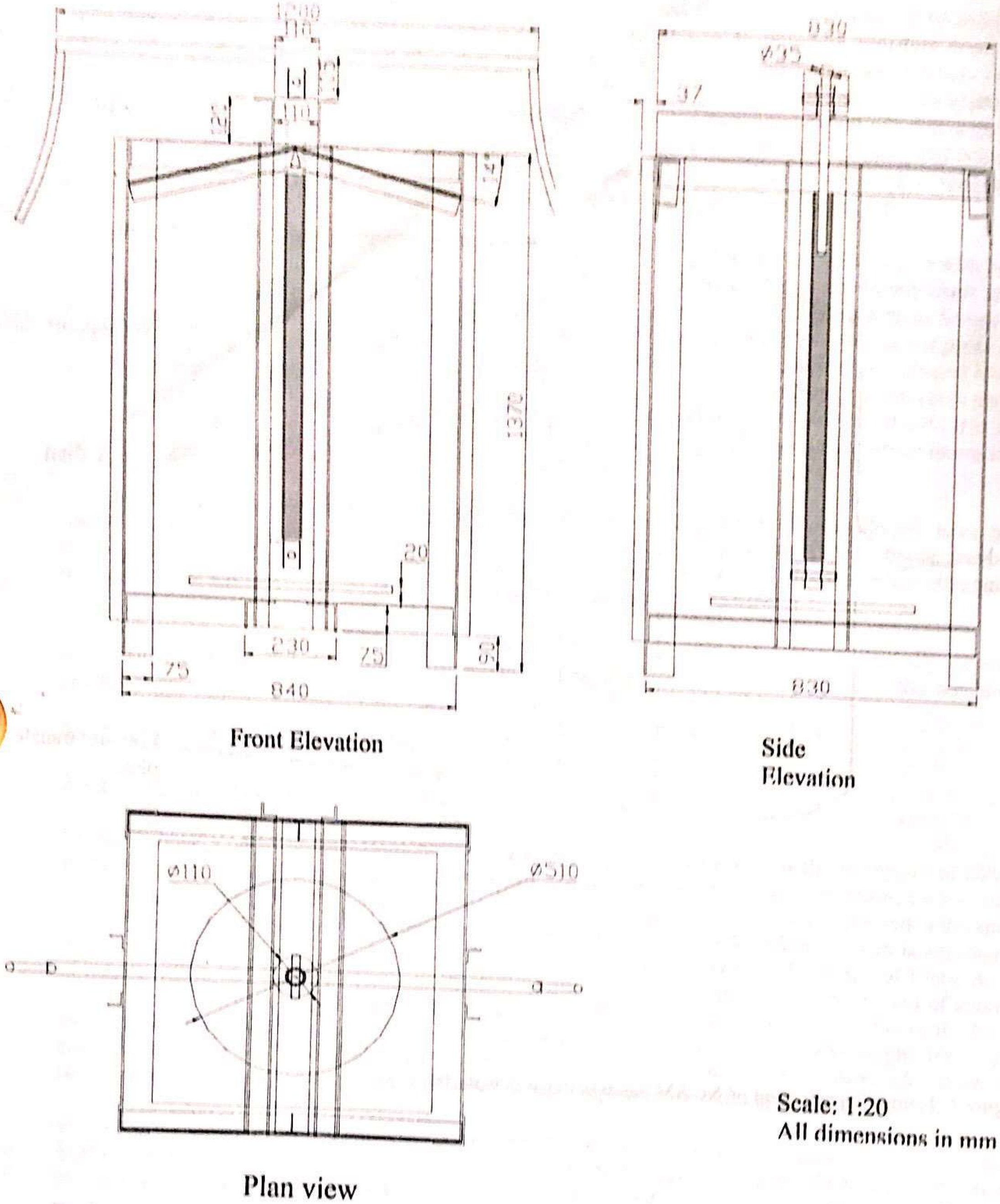

Figure 2. Orthographic Projection of NCAM cassava mash dewatering press

2.2 Performance Evaluation of the Press

The NCAM manually operated cassava dewatering press was tested as follows:-

- Grated cassava roots were used to test the dewatering press.
- Each 60kg of the grated cassava mash was weighed out and bagged into jute bags.
- The number of bags loaded was eight (8) bags each of 60kg of the mash.
- The bagged cassava mash was loaded into the dewatering press.
- The moisture content before and after dewatering was determined using an oven dry method.
- The load on the bags of cassava mash was increased gradually until no more water or effluent drips from the bags.
- The time taken to dewater loaded cassava mash to constant weight (i.e. till no more water or effluent drips from the bag) for each batch of operation was taken using the normal time clock.

The performance parameters were determined as follows:-

I. Dewatering rate, Dr kg/sec: This determines the quantity of moisture expressed from the mash per unit time and is expressed as

$$Dr = \frac{W_0 - W_1}{t} \text{ kg/sec} \quad \ldots\ldots (1)$$

Where W_0 - weight of cassava mash before dewatering.
W_1 - weight of the cassava mash after dewatering.
t= time of dewatering in seconds.

II. Moisture content, (Mc) wet basis: This determines the percentage of moisture (in wet basis) in the cassava mash before and after dewatering.

a. Moisture content (MC_1) was expressed as

$$Mc_1\ \%\ \frac{Wb - Wa}{Wb} \times 100\% \quad \ldots\ldots (2)$$

Where Wb = weight of the sample cassava mash before oven drying.
Wa = weight of the cassava mash after oven drying.

III. Dewatering Efficiency, E_d%: This determines how efficiently the press is dewatering, it is expressed as

$$ED\ \frac{W_2}{W_3} \times 100\% \quad \ldots\ldots (3)$$

Where W_2 = weight of water expressed from process.

$$(W_2 = W_0 - W_1) \quad \ldots\ldots (4)$$

W_3 = Total weight of water in the mash. Therefore $W_3 = \frac{WC1 \times W_0}{100}$ .... (5)

IV. Output capacity Oc kg/hr: This determines the amount of dewatered mash obtained from the dewatering press, it is expressed as

$$O_c \; \frac{W_1}{T} \; {}^{kg}/_{hr} \ldots\ldots\ldots\ldots\ldots (6)$$

Where T is dewatering time in hours V. Input capacity, (Throughput) Ic $^{kg}/_{hr}$: This determines the quantity of mash put(fed) into the dewatering press per unit time, it is expressed as

$$I_c \; \frac{W_o}{T} \; {}^{kg}/_{hr} \ldots\ldots\ldots\ldots\ldots (7)$$

VI. Fineness Modulus, F.M: This indicates the uniformity of grind (cassava mash) in the resultant product and is defined as the sum of the weight fractions retained above each sieve divided by 100 (Akintunde and Tunde, 2001).

$$F.M = \sum \frac{percent material retained \times pan No}{100} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

A set of Tyler sieves was used in determining the fineness modulus of the cassava mash.

VII. Average particle size of cassava mash, Dm in S.I unit indicated by a modulus number F.M can be calculated by the following equation, (Akintunde and Tunde, 2001).

$$Dm = 0.0041 \times 2.54(2)^{FM} \text{ mm} \ldots\ldots\ldots\ldots (9)$$

VIII. Uniformity Index (ID) of the cassava mash: This indicates the proportion (or ratio) of coarse, medium and fine particles in the cassava mash. This is expressed as:

U.I= coarse: medium: fine size particles {to the nearest whole number} .... (10) (Akintunde and Tunde, 2001)

3. RESULTS AND DISCUSSION

The performance evaluation of the NCAM dewatering press was carried out during the rainy season which has a great effect on the data obtained because of the high level of moisture in the soil and in the atmosphere at the time of tests.

The particle size analysis carried out on the sample of the undewatered cassava mash gave values of the fineness modulus and uniformity index of the mash as 3.06 and 1:4:0 respectively, while the average particle size was found to be 0.76mm. The particle size analysis of dewatered cassava mash from the press gave values of the fineness modulus and uniformity index as 2.55 and 1:7:0 respectively, while the average particle size was found to be 0.61mm. The results of the particle size analyses showed that the dewatered mash has more uniform particle sizes of the product than the undewatered mash. This is because the pressure exerted on the cassava mash during dewatering operation reduces large particle size of 0.76mm of the mash to a smaller 0.61mm particle sizes. Hence, the large coarse sizes are reduced to medium or smaller sizes.

Table 1 shows the performance evaluation of the NCAM manually operated dewatering machine. The highest mean dewatering efficiency of 38.15% was obtained, on the fermented cassava mash when the mean moisture content was at 66.7% wet basis while the lowest mean dewatering efficiency of 37.68% was obtained, on the unfermented cassava mash when the mean moisture content was at 70.11% wet basis with the mean dewatering time of 7hrs:45mins and 8hrs:30mins for fermented and unfermented cassava mash respectively. However, the dewatering time was found to depend on the quantity and the initial moisture content of cassava mash loaded into the press.

Table 1: Performance Test of the NCAM Dewatering Press

	Unfermented cassava mash No. of batches						Fermented cassava mash No. of batches					
Performance parameters	1	2	3	4	5	Mean value	1	2	3	4	5	Mean value
Wt before dewatering; W_0 (kg)	414	412	415	414	416	414.2	407	405	408	404	402	405.2
Wt after dewatering; W_1 (kg)	306	302	308	303	305	304.8	305	303	306	298	301	302.6
Wt of water expressed from process W_2 (kg)	108	110	107	111	111	109.4	102	102	102	106	101	102.6
Moisture content before dewatering; Mc_1%wb	70.25	70.04	70.15	70.07	70.02	70.11	68.51	67.91	65	66.8	64.15	66.47
Moisture content after dewatering; Mc_2%wb.	48.10	45.13	49.18	45.36	47.02	46.96	45.11	46.08	45.18	46.21	48.05	46.13
Total wt pf water in the mash; W_3 (kg)	290.8	288.57	291.13	290.10	291.28	290.38	278.84	275.04	265.20	269.87	257.88	269.37
Time of pressing; T hr: min	8:15	8:30	8:10	8:30	8:05	8:30	7:50	7:20	8:10	7:45	7:40	7.40
Dewatering rate; DR $^{kg}/_{sec}$	3.6×10^{-3}	3.6×10^{-3}	3.6×10^{-3}	3.6×10^{-3}	3.8×10^{-3}	3.6×10^{-3}	3.6×10^{-3}	3.8×10^{-3}	3.5×10^{-3}	3.7×10^{-3}	3.7×10^{-3}	3.6×10^{-3}
Dewatering Efficiency; D_E %.	37.13	38.12	36.75	38.26	38.11	37.68	36.59	37.09	38.46	39.27	39.17	38.15
Output capacity; Oc, $^{kg}/_{hr}$.	37.09	35.52	38.40	35.65	38.13	37.00	43.51	43.22	38.25	42.51	42.94	42.09
Input capacity; Ic, $^{kg}/_{hr}$.	50.19	48.48	51.76	48.71	52	50.23	58.06	57.77	51	57.63	57.35	56.36

The mean dewatering rate of the press for both fermented and unfermented cassava mash was found to be $3.6 \times 10^{-3}\ ^{kg}/_{sec}$. Thus, it is evident that the unfermented mash retained more moisture that took longer time to be expressed during the dewatering operation than the fermented mash. This is because there was a higher reduction of moisture from the mash during the fermentation and due to the use of porous material for fermentation operation, hence, the dewatering time and the amount of moisture retention from the unfermented mash become larger than from the fermented mash.

The mean output capacity of the press on the fermented and unfermented cassava mash is found to be 37 $^{kg}/_{hr}$ and 42.09 $^{kg}/_{hr}$ while the mean input capacity of the press on the fermented and unfermented was found to be 56.36 $^{kg}/_{hr}$ and 50.23 $^{kg}/_{hr}$. The pressure from the circular plate of the press which acted on the centre of the loaded bags of the cassava mash is not evenly distributed. This is due to the limited surface area covered by the plate that could have covered the entire surface area occupied by the loaded cassava mash in the press. This gave rise to lower dewatering rate and longer operational time of the press. The dewatering press required a constant screwing down of the screw shaft during operation with human effort. This resulted in fatigue and drudgery during the operation.

4. CONCLUSION AND RECOMMENDATION

In spite of the observed inadequacies of the press during operation, the NCAM manually operated dewatering press can be considered as an appropriate technology in cassava processing suitable for the small to medium scale cassava processing industries. It is recommended that an improvement should be made on the dewatering press so as to aid its dewatering rate and increase its efficiency. Considerations may also be given to automating the dewatering operation so as to completely eliminate human fatigue and drudgery during the operation of the press.

REFERENCES

Akande, F. B, Omisore, G. O and S. I. Obiakor. 2004. Effects of moisture content of dewatered cassava mash on the particle size of gari grains and the garifying period: Proceeding of annual conference of NIAE vol. 25. 2004, Pp 376-380.

Akintola, A. A. 1996. Design and Construction of a mobile motorized cassava grater and chipper: Proceedings of Annual conference of NSAE. 1996, 18:52-59.

Akintunde, B. O. and Tunde, T. Y. 2001. Development and Performance Evaluation of pedal operated grain mill. Proceeding of 2nd International conference and AGM of the NIAE. 23:253-260.

Asiedu, J. J. 1989. Processing Tropical Crops: A technological approach. Macmillan. Pp 11-12.

Ihekeronye and Ngoddy 1985. Integrated food science and Technology for the tropical Macmillan publishing ltd London. Pp 10-26, 270-272.

Odigboh, E. U. 1985. Mechanization of cassava production and Processing: A decade of design and development, University of Nigeria Nsukka. Inaugural Lecture series, No. 8.

Raji, A. O. 2006. A preliminary report on Design of the Flash Drier System submitted to IITA, Ibadan. 13th October, 2006.