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DETERMINATION OF APPROPRIATE PRESSING PRESSURE FOR SELECTED SACKS USED IN CASSAVA PULP DEWATERING

K. O. Chilakpu*
AGRICULTURAL & BIORESOURCES ENGR'G DEPT., FEDERAL UNIV. OF TECHNOLOGY, OWERRI, IMO STATE, NIGERIA
E-mail address: *kchilakpu@yahoo.com*

ABSTRACT
Selected Jute fiber reinforced composites sacks locally used for cassava pulp dewatering were subjected to dewatering pressure tests to ascertain their average maximum dewatering pressure bearing capacity. Existing hydraulic jack was modified for the purpose of the experiment at Divine engineering works Owerri. In the course of this study, fifteen independent trials were performed. The summary of the results show that, the maximum breaking pressures of 152.068kN/m^2, 160.632kN/m^2, and 174.465kN/m^2 at 10kg, 15kg and 20kg respectively of the product were recorded. These maximum sack breaking pressure values were observed for all product quantities when the Jute fiber reinforced composites sack for Rice packaging was used. It is therefore recommended that improved jute fiber reinforced composites popularly used for bagging rice products be use for the dewatering operations of cassava pulp especially where high dewatering pressure is required.

Keywords: *Dewatering, pulp, sack, pressing, pressure, cassava.*

1. INTRODUCTION.

Cassava (Manihot esculenta) is a good source of carbohydrate and the improved varieties are rich in vitamin A and C among other trace minerals. Marcola [1] reported that 100grams of cassava tuber provides 38.06g of carbohydrate, 1.8g of dietary fiber, 1.36g of protein, 16mg of calcium, 27mg of phosphorus, 20.6mg of vitamin C amongst others. The tubers are processed into different forms of traditional food such as tapioca, fufu, and garri among others. Processing fresh cassava tubers into delicacies involves peeling and washing, grating/slicing, and in most cases dewatering before getting to the final product. Fresh cassava tuber has high water content of up to 65% - 70% and requires appreciable dewatering for proper storage and high product value [2].

Generally, dewatering in cassava tuber processing involves applying pressure on the grated pulp sealed in a sack to expel its water content. In the dewatering of cassava mash, the particles are constrained in a sack or solid container while the liquid is allowed to drain out through application of pressure. Some known Cassava processing sites in South-East Nigeria were investigated in Owerri, Mbaise, Ohaji, Aba and Umuahia. It was observed that Jute fiber reinforced composites sacks were mostly used for cassava pulp dewatering operations. Jute fiber appears to be a promising fiber due to its good strength and breathability when compared with other natural fibers, such as sisal, coir, and ramie [3 – 4]. Jute fiber is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and modulus [5]. In addition to its eco-friendliness as a biodegradable material, some characteristics of this fiber, such as low cost, low specific gravity, high specific strength, and its availability, encouraged the use of sacks made of jute fiber for various agricultural purposes [6]. The high tensile strength, low extensibility, and availability of jute materials make it very suitable for the packaging of wide varieties of agricultural products [5]. The enhanced breathability of the fabric encouraged the use of jute reinforced sacks for the dewatering process of most agricultural products. Study by Mohanty, *et al* [8]; Debiprasad [5]; Prabaharan and Venkatachalam [6] revealed that, fibers used in composite will have increase stiffness, strength and Young modulus as shown in Table 1.

The pressure to be exacted may be a function of –the strength of the sack carrying the pulp and allowable dewatering duration to achieve the desired moisture content.

*** Corresponding author tel: + 234 – 803 – 342 – 2275**

Table 1. Properties of jute fiber in comparison with other fibers [5]

Fiber	Density (g/cm3)	Young's modulus (GPa)	Tensile strength (MPa)	Elongation at break (%)
Jute	1.3	26.5	393-773	1.5-1.8
Cotton	1.5-1.6	5.5-12.6	287-597	7-8
Flax	1.5	27.6-46.9	345-1035	2.7-3.2
Ramie	-	61.4-128	400-983	3.6-3.8
Sisal	1.5	9.4-22	511-635	2-2.5
Viscose (cord)	-	11.0	593	11.4

Traditionally, several methods are used for cassava mash dewatering these include: use of sticks or logs, parallel board method, tying the pulp bags to tree stumps, chain or string and screw jack methods [9]. The need for more efficient ways of dewatering cassava pulp has led to the application of hydraulic pressing devices in this area of agricultural product processing.

The modern use of hydraulic systems and other improved mechanical means of pressing cassava mash have revolutionized the dewatering process with its attendant problems such as, sack busting under excessive pressure and leakage (wastage) of the product. The danger of product loss is higher if unchecked with these modernized dewatering systems. To minimize product wastages, the maximum amount of pressure required to dewater any given quantity of cassava pulp given the strength of the sack used need to be determined. This study is aimed at investigating selected locally available jute fiber reinforced composites sack materials commonly used for cassava pulp dewatering operations. This is with the view to determine the acceptable pressure the selected sacks can withstand during a cassava pulp dewatering operation so as to minimize product loss as a result of sack busting under excessive dewatering force application. Minimizing product losses will lead to increased food production as well as reduced cost of production. On the other hand, obtaining relevant information on the strength of the various sack materials will reduce the constraints militating against the automation of pulp dewatering machines.

A review of literatures revealed that not much work has been documented in this research area. Some cassava processing factories in South-East Nigeria were visited to understudy their basic practices.

2. MATERIALS AND METHODS.

Three major types of Jute fiber reinforced composites sacks were commonly used by the local farmers for cassava pulp dewatering operations, these include; granular sugar bags labeled as sample (A), the rice sacks labeled as sample (B), and flour sacks labeled as sample (C). These three main sack types as shown in Fig. 1 were tagged with their common products for the purpose of this study for ease of identification. An existing hydraulic press was modified to accommodate a 9 ton hydraulic jack and two calibrated weighing springs for the determination of the applied force on the sacks as shown in Fig. 1.2. A calibrated transparent bucket was used for the collection of effluent to give an idea of the draining rate for each sack in the course of the experiment. Unsorted locally available fresh cassava tubers were peeled, washed and grated for this work. An electric oven and digital weighing balance at the department of Agricultural and Bioresources Engineering, Federal University of Technology Owerri were used to determine the moisture content of the product before and after each experiment. The moisture content was noted to ensure that each batch of cassava pulp used for the experiment was fairly at the harvesting level of about 65% (wb). A digital weighing balance was used to measure the weight of an empty can labeled 'Wc'. Sample of the pulp was placed in the weighing can of known weight and labeled 'Wc+s'.

Figures 1: (A) Sugar jute sack (B) Rice sack and (C) Flour Sack

The initial moisture content of the samples was determined using HME Global electric oven with model number PHD-9101-ISA England. The weighed sample was placed in the oven heated to 60^{0}C for 60 minutes before it was reweighed and change in weight noted. To avoid the effect of sack over use or ageing with time, new and un-used sacks were selected for this study. The average tensile strength of the sacks were found to be 207kN/m^2, 215kN/m^2 and 211kN/m^2 for Sugar jute sack (A), Rice sack (B), and Flour Sack (C) respectively. This agreed with the work of Mwaikambo, (2009) [10] and Prabaharan and Venkatachalam, (2015) [6], which reported the tensile strength of Jute fiber reinforced composites to be in the range of 2000-25000kN/m^2.

Each type of sack was loaded with 10kg, 15kg and 20kg of the fresh cassava pulp and dewatered in turn. The number of jacking strokes on the hydraulic jack was noted to keep the applied force fairly uniform in all trials. The dewatering force was intermittently applied until the breaking point (marked by a clique sound) of the sack was noticed. The force reading on the weighing balance at this point documented before terminating the experiment.

Figure 2: Experiment in progress.

These procedures were repeated five times for each sack sample for each product quantity and the average values recorded. The recording format of the results obtained is as presented on table 2

Table 2 : Maximum Forces Applied on the Different Sack Materials.

Product quantity (Kg)	Spring balance reading at applied sack breaking force. (kgf)					Calculated Force (kgf x g(m/s^2) (Newton)				
	T_1	T_2	T_3	T_4	T_5	F_1	F_2	F_3	F_4	F_5

Where; T_1 – T_5 are test results for trials 1-5, F_1 – F_5 are calculated force values in Newton for trials 1-5.

In determining the applied force (F), applied pressure and moisture content of the samples, the mathematical formulas as presented in equations 1, 2 and 3 were applied;

$$F = ma \tag{1}$$

Where; F is the force (N), m is the weighing springs reading (kgf) and a is the acceleration due to gravity (m/s^2)

$$Pressure = \frac{Force}{Area} \left(N/_{m^2}\right) \tag{2}$$

$$Moisture\ content\ (w_b) = \frac{mass\ of\ wet\ sample - mass\ of\ dry\ sample}{mass\ of\ wet\ sample} \times 100(\%) \tag{3}$$

3. RESULTS

The hydraulic press makes a base contact with the sacks containing the cassava pulp. This rectangular contact surface area was determined using equation (4) as:

$$Area = lenght\ \times width\ = 0.456\, m^2 \tag{4}$$

Subsequently, equation 2 was applied to determine the required breaking pressure for each type of sack at the various product quantities as shown in Table 3. A graphical illustration of the plot of applied pressure against the various types of sacks used for the experiment for the different quantities of cassava pulp is as presented on Figure 2.

Table 3: Computation of breaking Pressure on Different Sack Types

Type of sack	Product quantity used					
	10 Kg		15Kg		20Kg	
	Average force applied (kN)	Average pressure (kN/m^2)	Average force applied (kN)	Average pressure (kN/m^2)	Average force applied (kN)	Average pressure (kN/m^2)
Sugar sack	68.670	150.592	71.476	156.746	78.480	172.105
Rice sack	69.343	152.068	73.248	160.632	79.556	174.465
Flour sack	69.016	151.351	73.040	160.175	79.048	173.351

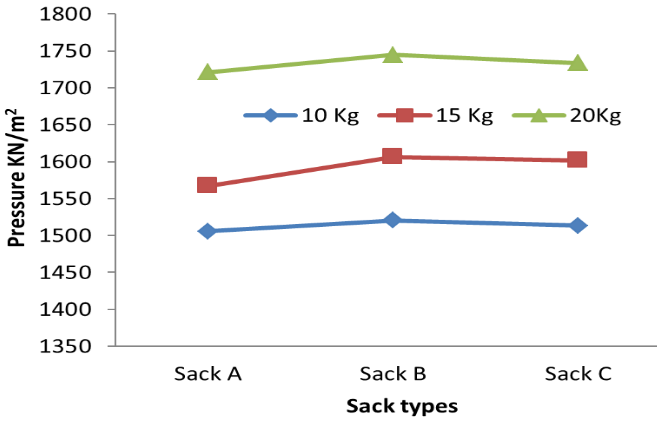

Figure 2: Graph of applied pressure against types of Jute sacks housing the cassava pulp.

4. DISCUSSIONS

The results of the experiment show that when 10kg of the product was used, the average maximum pressures obtained from the different five trials were: 150.592kN/m^2, 152.068kN/m^2 and 151.351kN/m^2 for sugar Jute fiber reinforced composites sack, rice Jute fiber reinforced composites sack and flour Jute fiber reinforced composites sack respectively. When 15Kg of the product was used, the average maximum pressures obtained from the different five trials were: 156.746kN/m^2, 160.632kN/m^2, 160.175kN/m^2 for sugar Jute fiber reinforced composites sack, rice Jute fiber reinforced composites sack and flour Jute fiber reinforced composites sack respectively. The results from the use of 20kg of the product reveal that the average maximum pressures were: 172.105kN/m^2, 174.465kN/m^2, 173.351kN/m^2 for sugar Jute fiber reinforced composites sack, rice Jute fiber reinforced composites sack and flour Jute fiber reinforced composites sack respectively. The graphical presentation of the results as shown in Figure 2 is a plot of the applied pressure (kN/m^2) on the Y-axis against the different types of sacks used for the experiments on the X-axis. The results reveal that the pressure required to dewater each quantity of the product to the sack breaking point varies with the type and strength of sack used. The results also show that more pressure is required to expel water from each type of sack used as the product quantity increases. The drop in tensile strength of the various sacks could be as a result of moisture absorption by the jute fiber material. Water absorption on composites is an issue to be considered since the water absorbed by the fibers in the composite could lead to swelling and dimensional instability and to a loss of mechanical properties due to the degradation of the fibers and the interface between the fiber and matrix [5].

5. CONCLUSION

In the course of this study, fifteen independent experimental trials were performed. The summary of the results show that the maximum breaking pressures of: 152.068KN/m^2, 160.632KN/m^2, and 174.465KN/m^2 occurred at 10kg, 15kg and 20kg respectively. These maximum sack breaking pressure values were observed for all product quantities when the sample (B) sack was used. It is therefore recommended that sample (B) which is a sack made from Jute fiber reinforced composites popularly used for bagging rice products be use for the dewatering operations of cassava pulp especially where high dewatering pressure is required.

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