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Full Length Research Paper

Evaluation of Cassava Tuber Resistance to Deformation

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A study was carried out, hardness and resistant ability of cassava tuber was investigated, the study involved the use of laboratory penetrometer and a data lodger. Hand-drilling machine was fitted with a 500mm diameter blade. These devices were powered manually and by application of electricity. Forces were applied by allowing direct cutting of the tubers using rotating sharp blade. The penetrometer was used to test the strength of fresh tuber. The result obtained indicated that cassava tuber hardness increases with the reduction of moisture content. The penetration force of 5.4 Newton at 70% moisture content wet basis was recorded while 9.2 Newton was recorded at 50% moisture content wet basis. The cutting time of 5.3 seconds was recorded for equal size tuber when the moisture was at 70%, at 50%moisture content 9.7 seconds was recorded. The implication is that all process handling of cassava tuber involving cutting must be carried out when the tuber is still tender.

Keywords: Hardness, penetrations, resistant, moisture, cassava Tuber,

INTRODUCTION

Cassava (*Manihot Esculenta*, Crantz) is an important root crop grown in many parts of the world. A large population of the people in the less developed countries of the world depends largely on cassava food products as a major source of carbohydrates. Cassava is grown in the tropical parts of Africa, Brazil, Malagasy, Indonesia, South India, Philippines, Malaya, Thailand and China. It has become the most important crop in terms of both the total land area devoted to its production and the proportion it contributes to the human diet. The cassava root tuber is the main economically useful part of the cassava plant. Apart from the importance of the cassava tuber as a constituent of human food, it has many non-food uses and it has become a foreign exchange earner for the

producing countries. China, the second largest producer of cassava in the world, earns over 2 billion dollars per year from the crop. This commercial potential of cassava is currently being under-utilized in Nigeria which is the largest producer of the crop in the world. Since 1990, Nigeria has surpassed Brazil as the world's leading producer of cassava (FAO, 1991). Other major producers of Cassava are Zaire, Thailand, Indonesia, China, India, Malaysia, Malawi, Togo and Tanzania.

Cassava products are very useful industrially in form of perfume and pharmaceutical, with others usefulness in engineering application as fuel, glue and fibbers (Gabarba, *et al.*, 2001). Industrial raw materials such as starch and alcohol have been reported. Cassava starch

is an ingredient in the manufacture of dyes, drugs, glucose, chemicals and carpets also in coagulation of rubber latex. Cassava, which has previously been regarded as, a poor man's food is increasing in industrial and economic potential.

To reduce the drudgery involve in cassava cultivation, so many engineering research is going on (Lungkapin *et al.*, 2007). Cassava production in Africa is projected to grow at about 3% per year within the next 20 years and double current level by 2020 (FAO, 2002). The first step in processing cassava into any product begins with the peeling after harvesting which involves cutting. Unfortunately harvesting and peeling constitute a serious bottleneck in the processing of cassava (Odighoh, 1991). The design of equipment for handling and processing cassava requires a thorough understanding of the engineering properties. (Kolawole *et al.*, 2007). The study of the physical properties and mechanical behaviour of some agricultural materials have been conducted by scientists, in order to improve their mechanisation, and commercial value (Agbetoye 1999).

In harvesting and processing of cassava, tubers are subjected to a number of forces without damage to the tuber; such are often determined in the laboratory for the purpose of predicting their resistance. Lilijedhal *et al.*, (1991) concluded that moisture content had very little effect on shear energy even with the use of sharp blade. The importance of moisture content on some properties of crops was demonstrated by Tunde-Akintunde and Akintunde (2007). McRandal and McNuty (1978 and 1980) made it known that the minimum blade velocity of satisfactory impact cutting was independent to the blade type but emphasises was laid on shear properties of various grasses because of the importance of the cutting operation in forage crop harvesting.

The objective of this study is to determine cassava tuber hardness and resistance to cutting, while evaluating the effect of tuber moisture content on the magnitude of the applied forces.

MATERIALS AND METHODS

Freshly harvested cassava tubers, Oven, Penetrometer, Hand drill with saw and a stopwatch were used in the experiment. The ability of the tuber to resist indentation when subjected to a compressive force was evaluated at different moisture content using a penetrometer with electronic sensitivity and data logger.

Resistance to cutting of the tuber was determined as another measure of hardness by cutting whole cassava tuber samples, relying on Robson (1966) technique which measures the force developed when a rotating blade cut a spiral path in cake. A circular saw blade was also used

by Wade (1968) to find the time required to cut into a stack of biscuits as a measure of hardness. A digital stopwatch, a circular cutting blade, a fabricated holder and a drilling machine for applying the cutting action on the sample were made available as described in 2.1 and 2.2 below.

Hardness Test Equipment Description

A cp20 cone penetrometer made by Agridmy Rimik Pty Ltd was used; it is a sophisticated cone penetrometer with data logger made primarily for use in soil laboratory for density, traffic ability and compaction studies. The instrument measures and records cone index data, it provides a flexible range of file recording formats for data up to 30,000 values. It stores and transfer to a computers via the in-built RS232 interface. Cone index measures down to a depth of 600 mm in soils with cone pressure values up to 500 kpa. The most important feature of this penetrometer is the use of an ultrasonic method for measuring depth. This unique feature allow for easier use of the instrument in the field, and the adaptability of it for cassava tuber hardness measurement without modification.

Cutting Test Equipment Description

A frame was constructed to hold Black and Decker drilling machine with a variable speed down. A blade of 500mm diameter with a 2 mm thick was attached to a 10mm diameter stud, 150mm long, held in the drill jaw. The weight of the drill machine is heavy enough to provide easy penetrations of the rotating blade over the cassava tuber sample. The cutting plate was secured with a nut and a spring washer firmly to a threaded rod holding the blade some 80 mm from the tip of the drill. A clamping device was provided such that the cassava sample can be held down firmly. A stopwatch was made available near the switch to the drill such that both the switch and the stopwatch can be activated and stopped simultaneously in figure 1.

Procedure

To carry out tests on the cassava tuber sample, an improved cassava from the International Institute of Tropical Agriculture (IITA) TMS 4(2) 1425 was used. The freshly harvested roots were sorted out for each class of test required, marked A B, C, D in that order for the one with the highest moisture content until E, the lowest for the penetrometer test. The cutting test samples were

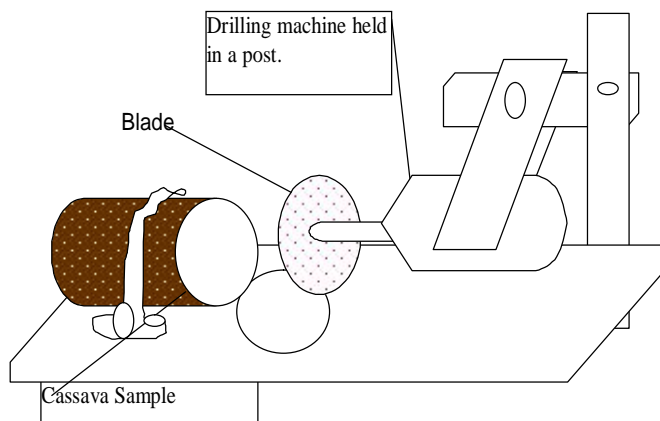


Figure 1. Experimental tool for resistance to cutting

Table 1. Result of hardness test

Sample	%mc wb	Force (N)
A	70	5.418
B	65	5.916
C	60	6.440
D	55	8.157
E	50	9.240

marked F to K (omitting I to avoid error). Fresh samples were taken in ten replicates and placed in an oven and they were re-weighed after 30 min, 1 hr, 1.5 hr and 2 hrs and 24 hrs. Experiments were carried out at five moisture contents based on the reserved marks. The near bone-dried sample confirms the total moisture contained by samples. Hardness was determined at different moisture contents using a CP20 cone penetrometer. The features of the penetrometer includes maximum depth of penetration of 600 mm, height parameter of 80 mm; the depth interval over which cone index values are integrated was set at 25 mm, maximum local value set up to 60 kg. The recording process was stopped occasionally at a predetermined load and maximum speed made to comply with ASAE standard S313.2, which specifies a maximum insertion speed of approximately 2 m/min.

The penetrometer and computer were connected with a cable for results down load. Steel cone was used as indenter; the angle of the cone was 15° . The cassava samples were placed on a concrete slab; the conical end of the penetrometer was forced into the sample. Force was applied at interval and the result was down loaded into the computer in the soil physics laboratory of IITA,

Ibadan. The hardness was then measured as the resistance to penetration. The penetrometer set gave the result for every 25 mm penetration.

The resistance to cutting was evaluated by cutting the sample with a disc as shown in figure 1, using a modified hand-drilling machine with a variable speed. Resistance to cutting was assessed as the time taken to cut through the samples, as Robson (1966) measured the force developed when a rotating blade cut a spiral path in the cake; Baryeh, (1990) cut stack of biscuit with a circular saw blade as a measure of hardness. A cassava tuber of 90-100 mm diameter was held down with clamp, and the speed of the drill was set at 250 rotations per minute with sharp blade of diameter 500mm.

RESULTS

From Table 1, the results of the hardness test show that for given moisture content the load varies with the instrument penetration. The cord and the pith of the cassava samples are harder compared with the medullar zone. The penetration increased with the given sample

Table 2. Cutting resistance result

Sample	%mc wb	Time in Sec.
F	70	5.3
G	65	6.6
H	60	7.5
J	55	8.4
K	50	9.7

moisture content. This indicated that the higher the moisture content the tenderer the crop. The crop is harder at low moisture contents.

Discussion

Machine for harvesting and tuber handling will normally operate on the crop at 60 to 70% moisture content. It is seen from table 2 that resistance to cutting depends on moisture content that the higher the moisture contents the less resistance the crop is and hence the faster the cutting. The laboratory evaluation of the hardness properties of cassava tuber for equipment designers was investigated to simplify design for notable damages that can occur when handling cassava tuber such as crushing, bruises, cracks or breakages. This study conducted determined the hardness property of cassava and the safely load it can withstand before damages. Simple fabricated equipment was used. It was found out that the lower the moisture content the harder the tuber become and the more it resists cutting and abrasion. This means that engineer wishing to design a machine for slicing the crop must consider the moisture content of the tuber at the design stage. The equipment capable of slicing it soon after harvesting should be the choice when it is still tender and energy can be utilized. Slicing at low moisture contents will require more time, energy and stronger cutter. This suggest that during transportation handling, sharp edges and objects may touch the tuber, this need to be protected or cushioned whenever possible to reduce the damage. Other stages operations can be performed at 65% to 70% moisture content wet basis when the tuber is in tenderness condition.

CONCLUSIONS

This study explains some engineering properties of cassava tuber, hardness and resistance to cutting was evaluated, the effect of tuber moisture content on the magnitude of the applied forces was

Documented. The penetration force of 5.4 Newton at 70% moisture content wet basis was recorded while 9.2 Newton was recorded at 50% moisture content wet basis. The cutting time of 5.3 seconds was recorded for equal size tuber when the moisture was at 70%, at 50%moisture content 9.7 seconds was recorded. These are useful data in reducing the drudgery involve in transportations and processing. The result obtained indicated that hardness of cassava tuber increases with the reduction of moisture content. The implication is that all process handling of cassava tuber involving cutting must be carried out when the tuber is still tender.

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