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STUDY OF IMPACT ENERGY REQUIRED FOR EFFECTIVE CRACKING OF DRIED OIL PALM NUTS

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ABSTRACT

This paper attempts to obtain the impact energy required for effective cracking of dried oil palm nuts to obtain high yield of whole kernels irrespective of the sizes and varieties. This is necessary because small scale farmers involved in cracking nuts do obtain nuts in most cases from processing of bulk nuts of mixed varieties. In this study, each variety (Dura, Tenera and Pisifera) of dried palm nuts were selected into classified size ranges based on their geometric mean diameter. Twenty-five nuts from each classified size range were picked randomly and mixed to form a group of nuts per variety. Ten groups and ten predetermined height drop of hammer mass were used per nut variety. Visual observations of cracking status after each nut has experienced hammer mass impact were assessed. In each group per variety, only energies that caused nuts to fully crack and release whole kernel were computed. For each variety, a plot of percentage fully cracked nuts in each group versus its corresponding average energy showed that impact energies of 2.6, 1.82 and 0.97 Joules can crack well Dura, Tenera and Pisifera nuts respectively. The result further revealed that impact energy of 2.34 Joules was adequate to crack any of the nut varieties to release 91.5 percentages of whole kernels. This implies that cost in terms of time and energy for sorting; and identifying nuts into each variety and size ranges from bulk nuts of mixed varieties before cracking would be conserved.

Key word: Impact Energy, Whole Kernel; Fully Cracked, Dried Palm Nuts.

1.0 INTRODUCTION

The oil palm varieties grown mostly in Nigeria are Dura, Tenera and Pisifera. The Dura type has thin mesocarp, thick shell with large kernels. The Tenera has thick mesocarp with thin shells and average size kernels; while the Pisifera has thick mesocarp and thin shells with small kernels. Oil palm nuts are obtained from oil palm fruits (Hartley, 1977). Each nut consists of shell, embryo embedded in a hard oily endosperm surrounded by a tough black intergument called testa (Wood et al., 1976). The nuts are usually dried for optimum cracking in order to release kernels (Okoli, 2003). The oil in the kernel could be extracted and used for production of edible vegetable oil, soap, etc. The cake obtained after oil extraction is useful for livestock (Kifli and Karishma, 1987). The shell particles can be used in decoration of apartment premises (Illechie et al., 2004). Generally, the quality parameters of palm kernels required for further processing are that they should have not more than 4 percent split kernels and 2 percent foreign matter including shells (Turner and Gillbank, 1974). Thus, cracking of nuts to obtain fully cracked nuts with release of whole kernels may be a necessary pre-requisite for achieving good quality processed kernels. Normally, the nuts cracked would release whole kernels when they are subjected to appropriate impact energy (Dienagha and Ibanichuka,

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1991; Asoegwu, 1995; Oje et al., 1997; Adigun and Oje, 1998; Babatunde and Okoli, 1988; and Okokon et al., 2007). Depending on the magnitude of the impact energy, the nuts may be smashed (i.e. kernels and shells broken together) (KS); fully cracked to release kernels that sustain wound (KW); fully cracked to release whole kernels (KF); un-cracked (KU); visibly cracked (KV). The physical and mechanical properties of oil palm nuts are likely to be influenced by the varieties of oil palm seed (Manuwa, 1998; Koya and Faborade, 2004). This is because nuts of the same size but of different varieties do have in most cases different thickness of the shell; hence their cracking energies may most likely be different (Babatunde and Okoli, 1988).

Studies on Dura Variety have shown that a certain range of energies when applied to nuts classified into a particular size range, would crack the nuts and release whole kernels (Dienagha and Ibianichuka, 1991; Babatunde and Okoli, 1988). However, small scale farmers involved in cracking nuts do obtained nuts in most cases from processing bulk nuts of mixed varieties. It would be difficult, time and cost consuming in identifying and sorting each nut into each variety and size range from the bulk nuts of mixed varieties. This study is to assess and determine a favourable energy which when applied on dried palm nuts ready for cracking, would achieve a high percent of KF irrespective of the nuts sizes and varieties. This would reduce overall cost of cracking operations as there would be no need to sort nuts into various varieties and sizes/size ranges before cracking vis a-vis applying different energies on the sorted varieties and sizes/size ranges of nuts. To obtain experimental data useful in determining a favourable impact energy for effective cracking of palm nuts, a nut cracking energy equipment (Figure 1) was employed.

2.0 THEORY

If a mass of hammer (M) is lifted vertically through a height (h), and then allowed to fall; the work done against gravity (g) is Mgh (Joules). The velocity (V) acquired as it falls before impact on the nut is

$$V^2 = U^2 + 2gh \text{ (Nelkon, 1981)} \qquad (1)$$

u = initial velocity = 0
V = final velocity
g = acceleration due to gravity

$$V^2 = 2gh \text{ or } V = \sqrt{2gh} \qquad (2)$$

When the hammer strikes on the nut some kinetic energy is lost due to heat, sound, etc. Moreover, if the hammer energy is:

(a) In excess required for nuts to be fully cracked (KF) then the nuts will either be smashed (KS) or fully cracked with wound (KW)
(b) Insufficient for nuts to be fully cracked (KF) then the nuts will either be visibly cracked (KV) or un-cracked (KU)
(c) Just enough to crack nuts fully (KF) then whole kernel would be released after impact.

Assume no rebound of hammer at KF, then the kinetic energy (K.E) of hammer is given as $K.E = {}^1/_2MV^2$. (Asoegwu, 1995)

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Also, as the hammer strikes the nut placed on a stationary impact surface of the nut cracking energy equipment, the

Initial Momentum = MV (3)

Final Momentum = $(M+m^*)V_1$ (4)

Where, V_1 = Common velocity of mass of hammer and cracked shell from point of impact. m^* = mass of the cracked shell facing the hammer impact. (note: shell at down part is immovable downwards during impact as it faces a stationary metal impact surface). Hence, m^* only move a distance equal to the clearance between the shell and the kernel inside the nut.

Therefore, $MV = (M+m^*)V_1$ (5)

From equation 2,

$$M\sqrt{2gh} = (M+m^*)V_1 \quad (6)$$

$$V_1 = \frac{M\sqrt{2gh}}{(M+m^*)} \quad (7)$$

m^* is so small compared with M, hence m^* would make little or no difference in velocities before and after impact.

$$\text{Hence, } V_1 = [M(\sqrt{2gh})/[M] \quad (8)$$

$$V_1 = \sqrt{2gh} \quad (9)$$

Moreover, Kinetic energy before impact ($K.E_b$) Kinetic energy after Impact ($K.E_a$) = loss of energy.

The loss of energy is assumed to be negligible. The Kinetic energy of the hammer and nut after impact

$$= \frac{1}{2}MV_1^2 \quad (10)$$

$$= \frac{1}{2}M(\sqrt{2gh})^2 \quad (11)$$

$$= Mgh \quad (12)$$

where, h = H-d and

H = height of hammer from the stationary plate of which the nut is placed before impact, m; d = geometric mean diameter of the nut placed on the stationary impact plate, m.

3.0 MATERIALS AND METHODS

Dried oil palm seeds of Dura, Tenera and Pisifera varieties were obtained from oil processing mill and subjected to further drying on the sun for six days so as to achieve optimum crack ability when the nuts experience impact. To obtain a comprehensive energy assessment, each variety of oil palm seeds were sorted into 22 (twenty two) size ranges based on their geometric diameters using venier caliper. In each size range, twenty five nuts were randomly picked and mixed to form a group.

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A total of 550 (five hundred and fifty) nuts per group per variety were then obtained as a fair representation for each assessment of nuts impact energy requirement. For each variety, ten (10) groups were obtained. The energies used were based on hammer mass height drops. These height drops covered beyond energy peak points by Dienagha and Ibanichuka, 1991 for fully cracked nuts that release whole kernels. The hammer mass energy applied on each nut per height drop was calculated based on equation (12). A grand total of 5,500 (five thousand five hundred) nuts were obtained for each variety of oil palm nuts and a static impact method was employed using nut energy cracking equipment and 1.25kg hammer mass as shown in Figure 1. For each variety, each nut was placed at the centre of the equipment base plate. The nuts after experiencing impact by the hammer mass was visually observed and only those nuts that were fully cracked with release of whole kernels were recorded. Based on equation (12), the energies of each nut in the ten (10) groups per height drop per variety were calculated; then averaged and recorded. The percent of fully cracked nut (KF) per height drop level per group was calculated as shown below.

$$\text{Percentage of fully cracked} = \frac{\text{(Number of Nuts observed to be fully cracked, (KF) per height drop level per group per variety)}}{\text{(total number of nuts used at height drop level (550))}}$$

$$\text{Average, Impact Energy} = \frac{100 \times \text{(Summation of values of computed nut energies per height drop level per variety)}}{\text{Total number of nuts used per height drop level (550).}}$$

The percentage fully cracked nut (KF) versus its corresponding impact energy per height drop per group per variety were plotted as shown in Figure 2 in order to determine a favourable impact energy required to crack palm nuts to achieve high yield of KF. The nuts used for this study were found to be within geometric mean diameter d<26mm.

4.0 RESULTS AND DISCUSSION

From Figure 2, the favourable impact energy for bulk nuts of mixed varieties of Dura, Tenera and Pisifera is extrapolated from the intersection of the curves; and the value is 2.34 Joules corresponding to 91.5 percent yield of KF. At this yield, the 8.5 percent left may most likely have equal or nearly equal percent representation of KS, KW, KV and KU depending on palm nuts sizes and other physical and mechanical properties. Moreover, each variety namely Dura, Pisifera and Tenera were observed to have optimum cracking energies of 2.6, 0.97 and 1.82 Joules respectively and yielding more than 92 percentage KF. Generally, increase in impact energy gradually decreases the percentages KU and KV but increases KF up to the crest point per nut variety as shown in Figure 2. Beyond the favourable impact

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energy, the percentage KW would be pronounced but with further increase in impact energy, the percentage KS would increase correspondingly.

It should be noted, that at any impact energy the percentages KU, KV, KF, KW and KS would be available singly or with any combination of percent observation. This perhaps is due to the effect of nut physical (e.g. mass, shape, shell thickness, moisture content, etc) and mechanical (e.g. shell compressive strength, etc) properties; quantity of applied impact energy. From the experiment, it was observed that there is a range of energies for a particular nut size or classified nuts size range with respect to its geometric mean diameter.

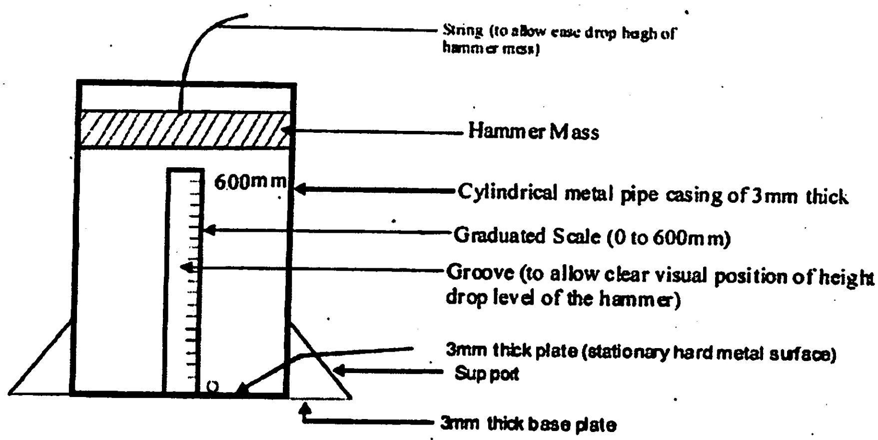

Figure 1a: Front view of Nut Energy Cracking Equipment

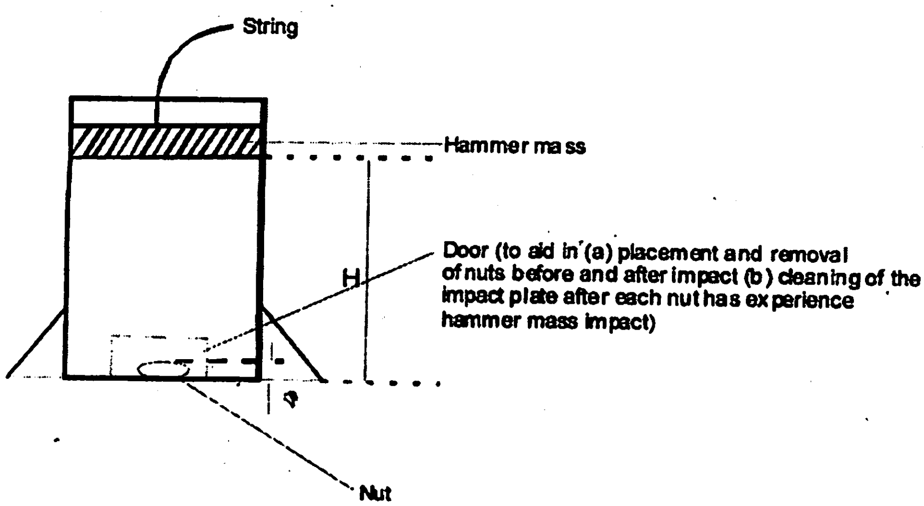

Figure 1b: Rear view Nut Energy Cracking Equipment

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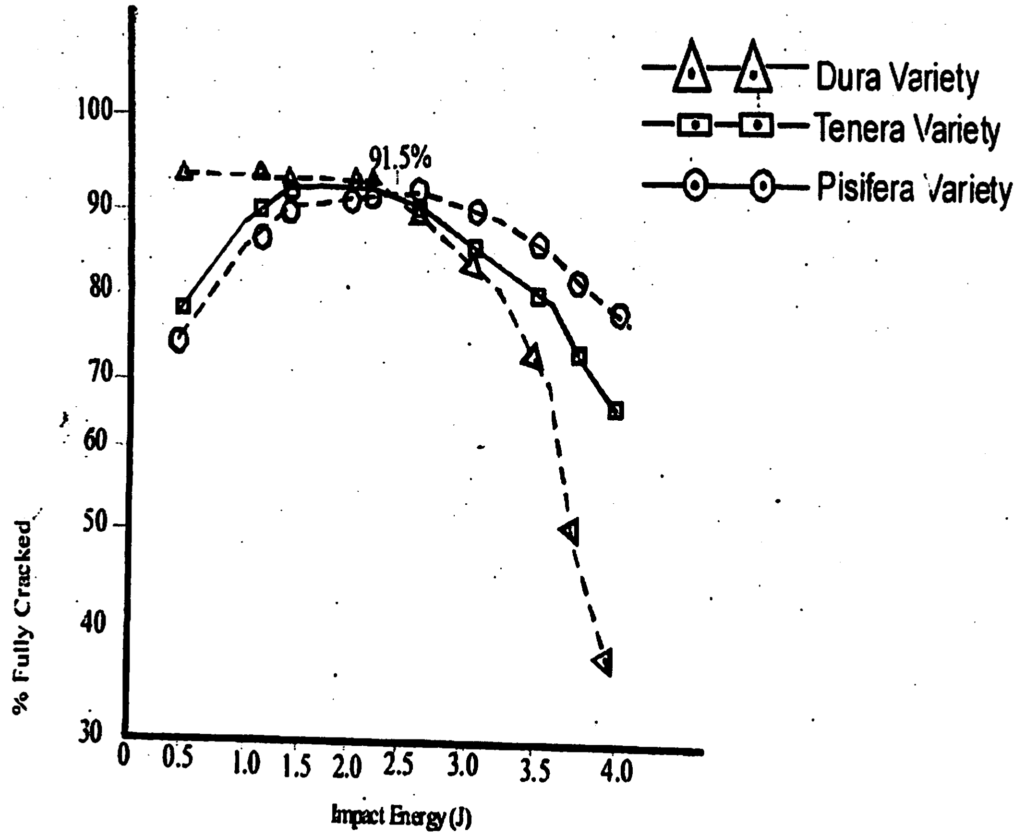

Figure 2: Percentage Fully cracked nuts against Impact Energy for different varieties of Oil Palm nuts

Furthermore, it is suggested that on application of appropriate impact energy in a nut cracker, more nuts that were KU and KV may become KF, if they are re-introduced into the nut cracker. This is because re- introduction of Ku and KV would weaken the compressive strength of the shell during each impact; and would result in high percentage KF yield. In a centrifugal nut cracker the presentation of the nuts at impact surface is highly randomized and therefore not necessarily be impacted on nominal diameter (smallest diameter through center of the nut as placed in the nut cracker energy equipment). Since each nut size range per variety have a range of energies that can give reasonable percentage KF, then the effect of nut random presentation at impact surface would most likely be absorbed within the energy range. Subsequently, the nuts would crack and possibly give KF. The nut orientation / presentation with regards to percentage KF can also be accommodated due to shell compressive strength weakening during re- introduction of nuts into the cracking unit.

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4.1 Practical Application

The impact energy of 2.34 Joules when applied in a centrifugal nut cracker yielded above 90 percent KF for bulk nuts of mixed varieties and sizes cracked.

5.0 CONCLUSIONS

From this study, it would be concluded that;

(1) Each 'well dried' nuts having similar geometric mean diameter irrespective of its other physical properties (e.g. mass; major, intermediate, and minor diameters; etc) would possess energy ranges that if applied would crack and cause release of whole kernels.

(2) Application of 2.34 joule on a 'well dried' bulk nuts of mixed varieties with geometric mean diameters d<26mm would yield about 91.5 percent KF

(3) The optimum impact energies that would yield more than 92percent KF for Dura, Tenera and Pisifera varieties are 2.6, 1.82, and 0.97Joules respectively.

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