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DETERMINATION OF THE OPTIMUM MOISTURE CONTENT FOR THE WHOLE KERNEL RECOVERY DURING THE CRACKING PROCESS OF OIL PALM NUTS

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ABSTRACT: *This study aimed to investigate the effect of moisture content on palm nut cracking and kernel production using a locally fabricated palm nut cracker. Palm nuts of mixed varieties (Dura, Tenera, and Pisifera) were manually cleaned and dried at different moisture content levels ranging from 8.53% to 26.82%. The palm nut cracker is designed with four major units: the in-feed unit, cracking unit, discharge unit and the driving unit. The cracking efficiency was determined by calculating the ratio of completely cracked nuts to the total nuts fed into the hopper. Results show that the whole kernel recovery varies considerably with moisture content and cracking speed. At the lowest moisture content of 8.58%, the whole kernel recovery is generally low across all the cracking speeds. As the moisture content increases, there is a significant improvement in whole kernel recovery at all the cracking speeds. The highest whole kernel recovery was obtained at intermediate moisture contents of around 14% to 18%, and the cracking speeds of 1000 rpm to 1400 rpm. The ANOVA table shows that both the cracking speed and moisture content have a significant effect on whole kernel recovery. Optimizing these parameters could lead to higher whole kernel recovery. However, it is important to note that other factors such as the cultivar of the nut and the equipment used may also affect the whole kernel recovery.*

KEYWORDS: Determination; Optimum; Moisture Content; Whole Kernel; Recovery; Cracking Process; Oil Palm Nuts

INTRODUCTION

Oil palm (*elaeis guineensis*) is one of the most important sources of oil for domestic and industrial purposes, and its fruit is a major export product for most countries of West Africa. Palm fruit is a composition of an edible kernel covered with a hard endocarp (shell), which constitutes the nut and is also covered by a fleshy outer pulp, the mesocarp (Sam *et al.,* 2022b). After the palm oil has been extracted, the chaff and the palm nut can further be processed to produce other valuable substances like palm kernel oil (P.K.O.) which is used in producing chemicals for the pharmaceutical, cosmetics and laundry industries (Okokon *et al.,* 2015). There are three basic varieties of the oil palm fruit, the *Dura*, the *Tenera* and the *Pisifera* (Jimoh, 2004). Palm nuts are important by-products from oil palm mills after extraction of palm oil from the fruits (Sam *et al*, 2022b). The nuts are dried and cracked to release the oily kernels. Palm kernels are crushed in the local mills for the palm kernel oil and kernel cake. The kernel oil is used for the production of glycerin, margarine, edible oil, confectionery, candles, soap, oil paint and medicines. The kernel cake is an ingredient for livestock feeds in the livestock industry. The economic importance of palm kernel is indicated by its wide use in food, traditional medicine and industries (Koya *et al.,* 2004; Edet *et al*., 2022). The cracked shell can be used for road constructions, brake pads and coarse aggregate in concrete for building (Sam *et al*, 2022a). The chaff and shell are used locally for the manufacture of candles and as fuel for cooking. Thus, every part of the palm fruit or its by-products is economically useful (Patrick and Godspower, 2014).

In the processing of kernel oil, nutshell cracking is the most critical and delicate operation. Its major concern is to extract the whole kernel from the shell. Cracking palm nuts to release the kernels is a step that affects the quality of kernel oil. There are two types of modern palm kernel crackers; the hammer impact and the centrifugal impact types (Biyeye, 2022). These modern crackers are not free of limitations. Hammer impact type breaks or cracks the nut on impact when the hammer falls on it; while centrifugal impact nutcracker uses centrifugal action to crack the nut (Ndukwu and Asoegwu, 2010). Conventionally, palm kernel cracking machines usually work on the principle of impact either using centrifugal means to deliver the energy or using the hammer mill. (Olaoye and Adekanye 2018).

Palm kernel is a major product of oil palm processing. It is obtained by cracking the oil palm nut. Nearly every household cracks oil palm nut and this can be done manually or mechanically. In either case, the nature of cracking depends on the moisture content of the nut which also depends on the method of handling. Some farmers, equally dry the oil palm nut overnight, some on trays near the fireplace and they can be over-dried or under-dried. These can pose a challenge during the cracking process (Ologunagba, 2012). Furthermore, efficient cracking and separation of cracked palm nut shells from kernels has been an age-long problem in the processing of vegetable oil in Nigeria. Largely, this has hindered the production of palm kernel in large quantities to satisfy the yearnings of agro-allied processing and manufacturing industries (Esua *et al*., 2015). The percentage damage of the palm kernels and recovery of whole kernels during the cracking process of the palm nut greatly influence the market value of palm kernels. The products of whole kernels, broken kernels and the shell particle size after cracking are equally affected by the nut moisture content (Adebayo, 2004). If the proper moisture content of a nut is achieved before cracking, the efficiency will improve and the power requirement reduced. Hence, the general objective of this study is to determine the optimum moisture content for whole kernel recovery during the cracking process of oil palm nuts.

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MATERIALS AND METHOD

Materials

The materials used during the experiment were palm kernels of different varieties (Figure 1a), digital weighing balance (ATOM A-120), basin, centrifugal nutcracker, oven (model MINO/50), stopwatch and tachometer (model: Lutron DT-2234A).

Figure 1a: Fresh palm nut

Figure 1b: Oven (model MINO/50)

Fresh palm nut of mixed varieties (Dura, Tenera and Pisifera) was purchased from the local market at Adiok Itam in Itu Local Government Area, Akwa Ibom State. The nuts were manually cleaned and washed to remove foreign materials, broken, immature nuts and fibre. The samples were oven-dried.

Figure 2: Ready to crack nut

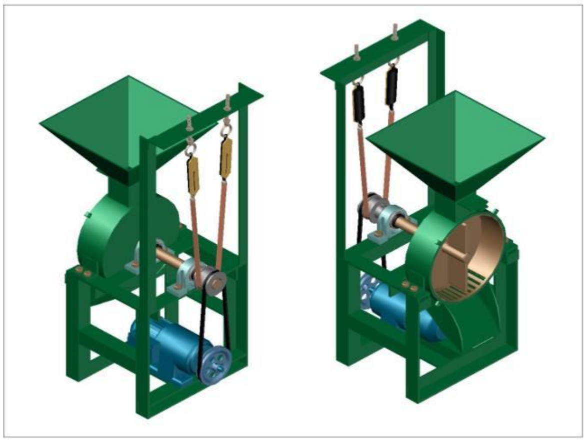

Figure 3: Palm nut Cracker

Description and Operation of the Experimental Machine

The machine consists of four major units: the in-feed unit, the cracking unit, the discharge unit, and the driven unit. The in-feed unit consists of the feed hopper and a slot which opens and closes the hopper. The feed hopper design was largely influenced by the throughput capacity required to make the performance of the machine satisfactory. The cracking chamber takes the shape of a hollow cylinder tube with rectangular (channel-shaped) impeller blades at its core. The core of the cracking chamber is characterised by the impeller blades and tubes; the tube

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being the carriage for the rotary motion of the blades. The cracking unit is made of mild steel. The discharge unit is situated directly below the cracking chamber with a discharge opening designed to allow for the passage of multiple cracked nuts per time, thus preventing jam at the discharge. The driving unit consists of the prime mover; the electric motor, the one-way pulley and the belt drive.

The machine is put into operation by starting the electric motor, which provides the required power to drive the pulley of the cracking machine thereby causing the impeller blades to rotate. The cracking speed was adjusted by adjusting the power supplied to the electric motor. The cracked mixture falls by gravity through a discharge outlet situated directly below the cracking chamber. The cracking process is achieved by the impact force exerted on the nuts by the impeller blades against the walls of the cracking chamber. The impact force is generated by the kinetic energy of the impeller blades; each palm nut being fed to the cracking chamber is struck against the walls of the cracking chamber by high-velocity impeller blades, thus creating sufficient impact force to crack and loosen each kernel seed from its shell covering and discharged through the delivery chute.

Experimental Design and Procedures

Sixty (60) samples of 1000g each of fresh palm nuts were used for the experiment. These samples were divided into two to make two replicates of thirty samples for each run.

The samples were dried in an oven at the temperature of 105^{o}c. At 2-hour intervals, 5 samples were removed, cooled and weighed for moisture content determination. The samples were cracked at 5 different speeds 1000, 1200, 1400, 1600, and 1800rpm. Depending on the speed used, it took approximately 8-15 seconds to crack each sample.

The cracked mixture was collected and sorted out for whole kernels, broken kernels and uncracked nuts. The procedures were repeated after 4,6,8 and 10hrs of drying. 5 samples of fresh nuts used as control were also cracked with the 5-level speed.

Figure 4: Whole kernel

Figure 5: Broken kernel

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Moisture Content Determination

The initial mass (Mo) was weighed using an electronic weighing balance. The weighed nuts were subjected to drying in a hot air convection oven operated at 105ºC. The drying process was carried out at intervals of 2, 4, 6, 8, and 10 hours respectively.

The moisture content was calculated using the equation below:

$$\%\ \text{moisture content} = \frac{M_0 - M_1}{M_0} \times 100 \quad (1)$$

Where: M_O is the weight of the sample before drying

M_1 is the final weight of the sample

Speed Determination

Based on the preliminary experiment and literature review, the speed range of 1000, 1200, 1400, 1600 and 1800 rpm was used during the experiment. A tachometer was used to set the rotor speed during cracking.

Cracking Efficiency

The cracking efficiency (Whole Kernel Recovery) was determined for each sample used during the experiment. The equation below was used.

$$Cracking\ Efficiency = \frac{Whole\ Kernel}{Total\ Nuts\ Inputs} x100 \quad (2)$$

Physical Characterization of Kernel Nut

Geometric diameter: The geometric mean diameter (GMD) was calculated as

$$GMD = (abc)^{1/3} \quad (3)$$

Sphericity: The sphericity *f*, was calculated using the equation:

$$f = \frac{(abc)^{\frac{1}{3}}}{a} \quad (4)$$

Unit volume B: The unit volume of 20 individual seeds was determined from values of a, b, and c using the formula:

$$v = \frac{abc}{\pi} \quad (5)$$

Projected area: The projected area was calculated using the equation proposed by Udo *et al*. (2015);

$$A_p = KV^{\frac{2}{3}} \quad (6)$$

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Where: A_p = average projected area (mm^2)

K = constant, 1.21

V = projected volume (mm3)

Surface area: The surface area was evaluated using the equation as proposed by Udo *et al*. (2015);

$$A_s = \left(36P\frac{1}{3}\right)V\frac{2}{3} \quad (7)$$

Where, = Average surface area (mm^2)

Bulk density: The bulk density was calculated by Udo *et al*. (2015);

$$L_b = \frac{W_b}{V_b} \quad (8)$$

Where: W_b= Mass of seeds (kg)

V_b= Volume of container (m^3)

V = product volume

The actual density was calculated as follows;

$$l_{Tr} = \frac{m}{V} \quad (9)$$

Where: l_{Tr}= true density (kg/m^3)

M = mass of individual seeds (kg)

V = product volume (m^3)

Porosity: The porosity of the bulk seed was computed from the values of the true density and bulk density of the seeds by using the relationship given by Ajewole (2014)

$$P_f = 1- \frac{l_d}{l_{Tr}} \times 100 \quad (10)$$

Where: P_f= porosity in %

l_d = Bulk density, kg/m^3

l_{Tr} = true density, kg/m^3

Determination of Geometric Mean Diameter of Shell Particles

The weights of the shell particles retained on each sieve at each run were used to determine the Geometric Mean Diameter (GMD_{SP}) and the Geometric Standard Deviation of the shell particles (GSD_{SP}) by using the logarithmic normal distribution parameters, according to ASABE (2006) Standard.

$$GMD_{SP} = Log^{-1}\left(\frac{\sum(W_i Logd_i)}{\sum W_i}\right) \quad (11)$$

$$GSD_{SP} = Log^{-1}\left(\frac{\sum W_i(Logd_i - LogGMD_s)^2}{\sum W_i}\right)^{\frac{1}{2}} \quad (12)$$

Where;

GMD_{SP} is the geometric mean diameter of shell particles in mm;

GSD_{SP} is the geometric standard deviation of shell particles in mm;

W_i is the weight of the sample on each sieve in g;

d_i is the diameter of the opening of each sieve and is defined as:

$$d_i = (d_r \times d_p)^{\frac{1}{2}}$$

where; d_r is the size of the sieve on which particles are retained in mm

d_p is the size of the sieve through which particles pass in mm

Analyses of Data

Analysis of variance (ANOVA) for Randomized Complete Block Design was used to analyze the experiment.

RESULT AND DISCUSSION

Moisture Content Determination

The average moisture content of the nuts varying with drying time is given in Table 1. The weight of the dry-cooled nuts was obtained at 2-hour intervals. The moisture content for each sample was computed (Sam, 2017; ASAE, 2000). Drying times for the study were 0,2,4,6,8, and 10 hours.

Table 1: Average Moisture Content of Nuts Varying with Drying Time

Drying Time (Hours)	**Moisture Content (%)(w.b)** **Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	Average Moisture Content (%)
0 (Fresh nuts)	26.7	27.0	26.8	26.6	27.0	26.82
2	22.9	22.9	21,8	21.6	22.3	22.3
4	19.0	18.5	18.3	18.3	17.9	18.46
6	14.5	14.7	13.6	13.6	14.3	14.34
8	9.9	10.4	10.0	10.6	10.1	10.12
10	8.0	8.9	8.5	8.5	8.7	8.58
12	6.6	6.6	6.6	6.6	6.8	6.94
14	2.9	3.1	2.6	2.6	3.4	2.98

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The initial weight was 1000g, and after 14 hours of drying, the constant weights ranging between 730 and 734g were obtained from the 5 samples. The average moisture content of the samples was found to be 26.82%, 22.30%, 18.46%, 14.34%, 10.10%, 8.70%, 6.80% and 3.40%.

Cracking Performance

Cracking Performance for Fresh Nuts

Table 2: Average Cracking Performance for Fresh Nuts at 26.82% Moisture Content

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	260	26.82	30.01	66.92	3.07	11
1200	227	26.82	21.14	76.66	2.20	12
1400	248	26.82	19.80	79.00	1.20	17
1600	259	26.82	13.52	86.48	0	11
1800	242	26.82	9.02	79.99	10.99	11

Table 2 shows the cracking performance of a nutcracker on the fresh palm nut with 26.82% moisture content. It shows that 30.01% whole kernel was recovered, 66.92% of the kernels were broken and 3.07% of the nuts were uncracked. At the highest cracking speed which is 1800rpm, the percentage of whole kernel recovered reduced drastically due to the increase in speed of the rotor leaving us with 9.02% of whole kernel only. This shows that acquiring high percent of whole kernel is dependent on both the moisture content and the rotor speed.

Cracking Performance after 2hours of Drying

Table 3: Cracking Performance after 2 hours of Drying at 22.30% Moisture Content

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	261	22.3	64.75	31.41	3.84	15
1200	243	22.3	64.19	34.15	1.66	11
1400	254	22.3	39.29	59.07	1.64	11
1600	264	22.3	25.75	73.86	0.39	12
1800	257	22.3	17.12	82.87	0.21	11

Table 3 shows that whole kernel recovery decreased with an increase in speed. The recovery of the broken kernel is directly proportional to the increase in speed. This means that the higher the speed the higher the percentage of the broken kernel we get and the lesser the cracking time.

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Cracking Performance after Drying for 4 Hours

Table 4: Cracking Performance after Drying for 4 hours at 18.5% Moisture Content.

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	247	18.46	88.25	5.26	6.49	14
1200	236	18.46	53.40	44.49	2.11	12
1400	227	18.46	44.49	54.62	0.89	11
1600	222	18.46	31.98	67.56	0.46	10
1800	228	18.46	21.92	77.19	0.89	10

As shown in Table 4, the whole kernel recovery was higher at a lower speed and decreased as the speed increased from 1000rpm to 1800rpm while the percentage of the broken kernel increased with an increase in the speed of the rotor.

Cracking Performance after 6 Hours

Table 5: Cracking Performance after 6 Hours at 14.34% Moisture content

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	259	14.34	81.65	16.97	1.38	14
1200	261	14.34	84.07	13.38	2.55	13
1400	241	14.34	50.58	48.15	1.27	11
1600	252	14.34	74.26	25.73	0	12
1800	260	14.34	19.82	80.18	0	11

After drying this sample for 4hrs about 12.49% of moisture was successfully removed and this happens to be the best moisture content for cracking in the cause of this experiment (Table 5). The highest percentage of whole kernel (84.07%) was recovered at 1200rpm with a low percentage of broken kernels respectively. The cracking performance here shows that cracking a nut with the speed of 1800rpm isn’t profitable as the percentage of broken kernels will be higher than that of the whole kernel.

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Cracking Performance after 8 Hours

Table 6: Cracking Performance after 8 Hours at 10.1% moisture content

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	218	10.12	67.18	31.27	1.55	11.5
1200	237	10.12	54.78	44.06	1.16	16
1400	236	10.12	29.04	70.12	0.86	10
1600	237	10.12	26.58	67.42	0.39	10
1800	227	10.12	17.33	82.29	0.38	8

Table 6 shows the cracking performance of nuts after 8 hours of drying. It was observed that, the highest percentage of the whole kernel which is 67.18% was obtained at the speed of 1000rpm while the lowest was obtained at 1800rpm.

Cracking Performance after 10 Hours Drying

Table 7: Cracking Performance after 10 Hours drying at 8.7% moisture content

Cracking Speed	Number of nuts	Moisture Content (w.b.) (%)	Whole Kernel Recovery (%)	Kernels Broken (%)	Uncracked nuts (%)	Cracking Time (second)
1000	239	8.58	28.03	71.96	1.25	12
1200	244	8.58	52.48	47.13	1.22	12
1400	234	8.58	42.73	57.69	0	12
1600	268	8.58	10.44	89.55	0	9
1800	246	8.58	8.13	91.86	0	10

Table 7 above shows the performance of the sample dried for 10hrs the only moisture remaining in this sample was 8.58% and its physical characteristic was like a burnt kernel. This produces one of the lowest whole kernels even at the lowest rotor speed and a higher percentage of broken kernels. The table shows that the highest percentage of broken kernels was gotten at this point.

Effect of Moisture Content on Whole Kernel Recovery at Various Cracking Speeds

For each cracking speed, the whole kernel recovery increased from the fresh sample with 26.82% moisture content to its peak at 22.3% moisture content (at 2 hours drying time) and then with a gentle gradient reduced to a level of 10.12% moisture content. This means that a reasonable quantity of whole kernels can be obtained at between moisture content levels of about 10% to 20% of the oil palm nuts when cracked.

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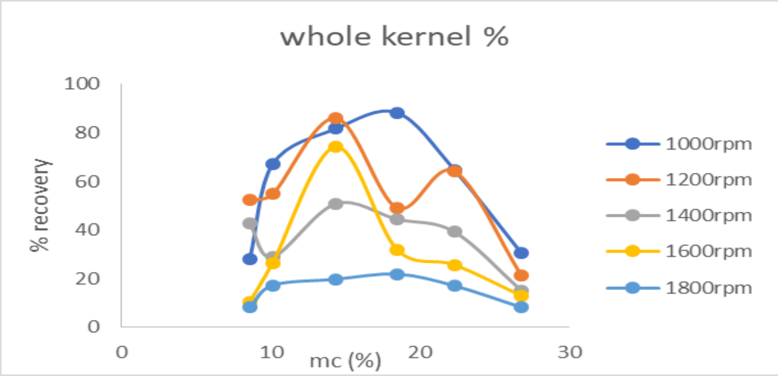

Figure 6: The effect of moisture content on whole kernel recovery at various speeds

This explained that low whole kernel recovery with the fresh sample at the beginning was due to high moisture content and that decline at very low moisture content was due to the shattering action of the over-dried samples. Figure 6 confirms that the whole kernel recovery decreases with an increase in speed at all moisture content levels. The nut cracking speed of 1200rpm produced the highest whole kernel quantity. This was followed by the cracking speed of 1400rpm and in that order.

It is observed that in these two performing cracking speeds (1000rpm and 1200rpm), the whole kernel recovery at the very dry state (down to 8.58% moisture content) was still higher than at the fresh state (high moisture content). At higher cracking speeds, the whole kernel recovery at the very dry state was lower than those of the fresh samples. The analysis of variance for the effect of moisture content and speed on whole kernel recovery is shown in Table 8.

Table 8: ANOVA Table showing the effect of moisture content and speed on whole kernel recovery

Source of Variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Speed	7929.401	4	1982.350	12.659	0.00	2.87
Moisture Content	6016.431	5	1203.286	7.684	0.00	2.71
Error	3131.863	20	156.593			
Total	46719.851	29				

alpha level = 0.05

The analysis in Table 8 shows that there was a significant effect of speed on whole kernel recovery since the calculated F-ratio (12.659) was greater than the critical value of 2.87. There was also a significant effect of moisture content on whole kernel recovery since the calculated F-ratio (7.684) is greater than the critical value of 2.71.

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Effect of Moisture Content on Broken Kernels at Various Cracking Speeds

For each cracking speed, the broken kernel recovery increased from the fresh sample with 26.82% moisture content, 22.3% moisture content (at 2 hours drying time) and then with a gentle gradient reduced to a level of 10.12% moisture content.

This explained that broken kernel recovery with the fresh sample at the beginning was due to high moisture content and that the increase at very low moisture content was due to the shattering action of the over-dried samples.

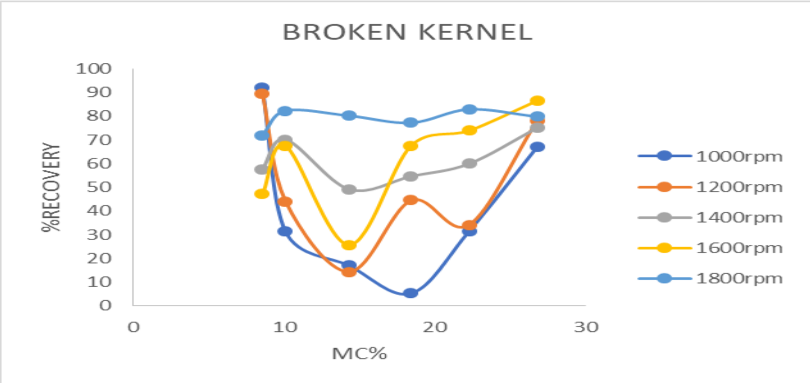

Figure 7: Graph showing the effect of moisture content and speed on broken kernels

As shown in Figure 7, broken kernel recovery increases with an increase in speed at all moisture content levels and the nut cracking speed of 1400rpm produced the highest broken kernel quantity. This was followed by the cracking speed of 1600rpm.

It is observed that in these performing cracking speeds (1400rpm 1600rpm and 1800rpm), the broken kernel recovery at the very dry state (down to 8.58% moisture content) were still higher than at the fresh state (high moisture content). At higher cracking speeds, the broken kernel recovery at the very dry state was higher than those of the fresh samples. The analysis of variance for effect of moisture content and speed on broken kernels is shown n Table 9.

Table 9: ANOVA Table showing the effect of moisture content and speed on broken kernels

Source of Variation	SS	Df	MS	F	P-value	F crit
Speed	4898.702	4	1224.675	3.576	0.023	2.87
Moisture Content	5267.917	5	1053.583	3.076	0.032	2.71
Error	6850.130	20	342.506			
Total	102920.376	29				

alpha level = 0.05

The analysis shows that, there was a significant effect of speed on broken kernel recovery in cracking palm nuts since the calculated F-ratio (3.576) was greater than the critical value of 2.87. There was also a significant effect of moisture content on broken kernel recovery in cracking palm nuts since the calculated F-ratio (3.076) is greater than the critical value of 2.71.

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CONCLUSION

The study aimed at investigating the optimum moisture content for whole kernel recovery during cracking process of palm nut. The sample used for the experiment are mixed variety (i.e dura, tenera and pesifera). The result of the experiment shows that as the speed increases from 1000 to 1800rpm, the recovery of whole kernel decreases at all moisture content levels. In other words, the recovery of whole kernel is inversely proportional to the speed. The recovery of broken kernel is directly proportional to the speed which implies that as the speed increases, the percentage of broken kernel increases too. The highest whole kernel recovery is obtained at the moisture contents between 14 to 18%. From table 8, it shows that the highest percentage of whole kernel recovery is at 14.34% which implies that, to get more whole kernel during cracking, at all initial moisture content the nut must be dried between 4 and 6 hours for effective recovery and more profit.

The analysis of variance (ANOVA) also showed that, both the cracking speed and moisture content have a significant effect on whole kernel recovery, indicating that optimizing these parameters could lead to higher whole kernel recovery.

REFERENCES

Adebayo, A. A. (2004). Development and Performance Evaluation of a Motorized palm Nut cracking machine. Proceeding of the Annual Conference, Nigeria Institution of Agricultural Engineers. Vol. 26, pp. 326-330

Ajewole P. O. (2014) Experimental Determination of the Rotor Speed of a Vertical Shaft Centrifugal Nut Cracking Machine; International Journal of Engineering Research and General Science Volume 2, Issue 5, pp 506-510.

ASABE, American Society of Agricultural Biological Engineers, ASABE Standard S. 351-353. Agricultural Engineers Year Book, ASABE, 2006, p. 345. Compendium of Engineering Monographs, pp. 11 – 13.

Edet, J. A., Sam, E. O., and Ahaneku, I. E., and Igbozulike, A. O. – (2022). Review of Relevant Evapotranspiration Models for Estimating Reference Evapotranspiration. Umudike Journals of Engineering and Technology (UJET); Vol. 8, No.1, pp. 88 – 97.

Esua, O. J., Onwe, D. N., Etuk, V. E., & Okoko, J. U. (2015). Investigation into the Energy Demand for Palm Nut Cracking Using the Static Impact Method, 3(1), 7–14.

Biyeye, Dare (2022). Design and development of a palm kernel nut cracking unit. In: Technology audit and production reserves http://journals.uran.ua/tarp/article/download/253931/251318/584161. doi:10.15587/27065448.2022.253931.

Jimoh M. O. and Olukunle, O. J. (2012) “Effect of heat treatment during mechanical cracking using varieties of palm nut” Agric Eng Int: *CIGR Journal*, Open access at http://www.cigrjournal.org Vol. 14, No.3, September, 2012

Koya, O. A., Idowu, A., &Faborode, M. O. (2004). Some properties of palm kernel and shell relevant in nut cracking and product separation. J. Agric. Eng. Technol, 12, 33-44.

Ndukwu, M. C., &Asoegwu, S. N. (2010). Functional performance of a vertical-shaft centrifugal palm nut cracker. Research in Agricultural engineering, 56(2), 77-83.

Article DOI: 10.52589/AJSTE-CWCBFGJP
DOI URL: https://doi.org/10.52589/AJSTE-CWCBFGJP

Okokon, F. B., Okoko, P., Akanga, A., Umani, K., &Obot, N. (2015). Effect of rotor speeds of centrifugal palm nut cracker on the characteristics of the constituents of the crack mixture. *International Journal of Agricultural Policy and Research*, 3(8), 323-327.

Olaoye, j. O., & Adekanye, t. A. (2018). Properties influencing cracking and separation of palm nuts in a mechanical cracker cum separator. *Croatian Journal of Food Science and Technology*, 10(1), 42-50.

Ologunagba, F. O. (2012). Design and Evaluation of a Horizontal shaft palm nut cracking machine. *Journal of Engineering and Applied Science*, Vol. 4, pp 81.

Partick, E. and Godspower, O. (2014). An experimental study on the use of temperature for effective separation of cracked palm nuts from their shells. Proceedings of the World Congress on Engineering and Computer Sciences. 2:123 - 130.

Sam, E. O. (2017) Determination of Power Requirements for Oil Palm Nut Cracking at Various Moisture Content Levels using Dynamometer. M.Eng. Thesis: University of Uyo.

Sam, E. O., Ndirika, V. I. O., Edet, J. A. and Udom, I. J. (2022a). Mathematical Model for Predicting Whole Kernel Recovery of a Palm Nut Cracking Machine using Mixed Variety of Palm Nut. Proceeding of 2022 Conference of Agricultural and Bioresource Engineering. UNN. Pp 458 – 469

Sam, E. O., Ndirika, V. I. O. and Etoamaihe, U. J. (2022b). Model Development and Optimization for Predicting Whole Kernel Recovery of Palm Nut Cracking Machine using Mixed Varieties of Palm Nut. Umudike Journals of Engineering and Technology (UJET); Vol. 8, No.1, pp. 37 – 48.

Udo, S. B., Adisa, A. F., Ismaila, S. O, Adejuyigbe, S. B. (2015) Development of palm kernel nut cracking machine for rural use; Agric Eng Int: *CIGR Journal* Open access at http://www.cigrjournal.org Vol. 17, No. 4, pg. 379

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