Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2018, 5(7): 470-473

Research Article ISSN: 2394 - 658X

Analytical Approach on the Influence of Some Chemical Constituents of Palm Nut Shells on Nut Cracking

Antia, O. O.*[1] and Oboh, I. O.[2]

[1]*Department of Agricultural and Food Engineering, University of Uyo, Uyo, P. M. B. 1017, Akwa Ibom State, Nigeria*

[2]*Department of Chemical and Petroleum Engineering, University of Uyo, Uyo, Akwa Ibom State, Nigeria*

** Email: oruaantia@yahoo.com; Phone: +234803106713*

ABSTRACT

Some chemical constituents such as Carbon, Sulphur, Calcium, Nitrogen, Hydrogen and Sodium in palm nut shells of the Dura and Tenera nut varieties were investigated to establish its existence; then analyze its potential to encourage nut cracking. In this study, dried palm nuts were obtained from a local palm oil processing mill; and each variety graded into three size ranges based on their minor axis d_1 as follows:

small size: $d_1 \leq 10$ mm, medium size: 10 mm < $d_1 \leq 20$ mm, and large size: $d_1 > 20$ mm.

Well dried and crushed shell samples following nut cracking to remove kernels were prepared from each of the size ranges per nut variety. The selected chemical constituents were then determined and analyzed. Result showed that there is a significant difference among the constituents in the two varieties. More so, there is no statistically significant difference in the constituents between the two varieties. Also, the difference in interaction between constituent and variety was not significant. Technical analysis revealed that it is possible to weaken the shell bonding through reactions by appropriate chemical application to form high covalent bonding in order to enhance easy release of whole kernels when appropriate impact energy is applied.

Key words: *Chemical constituent, Nut shell, Cracking, Covalent bond, Nut varieties*

Notation

K.E. = Kinetic energy for impact
M = Mass of nut
V = Speed of nut

INTRODUCTION

The oil palm (*Elaeis guineensis*) is a single-stemmed tree that can grow up to 20 m tall, with palm fruits taking five to six months to mature from pollination stage. It is believed that it origin from West Africa and America [1-2]. It has three main varieties namely: Dura, Tenera and Pisifera. The Dura is the thick shelled variety with thin mesocarp. The Pisifera is the shell-less variety while the Tenera is a hybrid of Dura and Pisifera. The Tenera has a much thicker mesocarp and a thin shell. Its fruits have a much larger content of palm oil than the Dura [3-4]. When the fruits are processed, the products obtained are the palm oil, the nuts and the fibres. The nuts can further be processed following drying and cracking to obtain kernels and shells. The kernel contains oil and could be extracted and used for various purpose including refining edible vegetable oil, soap making, etc [4-5]. The shells have economic values such as heating source, in promoting organic farming, in water purification when it is converted to activated carbon, etc [6-8]. Nut cracking requires the application of appropriate impact energy on the nuts in order to release whole kernels, since split kernels when exposure to environmental influences such as moisture, mould, etc lead to rancidity of oil [9-11]. There are various types of crackers developed in an effort to crack the nuts and remove high percentage of whole kernels. However, additional challenge is the separation of the kernels from the cracked shell fragments. In an effort to overcome these difficulties to a greater extent various approaches by researchers are still ongoing [12-13]. Thus, it is necessary to investigate into the chemical constituents and their concentration in the shell, in order to propose application of chemical treatment and any other additional approach that might enhance the cracking of nuts and perhaps producing the shells fragments that may be smaller than the kernels comparatively in order to enhance easy nut cracking and shell fragments separation from kernels.

MATERIALS AND METHODS

The chemical constituents of palm nut shell were investigated using the following procedures:

(a) Nut Grading:

The nuts of Dura and Tenera varieties were each graded based on its minor axis into size ranges of $d_1 \leq 10$ mm, 10 mm < $d_1 \leq 20$ mm, and d_1 > 20 mm. Vernier caliper was employed for the measurement.

(b) Preparation of Sample for Analysis:

Palm nuts were cracked and the shell fragments obtained from each classified size range of each variety. The shells from each classified size ranges were oven dried and crushed into powder using stone. The crushed shells were sieved and residue recrushed again. The sieved samples for each classified size range per variety were labeled and stored in a clean dry polythene bag for determination of chemical constituents of the shell.

(c) Determination of Chemical Constituents:

- (i) Determination of Total Nitrogen:
  The determination of nitrogen constituent of the crushed shell sample was carried out using Association of Official Analytical Chemist Procedure [14].
- (ii) Determination of Carbon Content:
  The wet acid dichromate digestion method by Walkley Black was used [15].
- (iii) Determination of Sulphur Content:
  The Turbidimetric method of determining total sulphur in plant materials was used [16].
- (iv) Determination of Calcium and Sodium:
  The concentration of calcium and sodium in the crushed sample of the palm nut shells were determined using EDTA titration method [17] and flame photometer [18] respectively.
- (v) Determination of Hydrogen Content:
  The hydrogen content in the crushed sample of shells were mixed with water at a 1:1 volume ratio; and pH meter was inserted to directly measure the value of proton concentration (H^+) of the sample [19].

(d) Statistical Analysis:

The data generated were statistically analyzed using mean, standard deviation, analysis of variance, t-test, etc [20]

RESULTS AND DISCUSSION

The chemical constituents and their concentrations in palm nut shell from this study are presented in Table 1.

Table -1 Chemical constituents of palm nut shell

Constituents (mg/l)	**$d_1 \leq 10$ mm**		**10 mm < $d_1 \leq 20$ mm**		**$d_1 > 20$ mm**	
	Dura	**Tenera**	**Dura**	**Tenera**	**Dura**	**Tenera**
Carbon	51.95 ± 1.72	52.20 ± 2.16	52.20 ± 1.71	52.60 ± 2.11	52.45 ± 1.72	53.10 ± 2.09
Sulphur	0.070 ± 0.02	0.067 ± 0.01	0.097 ± 0.03	0.110 ± 0.07	0.120 ± 0.02	0.121 ± 0.10
Hydrogen	7.246 ± 0.18	7.380 ± 0.29	7.506 ± 0.16	7.310 ± 0.22	7.506 ± 0.08	7.630 ± 0.36
Nitrogen	0.360 ± 0.03	0.339 ± 0.02	0.343 ± 0.01	0.313 ± 0.05	0.338 ± 0.03	0.302 ± 0.04
Calcium	6.470 ± 0.29	6.335 ± 0.27	6.296 ± 0.21	6.235 ± 0.26	6.370 ± 0.11	6.495 ± 0.25
Sodium	2.200 ± 0.30	2.140 ± 0.25	2.420 ± 0.29	2.270 ± 0.13	2.420 ± 0.29	2.270 ± 0.13

Bulk nut 10 mm$\leq d_1 >$ 20 mm	**Dura**	**Tenera**
Carbon (mg/l)	52.20 ± 0.250	52.63 ± 0.045
Sulhur (mg/l)	0.096 ± 0.025	0.099 ± 0.029
Hydrogen (mg/l)	7.412 ± 0.150	7.441 ± 0.168
Nitrogen (mg/l)	0.347 ± 0.012	0.318 ± 0.019
Calcium (mg/l)	6.379 ± 0.087	6.355 ± 0.131
Sodium (mg/l)	2.347 ± 0.029	2.227 ± 0.075

From Table 1, the Tenera species comparatively have higher carbon content than Dura but both varieties had carbon as dominant chemical constituent. Though the allotropes of carbon present (whether diamond or graphite) was not investigated, it is suggested that since diamond allotropes are harder than graphite; and the materials whose carbon content is of diamond allotropes will be very hard , then palm nut shell being hard might contain diamond allotrope. However, the concentration of carbon varied slightly but not significantly with nut size. It is known that the selectivity of carbons for absorption depends upon their surface chemistry, as well as their pore size distribution. Diamond carbon is known to have a large porosity and numerous disordered spaces, and so makes heteratom to readily combine on the surface. Various surface functional groups indentified with carbon contains oxygen, nitrogen, and other heteroatoms. The heteratoms bound to the surfaces assume the character of the functional groups typically found in aromatic compounds, and react in similar ways with many reagents. These surface groups therefore play key role in the surface chemistry of carbon containing compound. Hence, subjecting the nuts to chemical that contains oxygen, nitrogen, sulphur and others that can react with the carbon in the shell may likely aid in breaking the strong carbon hydrogen bond in the shell, thereby facilitating easy cracking of the nuts. The concentration of sulphur in the shells of Dura nut variety is slightly higher than that of Tenera for d_1 < 10 mm. For 10 mm < $d_1 \leq$ 20 mm, Dura had lower value than Tenera; but Dura and Tenera had almost similar concentration for d_1 > 20 mm. The sulphur content distribution of Tenera generally top Dura for size range 10 mm < $d_1 \leq$ 20 mm and d_1 > 20 mm. However, there was a significant variation in sulphur between varieties but very slight increase in sulphur with nut size. Structurally, sulphur bonds with nitrogen in most of the organic compound for the synthesis of protein and protein related compound. The bond is known to be covalent which is weak. This makes such compound weak and easily broken. Thus, sulphur to nitrogen bond in the shell structure could increase the compressive strength and thereby reducing the cracking force to be applied on the nut if the concentration in the shell is high. From Table 1, the concentration of sulphur in the shell is low, implying that it might require a significant amount of cracking force to cause nuts to crack except if the nuts are soaked for a reasonable time in compound such as ammonium sulphate that contains high content of sulphur.

The nitrogen concentration in the shell of Dura was slightly higher than its Tenera counterpart. It is known that nitrogen content of any organic compound forms covalent bond with sulphur; and so would encourage nut to crack with ease. The hydrogen content of the shells of the three nut sizes was observed to be almost constant irrespective of the nut size. Hydrogen influences structurally stability of organic compounds through its influence in bonding. It forms a strong electrovalent bond with carbon as a result of its positive ion and negative ion in carbon. High energy is required to break electrovalent bonds compared to covalent bonds. This implies that hydrogen is likely to reduce the compressive strength of the nut thereby increasing its cracking force. To overcome this influence, it might be necessary to soak the nut in compound that can react with hydrogen and carbon to yield compounds with covalent bond which is not as strong as electrovalent bond. For calcium, there was no specific pattern of distribution with nut size and between the two varieties. Calcium forms strong bonds with carbon containing compounds in the presence of oxygen. This oxygen bond is very strong. Therefore, high content Ca in the shell contributes to the hardness of the shell. Hence, increase in cracking force of the nuts. The concentration of sodium was almost constant across the shell irrespective of the nut size. Sodium is a dispering agent; and it works against bond formation in compound. This might lead to decrease in the cracking force depending on its concentration in the shell.

The chemical constituents of palm nut shell showed variation between the two varieties of oil palm. The t-test was used to measure the difference and evaluate its magnitude disparity since it is a bivariate comparison. The t-test is presented in Table 2.

Table -2 T-test comparing chemical constituents between the Dura and Tenera palm nut shell

Constituent (mg/l)	Mean value		T_c	T_t		Significance?
	Dura	Tenera		Probability level		
				1 %	5 %	
Carbon	52.20	52.63	0.03	4.604	2.776	No
Sulphur	0.0957	0.0993	0.26	4.604	2.776	No
Hydrogen	7.412	7.44	0.43	4.604	2.776	No
Nitrogen	0.347	0.318	0.01	4.604	2.776	No
Calcium	6.379	6.355	0.39	4.604	2.776	No
Sodium	2.347	2.227	0.03	4.604	2.776	No

Since $T_c < T_t$ at both probability level in all the constituents, there was no significant difference in their mean values of each constituent between the two varieties of palm nuts.

The effect of nut size on chemical constituents of the shell was evaluated using analysis of variance (ANOVA) as it compares mean of many groups of treatment unlike t-test that compares mean of two groups. The F-values for the respective constituents are presented.

Table -3 Analysis of variance (ANOVA) showing variation in constituents among the varieties

Source	Sum of Squares	df	Mean Square	F	Sig.
Intercept	4752.655	1	4752.655	155093.346	0.000
Constituent	12338.911	5	2467.782	80531.122	0.000*
Variety	0.018	1	0.018	0.576	0.455
Constituents * Variety	0.289	5	0.058	1.884	0.135
Error(Residual)	0.735	24	0.031		
Total	17092.608	36			

(*) Significant difference

There was a significant difference among the constituents because p-value [0.00] < 0.05. This is because palm nut shell is an organic material expected to have variation in these constituents. For variety, p-value [0.455] > 0.05 indicates that there is no statistically significant difference in their constituents between the two varieties. Difference in interaction between constituent and variety was not significant, since (p [0.135] > 0.05).

From literature, Dura variety generally has higher cracking [3], [7], [21]. Thus, the difference in cracking force between these two varieties may be due to the thickness of the shell. The thickness contributes to mass of the nut; hence, since impact energy is a function of mass, it implies that speed of nut for impact is the controlling factor for effective cracking of these two varieties of nuts. This conforms to a study by [4] on speed requirement for nut cracking based on the equation:

$$K.E. = \frac{1}{2} MV^2 \qquad (1)$$

The application of appropriate chemicals on nut shells to cause formation of high covalent bonding will reduce the required cracking force and could possibly cause nuts to have small shell fragments comparable with kernel sizes following nut cracking. These products would encourage quick separation from kernels due to size and shape difference between the shell fragments and kernels.

CONCLUSION

It is likely possible to weaken palm nut shell bonding by soaking the nut for a reasonable time in a chemical compound that can react with the chemical constituents of the nuts to form high covalent bond. Thus, application of appropriate impact energy on the soaked nuts could result in having small shell fragments and whole kernel following nut cracking.

REFERENCES

[1]. DK Salunkhe, JK Chaven, RV Adsule and SS Kadan, *World Oil Seeds, Chemistry, Technology and Utilization*, AVI Publishers, N.Y, **1992**, 217-248.

[2]. FAO, Small Scale Palm Oil Processing in Africa, *FAO Agricultural Service Bulletin,* **2009**, (148), 1-56.

[3]. Y Mijinyawa and S Omoikhoje, Determination of Some Physical Properties of Palm Kernel, *Proceedings of the Nigeria Institution of Agricultural Engineers*, **2005**, (27), 157-160.

[4]. O Antia, K Obahiagbon, E Aluyor, E. and P Ebunilo, Modeling of Some Related Parameters for Cracking Palm Nut in a Centrifugal Cracker, *Advance Material Research*, **2013**, (824), 255-261.

[5]. VE Emeka and JM Olumu, Nutritional Evaluation of Palm Kernel Meal Type I, Proximate Composition and Metabolizable Energy Values, *African Journal of Biotechnology*, **2007**, 6(21), 2484-2486.

[6]. GO Omange, Palm Kernel Shell as Road Building Material, *Technical Transaction of the Nigerian Society of Engineers,* **2001**, 36 (1), 17-25.

[7]. CO Illechie, U Omoti, ME Bafor, SB Ogblechi, GF Aibangbee and PE Amiolemhen, Palm Waste Briquette Substituted for Fuel Wood. *Journal of Engineering Science and Technology*, **2004,** 2 (3), 64-67.

[8]. H Mahmud, MZ Jumat and UJ Alengaram, Influence of Sand/ Cement Ratio on Mechanical Properties of Palm Kernel Shell Concrete, *Journal of Applied Science*, **2009**, 9 (9), 1764-1769.

[9]. K Poku, Small-scale Palm Oil Processing in Africa, *FAO Agricultural Service Bulletin, No. 148, Publishing Management Service, Information Division, FAO, Rome*, **2002**, 56, Accessed February, 2008, https://fao.org/DOCREP/005.

[10]. MH Rohaya, AB Nasrin, YM Choo, AN Ma and N Ravi, A Commercial Scale Implementation of Rolek ™ Palm Nut Cracker, Techno-Economic Viability Study for Production of Shell-Free Kernel, *Journal of Oil Palm Research (Special Issue),* **2006**, 153-167.

[11]. O Antia and K Obahiagbon, Determination of Nut Exit Configuration on Rotor for Effective Whole Kernel Production in Centrifugal Cracker, *IOSR Journal of Engineering*, **2018**, 8 (1), 15-18.

[12]. LA Sani and AO Adegbenjo, Properties of Palm Nuts and Fibre Residue that Influence the Mechanical Separation after Palm Oil Extraction, Proceedings of the Regional Workshop on Promotion of Appropriate *Agro-Processing Technologies in West Africa, Ile –Ife, Nigeria, Post Harvest Technology Research Group*, **2002,** 186-196.

[13]. MH Rohaya, MB Nasrin, CY May, R Ramli, MA Ngan, and R Menon, Maximizing the Recovery of Dry Kernel and Shell Via Four-Stage Winnowing Column, *MPOB Information Series. ISSN 154- 7871, MPOB TT*, **2009**, (427), 468-471.

[14]. Kjelddahl Method of Determination of Total Nitrogen Content https://www.cabdirect.org., Accessed, **2018**.

[15]. Soil Survey Standard Test Method Organic Carbon, www.environment.nsw.gov.au., Accessed **2018**.

[16]. Simple Turbidimetric Method of Determining Total Sulphur in Plant Materials, https://www.researchgate.net., Accessed **2018**.

[17]. Determination of calcium by Standard EDTA Solution, https://www.mtsu.edu., Accessed **2018**.

[18]. The Flame Photometric Determination of Sodium and Potassium in Plant Ash Extract, https://www.sciencedirect.com., Accessed **2018**.

[19]. Using a pH meter, https://www.jove.com., Accessed **2018**.

[20]. MR Spiengel and LJ Stephens, *STATISTICS, Schaum's Outline Series*. McGraw- Hill Companies. 3rd Ed., **1999**, 362-401, 281-286.

[21]. O Antia, Study of Impact Energy Required for Effective Cracking of Dried Oil Palm Nuts, *Nigerian Journal of Technological Development*, **2011**, 8(1&2), 23-30.