ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering
Tome XV [2017] – Fascicule 3 [August]

ISSN: 1584-2665 [print; online]
ISSN: 1584-2673 [CD-Rom; online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1]Abraham KABUTEY, [1]David HERÁK, [1]Oldrich DAJBYCH,
[1]Olaosebikan Layi AKANGBE, [2]R. NAPITUPULU, [3]S. PANDIANGAN

MECHANICAL BEHAVIOUR OF ROASTED AND UNROASTED OIL PALM KERNELS UNDER COMPRESSION LOADING

[1]Czech University of Life Sciences Prague, Faculty of Engineering, CZECH REPUBLIC
[2]University of HKBP Nommensen, Faculty of Engineering, INDONESIA
[3]University of HKBP Nommensen, Faculty of Agriculture, INDONESIA

Abstract: This article follows the previously published study on the mechanical behaviour of oil palm kernels under compression loading. A slight change in deformation of the heat-treated kernels was observed at force 100 kN and speed 60 mm/min. Therefore, a greater force was required to produce higher percentage kernel oil.In this present study, however, both roasted and unroasted kernels were compressed in a vessel with diameter of 60 mmat varying forces from 150, 200, 250 and 300 kN and speed 10 mm/min aimed at determining the optimal pressing force without serration effect on the force-deformation curve.
Keywords: compressive force, speed, deformation, energy, serration effect

1.INTRODUCTION

The oil palm (Elaesis guineensis) is a perennial monoecious crop originated from the tropical climates with high rainfall, which belongs to the family Palmae (Ozumba and Obiakor, 2011). The tree starts to produce fruits four to five years after planting and the fruits bunch weighs between 10 and 75 kg depending on the varieties (Kabutey et al., 2013; Owolarafe et al., 2007).

The processing of the fresh fruit bunch to yield red palm oil gives the shelled palm nut which is cracked to produce the palm kernel nut and the shell. The shells are used as energy and road construction whiles the palm kernel nut is processed to yield palm kernel oil and cake. The palm kernel oil is 81% saturated and is obtained a white to yellowish vegetable oil similar to coconut oil beingsemi-solid at normal temperature while the palm mesocarp oil is 41% saturated and it is red due to the presence of carotenoids (Akinoso et al., 2009; Akinoso and Raji, 2011; Keshvadi et al., 2011).

Palm oil is used in packaged edible products including cooking oils, margarine, mayonnaise, ice cream, cookies and chocolates; and non-edible products such as soaps, detergents and cosmetics. It is also used as a biodiesel through the trans-esterification process and also used in the metal and leather industries (Morrison and Heijndermans, 2013). Palm kernel oil is used in commercial cooking because of its relatively low cost and longer storage period. It can also be used for the manufacture of soaps and washing powders. The meal is used as a fertilizer and livestock feed.

The processing of the fruits and nuts for the edible oils especially in the developing countries is labour intensive and time consuming.The mechanical extraction process is suitable for oil extraction in both small and large-scale operations by the application of pressure. However, the relevance of optimal pressure in mechanical oil expression has been rapidly mentioned (Oriaku et al., 2013).

Technological improvement of the oil processing requires accurate knowledge on both the physical and mechanical properties of the oil palm fruit, nut and kernel.These properties include among others moisture content, sphericity, porosity, pressing force, deformation and energy balance (Akinoso et al., 2009; Akinoso and Raji, 2011). In the literature, such informations are limited. Therefore, in this present study, the mechanical properties of unroasted and roasted oil palm kernels were mainly investigated under compression loading.

2.MATERIAL AND METHOD

The unroasted and roasted oil palm kernels procured from New Tafo, Eastern Region, Ghana were used for the compression test. The moisture content of unroasted and roasted oil palm kernels was determined to be 9.67±0.196 and 3.33±0.191 using the standard oven method with a temperature setting of 105ºC and a drying time of 17 h (Kabutey et al., 2014).

A compression device (ZDM 50, Czech Republic) was used at speed 10 mm/min for varying forces between 150 kN and 300 kN. The kernels were measured at the initial pressing height of 60 mm in a pressing vessel of 60 mm diameter. After the initial test,the kernels were again pressed to ensure permanent deformation which was observed at pressing heights 55 mm and 50 mm respectively. However, the test was stopped for kernel pressing height of 50 mm at force 300 kN as a result of the ejection of kernel cake through the holes beneath the pressing vessel.

3.RESULTS

The results of the compression test are presented in table 1. Percentage oil yield and energy increased with increasing pressing force for both unroasted and roasted kernels at speed 10 mm/min.Unroasted kernels produced higher percentage oil yield compared to roasted kernels. Hence, energy demand was higher.

Table 1. Energy (kJ) and oil yield (%) of oil palm kernels at speed 10 mm/min

Pressing force [kN]	Pressing height [mm]	Unroasted kernels		Roasted kernels	
		Energy [kJ]	Oil yield [%]	Energy [kJ]	Oil yield [%]
150	*60	0.907	22.09	0.824	14.50
	55	0.699	10.50	0.490	7.82
	50	0.588	6.20	0.341	4.44
	Sum	2.194	38.79	1.655	26.76
200	60	1.045	22.75	1.091	18.38
	55	0.654	10.50	0.707	9.22
	50	0.783	7.30	0.985	6.73
	Sum	2.482	40.55	2.782	34.33
250	60	1.226	25.27	1.225	18.19
	55	0.717	12.38	0.742	7.44
	50	0.958	7.40	0.543	6.29
	Sum	2.901	45.05	2.510	31.92
300	60	1.536	31.06	1.339	20.54
	55	0.929	14.00	0.869	8.21
	**50	-	-	-	-
	Sum	2.465	45.06	2.208	28.75

* Initial pressing height of kernels; ** Compression was ceased due to the ejection process.

The coefficients of determination (R^2) of oil yield for both unroasted and roasted kernels were approximately 72% (Figure 1). On the other hand, that of energy was72% and 47% respectively (Figure 2). The 72% explain the significant effect of compressive force on oil yield and energy whiles the 47% suggestpartly effect. The decrease in percentage oil yield of roasted kernels compared to unroasted kernels could be attributed to the change in the physical, mechanical and chemical structure during the heat-treatment process.

Traditionally, the roasting of the kernels is to aid oil extraction. However, due to the energy intensive process of the traditional oil processing of the roasted kernels(drying of nuts, cracking of nuts, sieving of cracked nuts, separation of kernels, sun-drying of kernels, winnowing of kernels, removal of undesired materials, roasting of kernels, milling of roasted kernels into paste and cooking and collection of oil), direct compressionof the unroasted kernels would be more convenient and environmentally friendly.

Although, the kernels required repeated pressing for complete deformation to achieve maximum oilrecovery at optimal pressing force of 250kN, there is still need to examinethe variation offorces, moisture content, heat-treatment duration, pressing vessel diameters and speeds in relation to oil yield and energy requirement of both the unroasted and roasted oil palm kernels under compression loading.

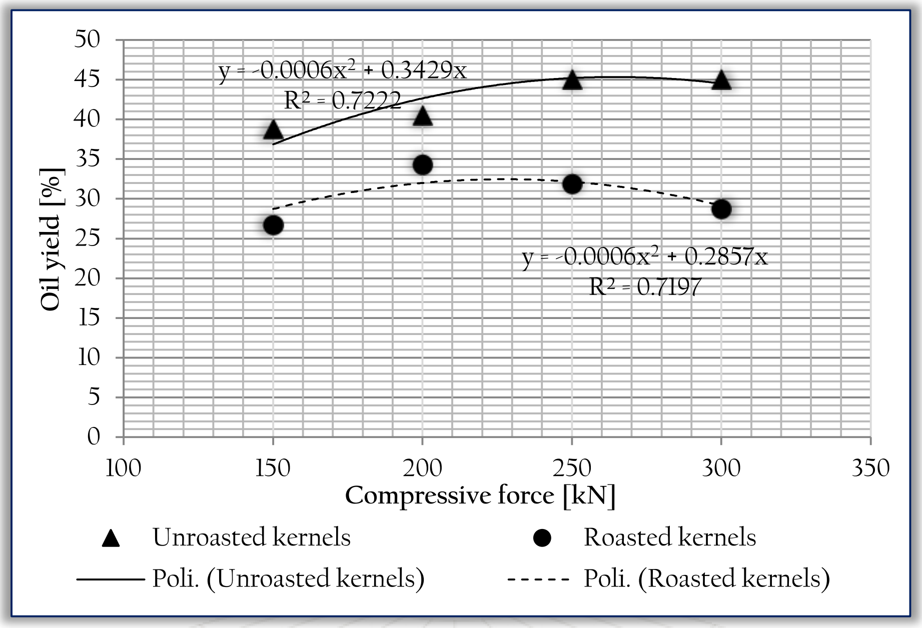

Figure 1. Relationship between oil yield (%) and compressive force (kN) of unroasted and roasted oil palm kernels at speed 10 mm/min

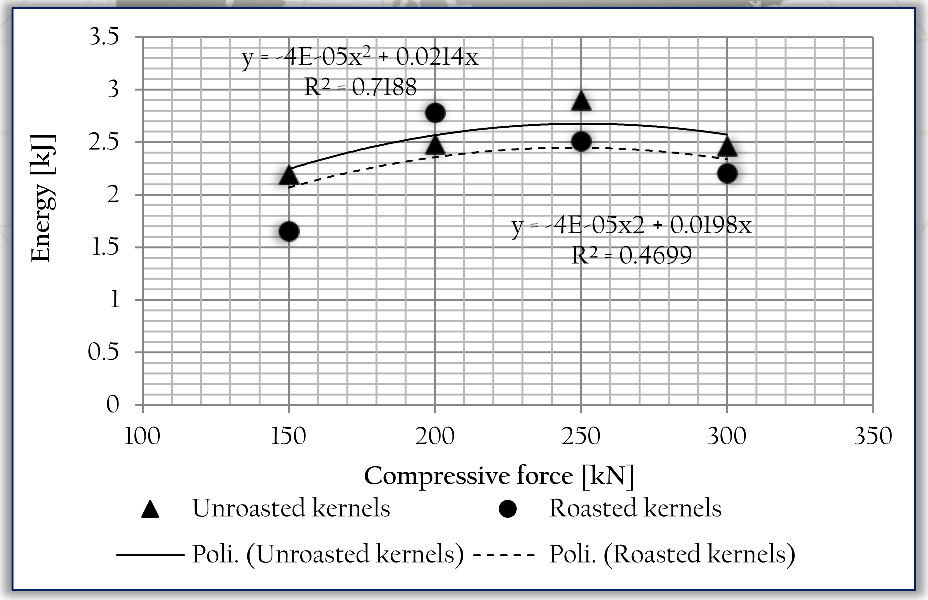

Figure 2. Relationship between energy (kJ) and compressive force (kN) of unroasted and roasted oil palm kernels at speed 10 mm/min

4.CONCLUSIONS

Knowledge of the mechanical properties of bulk oilseeds or kernels isessential in determining the energy requirement for obtaining higher percentage oil. The study findings include the following:

- Optimal pressing force without serration effect on the force-deformation curve was observed at250 kN. However, the kernels were not permanently deformed.
- Serration effect was noticed at force 300 kN and pressing height of 50 mm. Compression was ceased here as a result of the ejection of the crashed kernels through the holes beneath the pressing vessel.
- Oil yield and energy requirement of unroasted kernels were higher in comparison with roasted kernels.

It is necessary to consider the variation of compressive forces, moisture content, heat-treatment temperatures, pressing vessel diameters and speeds to adequately understand the mechanical behaviour of oil palm kernels under compression loading.

Acknowledgment

The study was financially supported by the Internal Grant Agency of the Faculty of Engineering, Department of Mechanical Engineering, Czech University of Life Sciences Prague, IGA 2016:31130/1312/3106.

Note: This work is based on the paper presented at International Symposium on Agricultural and Mechanical Engineering – ISB-INMA TEH' 2016, organized by National Institute of Research–Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, „Politehnica" University of Bucharest – Faculty of Biotechnical Systems Engineering, EurAgEng – European Society of Agricultural Engineers and Romanian Society of Agricultural Engineers – SIMAR, in Bucharest, ROMANIA, between 27–29 October, 2016.

References

[1.] Akinoso, R., Raji, A.O., Igbeka J. C. (2009). Effects of Compressive Stress, Feeding Rate and Speed on Palm Kernel Oil Yield. Journal of Food Engineering, vol.93, pp.427-430, Los Angeles/Califonia;

[2.] Akinoso, R., Raji, A.O. (2011). Physical properties of fruit, nut and kernel of oil palm. International Agrophysics, vol.25, pp.85-88, Institute of Agrophysics, Polish Academy of Sciences, Lublin/Poland;

[3.] Divisova, M., Herak, D., Kabutey, A., Sleger, V., Sigalingging, R., Svatonova, T. (2014). Deformation curve characteristics of rapeseeds and sunflower seeds under compression loading. Scientia Agriculturae Bohemicae, vol.45(3), pp.180-186, Czech university of Life Sciences Prague, Prague/Czech Republic;

[4.] Kabutey, A., Divisova, M., Sedlacek, L., Boatri, W.E., Svatonova, T., Sigalingging, R. (2013). Mechanical behaviour of oil palm kernels (Elaeis guineensis). Scientia Agriculturae Bohemica, vol.44, pp.18-22,Czech university of Life Sciences Prague, Prague/Czech Republic;

[5.] Kabutey, A., Herák, D., Dajbych, O., Boatri, W.E., Sigalingging, R. (2014). Deformation energy of Jatropha curcas L. seeds under compression loading, Research in Agricultural Engineering, vol.60(2), pp.68-74, Czech Academy of Agricultural Sciences, Prague/Czech Republic;

[6.] Keshvadi, A., Endan, J.B., Harun, H., Ahmed, D., Saleena, F. (2011). The relationship between oil index development and mechanical properties in the ripening process of Tenera variety fresh fruit bunches. Research Journal of Applied Sciences, Engineering and Technology, vol.3, pp.373-380, Maxwell Scientific Publishing Corp, Reading/U.K;

[7.] Morrison, A.K., Heijndermans, E. (2013). Palm Kernel Oil Production Process Characterization,An Energy, Poverty and Gender (EnPoGen), pp.1-47, Initiative of SNV, Accra/Ghana;

[8.] Oriaku, E.C., Agulanna, C.N., Edeh, J.C., Nwannewuihe, H.U. (2013). Determination of optimal angle of projection and separation of palm nut shell and kernel using a designed cracker/separator machine. International Journal of Scientific and Technology Research, vol.2. no.10. ISSN 2277-8616, pp.289-292, Creative Commons Attribution;

[9.] Oworlarafe, O.K., Olabige, M.T., Faborade, M.O. (2007). Physical and mechanical properties of two varieties of fresh oil palm fruit. Journal of Food Engineering, vol.78, pp.1228-1232, Los Angeles/Califonia;

[10.] Ozumba, I.C., Obiakor, S.I. (2011). Fracture resistance of palm kernel seed to compressive loading. Jouranal of Stored Products and Postharvest Research, vol.2(13), ISSN: 2141-6567, pp.248-253, Creative Commons Attribution.

ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering