Journal of Agricultural Technology 2009 Vol.5(2): 239-248
Available online http://www.ijat-rmutto.com
ISSN 1686-9141

Moisture dependent physical properties of *Garcinia kola* seeds

Igbozulike, A.O.* and Aremu, A.K.

Agricultural and Environmental Engineering Department, University of Ibadan, Nigeria.

Igbozulike, A.O. and Aremu, A.K. (2009). Moisture dependent physical properties of *Garcinia kola* seeds. Journal of Agricultural Technology 5(2): 239-248.

The effect of moisture content on some physical properties of *Garcinia kola* seeds. The properties are size, shape, densities, porosity, one thousand seed weight, static coefficient of friction on different structural surfaces and angle of repose was investigated. Linear regression equations were used to express relationship between the properties and moisture. Experimental results revealed that moisture content affected on the properties. The moisture ranged from 39.79% to 52.45%. The length, width and thickness of the seeds increased linearly from 28.425 to 32.644mm, 15.849 to 17.542 mm and 14.524 to 16.043 mm, respectively. In the same moisture range, true density decreased from 1249 to 1161kg/m^3, bulk density increased from 690 to 728kg/m^3, while porosity decreased from 44.76 to 37.24%. The angle of repose was found to vary from 30.42 to 40.86^0. In the same moisture range, the static coefficient of friction against different structural materials varied from 0.20 to 0.46.

Key words: Moisture content, axial dimensions, physical properties, *Garcinia kola* and regression equation

Introduction

Garcinia kola seed has been of great interest to human because of its medicinal and cultural uses in Africa and beyond. It is commonly called bitter *kola* because of its bitter taste. It belongs to the family of *Clusiaceae*, formerly *Guttiferae*. *Garcinia kola* is found mostly in Central and Western Africa. An average of four seeds is contained in a fruit. Apart from the seeds, other parts like the fruits, leaves, roots, barks, stems and twigs are also important to human in various ways. Its common names in these areas include a*kuilu* or *agbuilu* (Igbo), *orogbo* (Yoruba), *namijin goro* (Hausa). According to Agyili *et al.* (2006), its other names as *onie*, *munjari* and *ya*. *Garcinia kola* is a non-timber forest that is mostly utilized in Africa (Adebisi, 2004). Virtually all the parts can be used for medicinal purposes. The fruit pulp is used in treatment of

*Corresponding author: Igbozulike, A.O.; e-mail: austin.igbozulike@gmail.com

jaundice. *Garcinia kola* extract can prevent Ebola virus from replicating itself (Agyili *et al.*, 2006). Also, extracts from bark, stem and seed inhibit the growth of *Plasmodium falciparum* over 60% in-vitro at a concentration of 6 mg/ml (Tona *et al.*, 1999*)*. The seed which contains 10% carbohydrate, >10% crude fat, 5% protein, 215.10 ppm sodium and biflavonoids, xanthones, and benzophenones (Agyili *et al.*, 2006; Iwu, 2003). The seed is used in treatment of bronchitis and throat infection, catarrh, abdominal colicky pain, improving singing voice, and when mixed with honey makes a cough syrup (Adaramonye *et al*., 2005; Iwu, 2003; Irvine, 1960). The split stems and twigs are used as chewing stick in many parts of Africa, offering dental care. *Garcinia kola* pulp is used in ethanol production (Nzelibe *et al*., 2007). Besides, *Garcinia kola* has shown great potential as substitute for hop in tropical beer brewing (Ajebesone and Aina, 2004). The seed is believed to expel snake where they are kept. *Garcinia kola* has shown anti-inflammatory, antimicrobial, antiviral properties and possesses anti-diabetic and antihepatotoxic activities and it is an effective plant derived medicine alternative to synthetic drugs (Iwu, 2003; Iwu *et al*., 1999). The seed is also believed to possess aphrodisiac and purgative properties.

Presently, the seeds are extracted manually by breaking the fresh fruit with stone and allowing the pulp-covered seed to macerate and washing off in water. Alternatively, the fruits are allowed to decay and then washed off in water using basket, to extract the seeds. The seeds are ground with stone or by pounding in a mortar using wooden pestle. These methods of handling and processing seeds are not only time and energy consuming, but also inefficient. However, no work appears to be done on the physical properties of *Garcinia kola* seed and since these properties are pre-requisites for the design of equipments for de-hulling, handling and other post harvest operations, it is essential to determine them.

Fig.1.. *Garcinia kola* fruits (a) *Garcinia kola* seeds (b).

Many researchers have been described and investigated these properties for a number of crop and food materials which included pumpkin seed and kernel by Joshi *et al*. (1993), *Prosopis* Africana seed by Akaimo and Raji (2006), watermelon seeds by Razavi and Milani (2006), *karingda* seed by Suthar and Das (1996), *guna* seed by Aviara *et al*. (1999) African oil bean seed by Asoegwu *et al*. (2006), melon seed by Makanjuola (1972).

The aim of this study was to investigate some physical properties of *Garcinia kola*, namely size, volume, shape, 1000 seed weight, true density, bulk density, porosity, angle of repose and coefficient of friction on different materials to determine whether or not these properties were moisture content dependent.

Materials and methods

A bulk sample of *Garcinia kola* seeds at the moisture content of 39.79% were obtained from Ndiowerre-Orlu in Imo State, Nigeria. The samples were cleaned to remove the damaged and foreign matters. The moisture content of the seeds was determined by oven drying method, using ASAE standard at 105 $\pm$ 1^0C for 24 h. Samples were conditioned to moisture contents in the range of 39.79-52.45% by adding calculated amount of tap water and sealed in double-layer low density polythene bags and stored at a low temperature. For each test the required quantity of seeds were taken out and allowed to equilibrate with the room temperature.

Size was determined by measuring the axial dimensions of 100 seeds; length, width and thickness, using micrometer reading up to 0.001mm. One thousand seed weight (W_{1000}) was determined using the method described by Nalladulai *et al*. (2002) and Varnamkhasti *et al*. (2007), where 100 seeds were weighed with the aid of an electronic balance and multiplied by 10. The bulk density was determined using AOAC method. The true density was determined using water displacement method. A thin layer of araldite was used to coat the seeds to prevent moisture absorption, and the average weight increase due the adhesive was negligible (less than 2%). Porosity was calculated from the values of true and bulk densities using the relationship given by Mohsenin (1986). The static coefficient of friction was determined using an inclined plane (Suthar and Das, 1996). Three test surfaces namely plywood, mild steel and galvanised steel sheet were used. The angle of repose was determined using a topless and bottomless cylinder (Razavi and Milani, 2006).

Results and discussion

Seed dimensions

Results showed that the 100 measurements taken for the axial dimensions of the seeds at different moisture contents are presented in Table 1. It was showed that the three axial dimensions increased with increase in moisture content in the range of 39.79-52.45%. This explains the reason why seed shape remains unchanged with change in moisture content.

Table 1. Axial dimensions of *Garcinia kola* seed (standard deviations in parentheses).

Moisture content, % w.b.	Length, mm	Width, mm	Thickness, mm	Geometric mean diameter, mm	Arithmetic mean diameter, mm	Sphericity
39.79	28.425	15.849	14.524	18.598	19.599	0.660
	(3.351)	(1.452)	(1.300)			
40.49	30.504	16.869	15.111	19.732	20.827	0.648
	(1.580)	(1.263)	(0.875)			
43.98	31.125	16.986	15.400	20.029	21.170	0.645
	(2.008)	(1.329)	(1.278)			
46.74	32.480	17.436	15.997	20.747	21.971	0.642
	(3.449)	(1.687)	(1.408)			
52.45	32.644	17.542	16.043	20.849	22.077	0.641
	(2.386)	(1.300)	(1.354)			

The sphericity values for *Garcinia kola* seed fall within the range of 0.32-1.00 for most agricultural products (Mohsenin, 1986). The relatively low sphericity (0.66) shows that the seed will not rotate easily during handling. The closer the sphericity to 1.0, the higher the tendency to roll about any of the three axes. The dimensions of *Garcinia kola* seeds were observed to be larger than that of *guna* seed (Aviara *et al*., 1999), pumpkin seed (Joshi *et al*., 1993), lower than African oil bean seed (Asoegwu *et al*., 2006) and lie within the same range with cashew nut (Oloso and Clarke, 1993).

One thousand seed weight

At the moisture content of 39.79% w.b., the one thousand seed weight was 4.425 kg with a standard deviation of 0.29 kg. One thousand seed weight W_{1000} was found to increase with moisture from 4.425 to 6.286 kg in the moisture range of 39.79-52.45%. A linear relationship between W_{1000} and moisture M was obtained and can be expressed using the following regression equation thus:

$$W_{1000} = -0.766 + 0.14M \quad (1)$$

With a correlation coefficient $R^2 = 0.91$. Similar trends have been reported for other seeds.

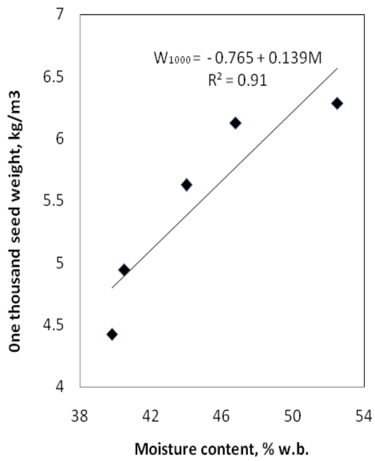

Fig. 2. Variation of one thousand seed weight with moisture content.

True density

The true density ρ_t decreased from 1249 to 1160 kg/m^3 as the moisture increased from 39.79 to 52.45% w.b. The variation was found to be linear and this linear relationship can be expressed with a regression equation as;

$$\rho_t = 1536.70 - 7.31M \quad (2)$$

With correlation coefficient, $R^2 = 0.97$

The decrease of true density with moisture increase may be due to some composition of the seed. Similar trends have been reported for other seeds (Joshi *et al*., 1993; Suthar and Das, 1996; Aviara *et al*., 1999). The result of the true density (greater than 1000kg m^{-3}) indicated that the seed was heavier than water, hence, will sink in water. This is useful in cleaning and separation operations.

Bulk density

The bulk density ρ_b increased from 690 to 728 kg/m^3 as the moisture increased from 39.79 to 52.45% w.b.

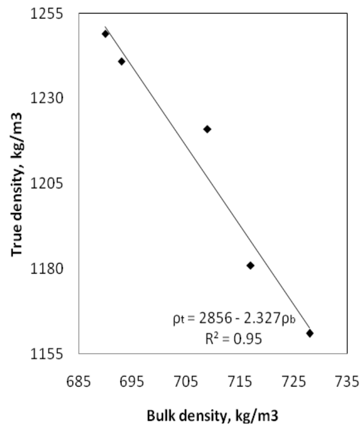

Fig. 3. Relationship between true density ρ_t and bulk density ρ_b of *Garcinia kola*, with correlation coefficient R^2.

A linear relationship was found to exist between moisture and bulk density, and this can be expressed using regression equation as;

$$\rho_b = 571.46 + 3.04M \quad (3)$$

With a correlation coefficient, $R^2 = 0.98$

The increase in bulk density with moisture increased and followed the trends for other seeds (Suthar and Das, 1996). The bulk density of the seed was within the range of bulk density determined for other seeds like millet (673 k gm^{-3}) by Mohsenin (1986), and for African yam bean TSs 137 (760-741 kg m^{-3}) by Irtwange and Igbeka (2002).

Porosity

The estimated porosity, from the relationship between true and bulk density was found to decrease from 44.76 to 37.24% as the moisture content increased from 39.79 to 52.45% w.b. The relationship existing between porosity ε and moisture content M can be expressed by a regression equation thus:

$$\varepsilon = 68.79 - 0.61M \quad (4)$$

With a correlation coefficient, $R^2 = 0.98$

This follows the same trend for other seeds like pumpkin seed by Joshi *et al*. (1993) and karingda seed by Suthar and Das (1996).

Seed volume

Seed volume was found to increase linearly from 3.56 to 5.61 cm^3 as the moisture increased from 39.79 to 52.45% w.b.

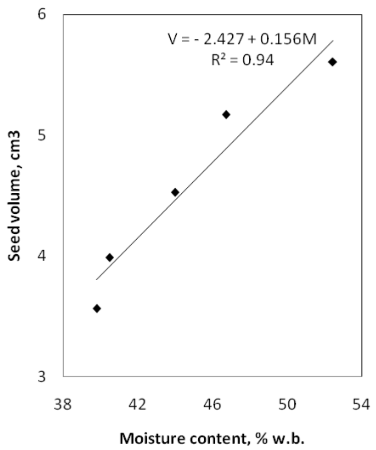

Fig. 4. Variation of *Garcinia kola* seed volume V with moisture content M; correlation coefficient R^2.

The linear relationship between seed volume V and moisture content M can be expressed using regression equation thus:

$$V = -2.43 + 0.16M \quad (5)$$

With a correlation coefficient, $R^2 = 0.97$

Static coefficient of friction

The static coefficient of friction of the seeds obtained experimentally on three structural surfaces (plywood, mild steel and galvanized steel sheet) was found to increase with moisture content and varies according to the surface.

The coefficients of frictions of *Garcinia kola* seed vary with moisture content of the sample irrespective of the surfaces employed. The coefficient of friction is important in selecting appropriate materials for different units of machinery especially those components requiring flow. The friction property also finds its application in design of loading and unloading materials such as hopper, and for storage containers such as silo.

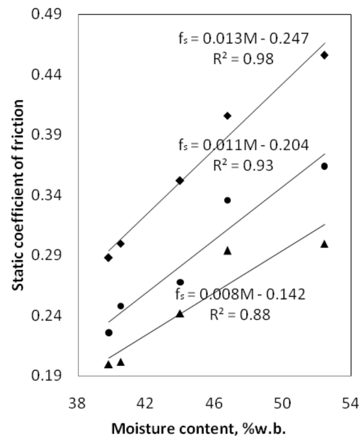

Fig. 5. Variation of *Garcinia kola* seed static coefficient of friction (f_s) with structural surfaces and moisture content M; correlation coefficient R^2 ◆ plywood; • mild steel; ▲ galvanised steel sheet.

Angle of repose

The values of angle of repose increased from 30.42 to 40.86^0 as moisture content of the seeds increased from 39.79 to 52.45% w.b. The value was below the highest possible angle of repose of 45^0 for most agricultural materials (Mohnsenin, 1986). It was the same range as that of *guna* seed (Aviara *et al*., 1999), *karingda* seed (Suthar and Das, 1996) and cowpea (Oje, 1994) and lower than pumpkin seed (Joshi *et al*., 1993).

A linear relationship that exists between angle of repose θ_r and moisture M can be expressed by the following regression equation:

$$\theta_r = -1.43 + 0.81M \quad (6)$$

With a correlation coefficient, $R^2 = 0.99$

Conclusions

The investigation of various physical properties of Garcinia kola seeds revealed that the dimensions of the seeds increased uniformly as the moisture increased, the length was greater than the width, so the seed could be described as being oblong, the bulk density increased linearly with moisture content, while true density decreased linearly with increase in moisture content, seed volume and weight also increased linearly with moisture content, porosity was found to decrease with moisture content. The static coefficient of friction increased linearly with moisture content and varies according to the surface. The angle of repose increased with moisture content.

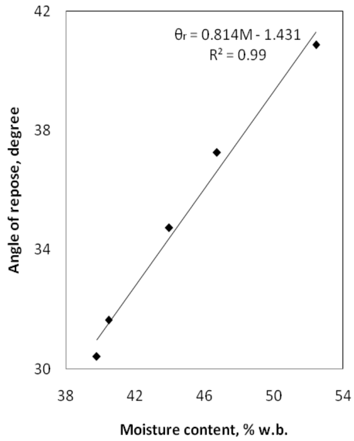

Fig. 6. Change of angle of repose θ_r of *Garcinia kola* with moisture content M; correlation coefficient R^2.

Acknowledgements

The authors acknowledge the staff of Analytical Laboratory, International Institute of Tropical Agriculture (IITA) Ibadan and Federal Institute of Industrial Research Oshodi (FIIRO) Lagos, for assistance received in carrying out some experiments.

References

Adaramonye, D.A. Farombi, E.O. Adeyemi, E.O. and Emerole, G.O. (2005). Comparative study of the antioxidant properties of flavonoids of garcinia kola seeds. Professional Medical Publication 21(3).

Adebisi, A.A. (2004). A case study of garcinia kola nut production – to- consumption system in J4 area of Omo forest reserve, South West Nigeria. Forest Production, Livelihood and Conservation 2: 115-132.

Agyili, J. Sacande, M. and Kouame, C. (2006). Garcinia kola heckel. Millennium seed bank project KEW. Forest and Landscape Denmark. Horsholm Kongerey II, DK – 2920 Horsholm. Seed leaflet No. 113.

Ajebesone, P.E. and Aina, J.O. (2004). Potential African substitutes for hops in tropical beer brewing. The Journal of Food Technology in Africa, 2004 9(1): 13-16.

Akaaimo, D.I. and Raji, A.O. (2006). Some physical and engineering properties of prosopis Africana seed. Journal of Bio-systems Engineering 95(2): 197-205.

AOAC Official methods of analysis. 13th Ed. Association of Official Analytical Chemists, Washington D.C. 1980.

ASAE Standards. Moisture measurement-unground grain and seeds. American Society of Agricultural Engineers. St. Joseph. Michigan 1988, S352.2.

Asoegwu, S.N., Ohanyere, S.O., Kanu, O.P. and Iwueke, C.N. (2006). Physical properties of African oil bean seed (*Pentaclethra macrophylla*). Agricultural Engineering International: The UGR Ejournal, Manuscript FP 05 006. vol. VIII.

Aviara, N.A., Gwandzang, M.I. and Haque, M.A. (1999). Physical properties of guna seed. Journal of Agricultural Engineering Research 73: 105-111.

Irtwange, S.V. and Igbeka, J.C. (2002). Some physical properties of two African yam bean (*Sphenostylis stenocarpa*) accessions and their interrelations with moisture content. Applied Engineering in Agriculture 18 (5): 567-576.

Irvine, F.R. (1960). Woody plants of Ghana. Oxford University Press, Oxford, 146-147.

Iwu, M. (2003). Handbook of African medicinal plants. CRC Press, Boca Raton, FL.

Iwu, M.W., Duncan, A.R. and Okunji, C. O. (1999). New antimicrobials of plant origin: perspectives on new crops and new uses. J. Janick (ed) ASHS Press, Alexandria, VA. 457- 462.

Joshi, D.C., Das, S.K. and Mukherjee, R.K. (1993). Physical properties of pumpkin seeds. J. Agricultural Engineering Research 54: 210 – 229.

Makanjuola, G.A. (1972). A study of some of the physical properties of melon seeds. Journal of Agricultural Engineering Research 17: 128-137.

Mohsenin, N.N. (1986). Physical properties of plant and animal materials 2nd Ed. (revised). Gorton and Breach Science Publishers, New York.

Nalladulai, K., Alagusundaram, K and Gayathri, P. (2002). Air flow resistance of paddy and it's by-products. Bio-systems Engrg. 83: 67-75.

Nzelibe, H.C. and Okafoagu, C.U. (2007). Optimization of ethanol production from garcinia kola (bitter kola) pulp agro-waste. African Journal of Biotechnology 6 (17)8: 2033-2037.

Oloso, A.O. and Clarke, B. (1993). Some aspects of strength properties of cashew nuts. Journal of Agricultural Engineering Research 55: 27-43.

Oje, K. (1994). Moisture dependent of some physical properties of cowpea. Ife Journal of Technology 4(2): 23-27.

Razavi, M.A. and Milani, E. (2006). Some physical properties of the watermelon seeds. African Journal of Agricultural Research 1 (3): 065-069.

Suthar, S.H. and Das, S.K. (1996). Some physical properties of karingda (citrullus ranatus (thumb) mansf) seeds. Journal of Agricultural Engineering Research 65: 15-22.

Tona, L., Ngimbi, N.P., Tsakala, M., Mesiak, K., Cimanga, K., Apers, S., DeBruyne, T., Pieters, L., Totte, J. and Vlientinck, A.J. (1999). Antimalarial activity of 20 crude extracts from nine African medicinal plants used in Kinshasha, Congo. Journal of Ethnopharmacol 5 68(1-3): 193-203.

Varnamkhasti, M.G., Mobli, H., Jafari, A., Rafiee, S., Heidarysoltanabadi, M. and Kheeralipour, K. (2007). Some engineering properties of paddy (rar. sazandegi). International Journal of Agriculture and Biology 9(5): 763-766.

(Received 18 June 2009; accepted 20 October 2009)