Continental J. Applied Sciences 7 (2): 9 - 18, 2012 ISSN: 1597 – 9928
© Wilolud Journals, 2012 http://www.wiloludjournal.com
Printed in Nigeria doi:10.5707/cjapplsci.2012.7.2.9.18

DETERMINATION OF SOME PHYSICAL PROPERTIES OF SELECTED NIGERIAN GRAINS

B. A. Alabadan[1] and I. M. Gana[2]
[1]Agricultural and Bio-resources Engineering Department Federal university of Technology Minna, Nigeria.
[2]Agricultural and Bio-environmental Engineering Department Federal Polytechnic Bida, Nigeria.

ABSTRACT
Some physical properties of selected Nigerian grains of relevant industrial application were selected for study under this study work. The grains considered are *Phaseolus lanatus, Pisum sativum, Cicer arietinum, Glycine max, Vicia fada, Cajanus cajan, Voandzeia subterranea, Lablab niger medik, Phaseolus angularis* and *Phaseolus vulgaris*. Standard test and experiment were used in studying the physical properties e.g shapes, sizes, number of grains per unit weight, sphericity, roundness, geometric mean diameter, surface area, volume and bulk density. Each of the test was replicated hundred times and their mean values were obtained. The result thus, obtained fully describes the physical characteristics of these grains growth in Nigeria.

KEYWORDS: Lima beans, Field pea, Pigeon pea, Chick pea, Soya bean, Bambara groundnut, Hyaciath beans, Adzuki bean, Haricot bean, Broad bean, Physical properties.

INTRODUCTION

Grains legumes occupy an important place in human nutrition, especially in the dietary pattern of low-income groups of people in developing countries. Legumes, considered as poor man's meat are generally good source of carbohydrate and are rich in protein. Legumes are normally consumed after processing, which not only improves palatability of foods but also increases the bioavailability of nutrient by in activating trypsin and growth inhibitors and haemagg-intinins. (Tharanathan & Mahadivamma, 2003).

Despite the importance of lesser Nigerian grains such as Lima beans (*Phaseolus lunatus),* Field pea *(Pisum sativum),* Pigeon pea *(Cajanus cajan),* Chick pea *(Cicer arietium),* Soya beans *(Voandzeia subbterranea*), Hyacinth bean *(Lablab niger medik),* Adzuki beans *(Pheseolus angularis)* Haricot beans *(Phaseolus vulgaris)* and Broad beans *(Vicia faba)* in human nutrition their production is low and restricted to some few part of Nigerian agricultural zones as such scientific data on their physical properties are not available and this caused low mechanization of technological processes especially as regards harvest and production line processing (Gana 2000, Anna and Julitta 2003).

Some researchers have reported the physical and mechanical properties of biomaterials (Manuawa and Muhammad 2010; Ogunjimi *et.al*,. 2002; Olaniyan and Oje 2002 and Davies 2010). The physical properties of biomaterials are essential in the design and development of specific equipment and structure and also for assessing the behavior of product quality (Kashaninejad *et.al*,. 2005).

Physical properties of the selected legumes grains are essential in the design of items of equipment for shelling, drying, cleaning, sorting, grading storage and oil extraction. The shape of the materials is an important design parameter in conveying of solid material by air or water, the areas and dimensions are essential for determination of thermal velocity, drag coefficient and Reynolds number. Also the shape and size also important in problem of stress distribution in the material under load, in electrostatic separation of seeds and grains, in light reflectance, colour evaluation and in development of sizing and grading machinery. Bhatia *et. el*,. (2009) also stated that the physical properties of legumes are very significant for the design of equipment, especially for handling, processing and storing the grains. The objective of the study of physical properties of some selected Nigerians grains has been an attempt to provide objective measurement resulting in more meaningful data in engineering analysis and designers to select appropriate method of processing these grains which will result in maximizing the product.

EXPERIMENTAL PROCEDURE

The legumes seeds were procured from Kaduna State, Nigeria. They constitute the commonly grown and consumed local seeds of the state.

The moisture content of the representative samples of different grains were determines using electrical resistance moisture meter. Chakraverty *et. al,.* (1980).

PHYSICAL CHARACTERISTICS

The shape of the grains were determined by tracing of the longitudinal and lateral cross section of the material, and then compared with the shape listed on a charted standard (Mohsenin, 1970). Using the standard charts descriptive terms were to define the shape of the products of hundred replicates.

The linear dimensions of the selected legume seeds were measured by using three major perpendicular dimension length (L), width (W) and thickness (T). The physical dimensions were randomly measured for 100 samples from each of the grains using vernier caliper. The geometric mean of the grains was determined using the relationship

$$d_s = (abc)^{\frac{1}{3}} \quad (1)$$ (Mohsenin 1970)

Where d_s is the geometric mean
a is major diameter
b is intermediate diameter
c is the minor diameter

iii) The sphericity of the grains were determined by tracing their outlines on paper and *di* and *de* were measured and used in the below equation according to Mohsenin (1970).

$$\text{Sphericity } (S) = \frac{d_i}{d_e} \quad (2)$$

Where S is the sphericity of the grains
di is the diameter of the largest inscribing circle
de is the diameter of the smallest circumscribing circle

iii) The roundness of the grains were determined by tracing their outlines on a graph paper, *Ap* & *Ac* are measured and used in equation 3 according to Mohsenin (1970).

$$\text{Roundness } (R) = \frac{A_p}{A_c} \quad (3)$$

Where R is the roundness of the grains
Ap is the traced area of the grains obtained
Ac is the traced area of the smallest circumscribing circle

iv) The weight of the grains under this study was recorded using electric balance (Ishida co. Ltd Japan) to an accuracy of 0.001g.

v) The Bulk density of the grains under this study was determined using Bulk density method which involves filling a standard container with the grains from a certain height, leveling the surface and weights the content (Mohsenin 1970). The standard container used in this case is small empty tin of tomatoes.

The volume of the grains that filled up the container to the surface is the volume of the inside container which is calculated using the conventional method of determination of volume of cylinder, which is given as

$$V = \pi r^2 h \quad (4)$$

Where V is the volume (m3)
π is constant
r is radius of the inside container
h is height of the inside container

The bulk density of the grains under the study were calculated using the conventional method of density calculation which is give as

$$\text{Bulk density} (\rho) = \frac{M}{V} \quad (5)$$

Where ρ is the density of the grains

M is the mass of the grains
V is the volume of the grains

vi) The surface area of the grains under this study was determined by the graph method due to unavailability of a palanimeter. The surface area was then calculated from the area covered by the on the graph paper.

RESULTS

Table 1: Moisture content, colour and shape of the Grains

S/No	Type of Grains	Moisture Content	Colour	Shape
1	*Phaseolus lanatus*	11.6	White Cream	Flat oblong
2	*Pisum sativum*	9.6	Brow	Sub-spherical
3	*Cajanus cajan*	10.1	White &	Round and
4	*Cicer arietinum*	9.8	Brown	oval
5	*Glycine max*	9.4	Brown	Angular
6	*Vicia fada*	11.3	Yellow to	Ovoid
7	*Voandzeia*	9.8	Brown	Oblong
8	*Subterranca*	11.8	Brown	Spherical
9	*Lablab niger medik*	11.6	Yellow	Oval compress
10	*Phaseolus angularis.* *Phaseolus vulgaris*	11.2	White to Yellow Red Brown & Light Yellow or with Black. Blood Red	Oblong Oblong

Fig. 1: Radar representation of selected physical characteristics of the selected grains

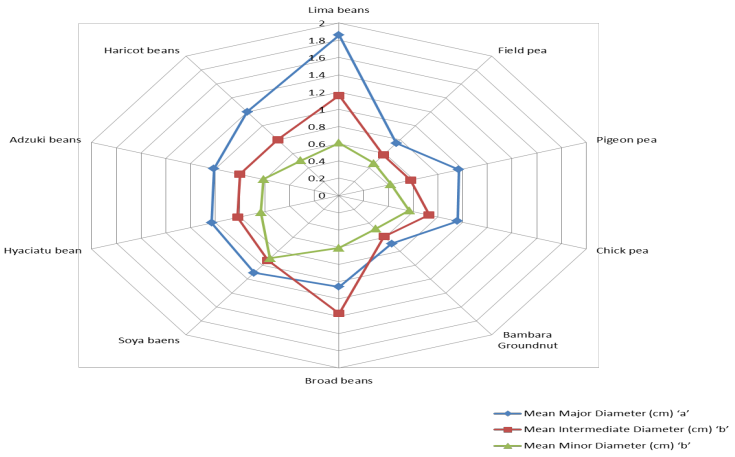

Table 2: Size of the Grains

Method	Property	Type of Grain	Number of Observation	Mean Major Diameter (cm) 'a'	Mean Intermediate Diameter (cm) 'b'	Mean Minor Diameter (cm) 'b'	Geometric Mean Diameter
Venier caliper & Calculation	Major Intermediate Minor and Geometric Mean diameter	*Phaseolus lanatus*	100	1.86	1.16	0.61	1.09
		Pisum sativum	„	0.75	0.58	0.46	0.59
		Cajanus cajan	„	0.97	0.58	0.42	0.52
		Cicer arietinum	„	0.96	0.73	0.57	0.74
		Glycine max	„	0.69	0.59	0.48	0.58
		Vicia fada	„	1.06	1.37	0.61	1.19
		Voandzeia subterranca	„	1.11	0.93	0.90	0.99
		Lablab niger medik	„	1.03	0.82	0.63	0.81
		Phaseolus angularis	„	1.01	0.80	0.61	0.80
		Phaseolus vulgaris	„	1.20	0.80	0.50	0.78

Table 3: Sphericity, Roundness and surface area of the Grains

Method	**Property**	**Num. of Observation**	**Type of Grains**	**di (cm)**	**de (cm)**	**Sher-icity (cm)**	**Ap (cm)**	**Ac (cm)**	**Roun-dness (cm)**	**Surface area (cm2) x 1**
Tracing Method	Sphericity, Roundness And Surface area	100	*Phaseolus lanatus*	1.12	1.72	0.65	42.7	61.25	0.70	4.27 x 10 $^{-5}$
			Pisum sativum	0.60	0.80	0.75	9.93	13.4	0.74	9.93 x 10 $^{-6}$
			Cajanus cajan	0.55	0.62	0.89	7.30	8.25	0.89	7.30 x 10 $^{-6}$
			Cicer arietinum	0.62	0.91	0.68	12.48	17.0	0.73	1.25 x 10 $^{-5}$
			Glycine max	0.56	0.69	0.81	8.45	10.90	0.77	8.40 x 10 $^{-6}$
			Vicia fada	1.25	2.05	0.61	56.13	87.72	0.67	2.11 x 10 $^{-5}$
			Voandzeia subterranca	0.92	1.13	0.81	21.15	26.5	0.80	2.11 x 10 $^{-5}$
			Lablab niger medik	0.68	0.97	0.70	14.58	17.75	0.82	1.46 x 10 $^{-5}$
			Phaseolus angularis	0.63	0.36	0.72	12.4	15.5	0.80	1.24 x 10 $^{-5}$
			Phaseolus vulgaris	0.73	1.13	0.65	18.3	26.7	0.69	1.38 x 10 $^{-5}$

Table 4: The number of grains per unit weight, volume and bulk density of the grains

Method	Property	Type of Grains	Num. of Grain/unit Weight	Weight (kg)	Volume (m^3)	Bulk Density (kg/m^3)
Electronic Weighing Balance and empty tomatoes Container	Weight & Bulk Density	*Phaseolus lanatus*	53	0.05583	7.5×10^{-5}	780.70
		Pisum sativum	480	0.05053	"	706.71
		Cajanus cajan	560	0.05866	"	788.39
		Cicer arietinum	178	0.06426	"	898.74
		Glycine max	435	0.05461	"	763.77
		Vicia fada	46	0.05000	"	699.30
		Voandzeia subterranca	123	0.05800	"	811.19
		Lablab niger medik	167	0.05861	"	819.70
		Phaseolus angularis	175	0.05825	"	814.69
		Phaseolus vulgaris	150	0.04763	"	666.15

Table 5: Standard deviation of the grain

Type of Grain	Major Diameter	Intermediate Diameter (b)	Minor Diameter (c)	Sphericity	Roundness	Surface area
Phaseolus lanatus	0.136	0.086	0.063	0.108	0.090	8.780
Pisum sativum	0.081	0.091	0.081	0.060	0.064	0.924
Cajanus cajan	0.168	0.061	0.059	0.094	0.087	4.240
Cicer arietinum	0.041	0.052	0.046	0.101	0.050	0.810
Glycine max	0.089	0.057	0.164	0.09	0.078	1.095
Vicia fada	0.176	0.120	0.051	0.065	0.059	7.620
Voandzeia subterranca	0.460	0.114	0.089	0.106	0.600	6.400
Lablab niger medik	0.081	0.137	0.065	0.062	0.078	1.773
Phaseolus angularis	0.108	0.054	0.053	0.102	0.085	7.822
Phaseolus vulgaris	0.218	0.104	0.096	0.650	0.061	4.090

DISCUSSION

The moisture content of the grains is presented in Table 1. It ranges between 9.4 to 11.8 % dry wet basis, with Bambara groundnut (*Voandzea Subterranean*) having the highest M.C of 11.8% while soya bean (*Glycine Max*) has the lowest M.C of 9.4%.

The shape and colour of the grains under the study is also presented in table 1. The grain varies in colour from white, brown, yellow, black to red. Some of the grains like Pigeon pea (*Cajanus Cajan*), Hyacinth bean (*Lablab niger medic*) and Adzuki beans (*Phaseolus angularis*) have combination of two or more colours. The shape of the grains varies from flat oblong, round and oval to oblong.

The size of the grains is presented in table 2. Lima beans (*Phaseolus lanatus*) has the highest value of 1.86 cm and 1.16cm for major and intermediate diameter respectively while soya bean (*Glycine max*) has the lowest value of 0.69cm for major diameter, pigeon pea (*Cajanus cajan*) has the lowest value of 0.58cm for intermediate and 0.42cm for minor diameter.

The mean major diameter, mean intermediate and mean minor diameter lies in the of 0.69cm to 1.86cm, 0.58 to 1.16 and 0.42 to 0.94 respectively (fig. 1)

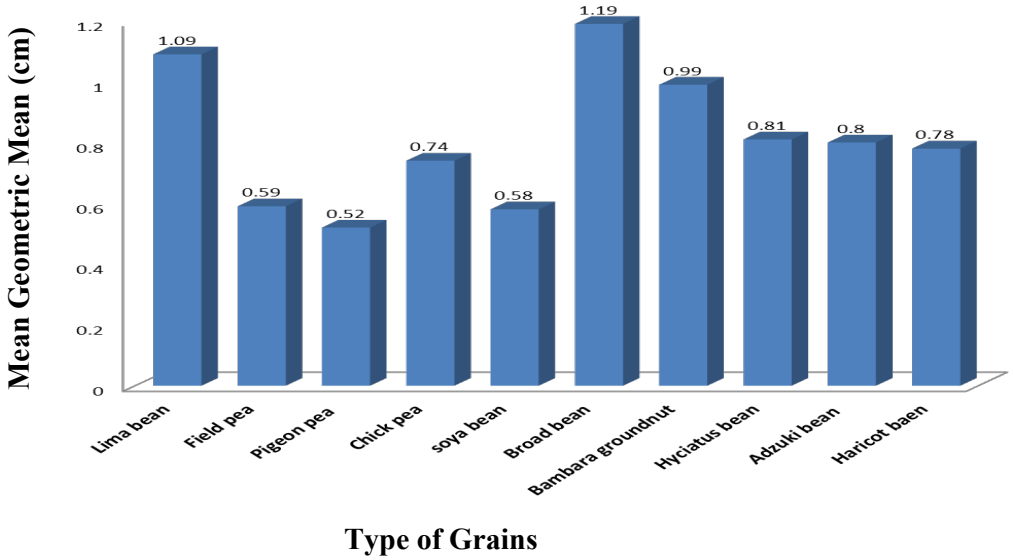

Fig 2. Relationship between Type of Grain and mean Geometric mean

From fig. 2 Broad bean (*Vicia faba*) has the highest value of mean geometric mean of 1.19cm while Pigeon pea (*Cajanus cajan*) has the lowest value of Broad beans (*Vicia faba*) geometric mean could be as result of it's large size and greater linear dimension.

The sphericity, roundness and surface area of the grains is presented in table 3. Pigeon pea (*Cajanus cajan*) has the highest value of 0.89 for both sphericity and lowest value of 0.61 and 0.67 for sphericity and roundness respectively.

The number of grains per unit weight, the volume and bulk density of the grains is presented in table 4. Pigeon pea (*Cajanus cajan*) has more number of grains of 560 in volume of 7.5 x $10^{-5}m^3$, while Broad beans (*Vicia faba*) has the least number of grains of 46 in volume 7.5 x $10^{-5}m^3$. This indicates that Pigeon pea is smaller in size while broad bean is bigger in size.

Chick pea (*Cicer arietnum*) has highest bulk density of 898.74kg/m^3 while Haricot beans. (*Phaseolus vulgaris*) has the least bulk density of 066.15 kg/m^3.

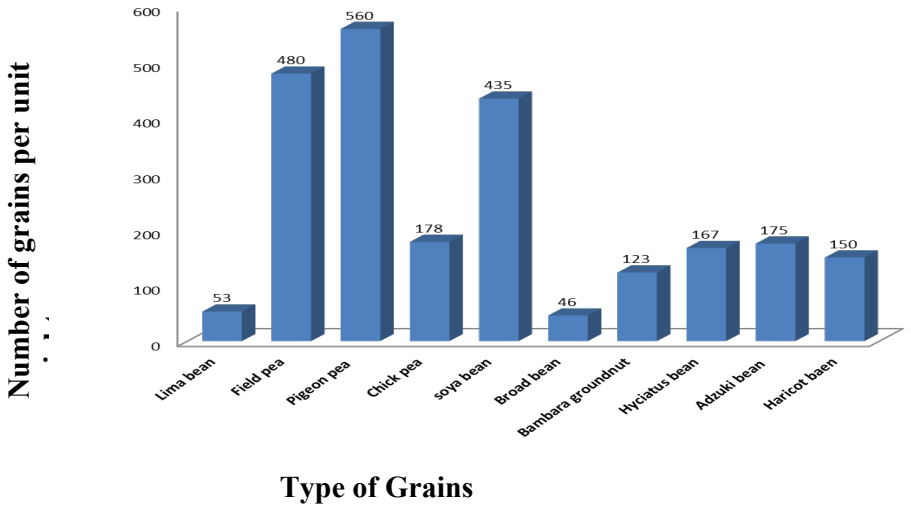

Fig. 3. Relationship between Grain type and Number of Grains per unit weight

From Fig. 3. Pigeon pea (*Cajanus cajan*) has the highest number of the seeds per unit weight while Broad beans (*Vicia faba*) have the least number of seeds per unit weight. This could be as result of the shape and large size of broad bean compare to other grains under the study that allows only few numbers of seeds to occupy a large space.

The standard deviation of the grains is presented in Table 6. From the result the surface area of Lima beans (*Phaseolus lunatus*) has the highest value of 8.780 for standard deviation while pigeon pea (*Cajanus cajan*)

CONCLUSION

The leguminous grains are an important protein rich biomaterial particularly used as major item of staple food. In this work an attempt has been made to determine some physical properties of *Phaseolus lanatus, Pisum sativum, Cicer arietinum, Glycine max, Vicia fada, Cajanus cajan, Voandzeia subterranca, Lablab niger medik, Phaseolus angularis and Phaseolus vulgaris*, capble of providing more meaningful data in engineering analysis and design of machine structures, process and control to enhance techno-scientific development of grains processing plant

REFERENCES

Anna G. Julitta B (2003)- Physical Properties of Selected Legumes Seeds as Indicators of Technological Suitability of Small-Seed Broad Bean. *Polish Journal of Food and Nutrition Science Pol. J. Food Nutri. Sci* 2003, Vol. 12/53 No 2. Pp. 9-13.

Bhatia T. Sharma R. K, Prasal K. K., and Prasal K. (2009) Studies on some Physical Properties of Protein-rich Legume (*Lens esculantus*) splits. *Asian Journal of Chemistry* Vol. 21, No. 10 (2009), S103-107.

Chakraverty A, D.S. Dec and E. A. Pains (1980)- Moisture Content Determination, Handbook of Food Nutrition; New York www.srmuviv.ac.in/engineering.php. Retrieved on 1st April, 2012.

Davies, R. M., (2010). Some Physical Properties of Arigo Seeds. *Int. agro Phys*, 24:89-92.

Gana I. M. (2001). Determination of Some Physical and Mechanical Properties of Selected Nigerian Grains Federal University of Technology Minna, Niger State, Nigeria Unpublished Undergraduate Project.

Kasharineja M., A Mortazavi, A Safekordi and L.g. Tabil. (2005). Some Physical Properties of Pistachio (*Pistachia vera L.*) Nut and its kernel. *J. Food Eng*., 72:30-38.

Manuwa S.I and H A. Muhammad (2010). Moisture Content and Compression Axis Effects on Mechanical properties of Shea kernel. *Journal of Food Technology* Volume: 8/Issue: 3/94-99.

Mohsenin N. N., (1970). Physical Property of Plant and Animal Materials Gondon and Breach Scientific Publishers, New York. Pp. 130-310.

Ogunjimi, L. A. O., N. A. Aviara and O. A. Aregbesola (2000). Some Physical and Engineering Properties of Locust Been Seen. *J. Food Eng*., 55: 95-99.

Olaniyan, A. M. and K. Oje (2002). Some Aspects of Mechanical Properties of Shea Nut. *Biosyst. Eng*., 81: 413-420.

Tharanathan R. N. and S. Mahadivamma (2003). Grains Legumes Aboon to Human Nutrition *Journal of Trends in Food Science & Technology*. Volume 14, Issue 12. Pp 507-513.

http://wwww.lininghub.ebservier.com. Retrieved on 2nd April 2012.

Received for Publication: 19/05/12
Accepted for Publication: 05/07/12

Corresponding author
I. M. Gana
Agricultural and Bio-environmental Engineering Department Federal Polytechnic Bida, Nigeria